NATIONAL NATURE RESERVES IN SCOTLAND AND THEIR MANAGEMENT

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Frontispiece: Inverpolly National Nature Reserve, Wester Ross, Scotland. Loch Sionascaig with Cul Mor shrouded in morning mist. The long-term survival of relict birch (Betula sp.) woodlands, such as those in the foreground, is threatened by excessive browsing and grazing on several reserves. (See Chapter 10.)

DECLARATION

I declare that this thesis has been composed by myself and has not been submitted for any other degree. The work of others has been acknowledged by an appropriate reference.

ABSTRACT

The land administering responsibility of the Nature Conservancy Council (NCC) in Scotland is compared with that of five other important conservation bodies. The NCC administers 75.2% of the 125,362 ha classed as National Nature Reserves (NNRs) or equivalent areas, but owns only 26.6% of the land it administers. The balance it manages under nature reserve agreements (NRAs).

Characteristics of the NRAs for 12 sample NNRs established before 1972 are examined.

The quality of NNR management for conservation purposes was estimated by scoring 20 variables for a sample of 15 NNRs. Overall, and in the critical area of animal management, NCC-owned NNRs were found to be generally better managed than NRA NNRs. Intensive wardening increases the quality of reserve management. It is suggested that wardening intensity on some reserves be augmented.

Commercial afforestation projects on Beinn Eighe and Cairngorms NNRs are studied. Suggestions are made for improvement of the conservation interest of the Forestry Commission plantation on Beinn Eighe NNR. Non-local provenances of Scots pine have been established on the reserve and the Forestry Commission and the NCC are urged to resolve the question of conservation of the Beinn Eighe/West Coulin native Scots pine genotype.

The establishment and management of Scots pine woodland is a major conservation concern on Beinn Eighe and Cairngorms NNRs. Neither reserve has a current management plan or long-term plans for afforestation and enclosure. The management of several exclosures has been unsatisfactory and it is suggested that good management plans are essential for continuity in the long-term management of woodlands.

Hardwood woodlands in three NNRs are shown to be declining. It is concluded that urgent and substantial changes in management are required to meet the NCC's objective of preserving them.

Generalised pest control and the shooting of gamebirds and waterfowl occurs widely on NRA NNRs. It is concluded that such practices are an anachronism, reflecting traditional land uses which are incompatible with the present land use.

Red deer frequently dominate the ecosystems on Highland NNRs. It is argued that the overall diversity of the ecosystems represented in Highland NNRs would be improved if most red deer were removed from some NNRs owned by the NCC.

Management practices which are impracticable on NRA NNRs should be optimised on owned NNRs. Increasing the number of owned NNRs will reduce land use conflicts within the NNR system.

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CONTENTS

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ABBREVIATIONS

AMP	Agreed Management Plan
App.	Appendix
CCS	Countryside Commission for Scotland
col.	column
FC	Forestry Commission
Fig.	Figure
FNR	Forest Nature Reserve
FOE	Friends of the Earth Limited
GCU	Gairloch Conservation Unit
ha	hectare
hon.	honorary
IUCN	International Union for Conservation of Nature and Natural Resources
LA	Local Authority
LHS	left-hand side
LNR	Local Nature Reserve
m	metre
NC	Nature Conservancy
NCC	Nature Conservancy Council
NCR	Nature Conservation Review
NERC	Natural Environment Research Council
NNR	National Nature Reserve
NRA	Nature Reserve Agreement
NS	not significant
NTS	National Trust for Scotland
pers. comm.	personal communication
pt	part
RDC	Red Deer Commission
RHS	right-hand side
RSPB	Royal Society for the Protection of Birds
s p ha	stems per hectare
SSSI	Site of Special Scientific Interest
SWT	Scottish Wildlife Trust
UNESCO	United Nations Educational, Scientific and Cultural Organisation

PART ONE

INTRODUCTION AND OUTLINE OF NATURE CONSERVATION IN SCOTLAND

CHAPTER 1

GENERAL INTRODUCTION AND DERIVATION OF OBJECTIVES

There are six major land-owning bodies committed, in different degrees, to fostering nature conservation interests in Scotland. The main objective in Part 1 of this study is to establish, in land-administering terms, the responsibility that each of these groups bears for nature conservation and to outline their basic management philosophies. The data is presented in terms of habitats which I have chosen, in subsequent sections of the work (see 2.2.1), as the fundamental unit of management. Part 1 also contains a highly distilled summary of the NCC's conservation strategy and some notes on its efficacy.

The data presented in Part 1 establishes that the Nature Conservancy Council (NCC), as the principal conservation body in Scotland, relies heavily on nature reserve agreements (NRAs) to promote its policies of conservation within National Nature Reserves (NNRs). NRAs were promulgated in the National Parks and Access to the Countryside Act 1949 and although not specifically designed to accommodate the wide scale of use to which they have been put (HMSO, 1977) it is through their use that at least part of 44 (out of 56) NNRs in Scotland (including 70.2% of the area) have been established (App. 1A). To a large extent NRAs have removed the incentive to purchase land for conservation purposes: if Rhum and Beinn Eighe NNRs are excluded only 12.2% of the area of NNRs is owned by the NCC. Although the first NRA reserve in Scotland was declared in 1954 (part of Cairngorms NNR) and declaration of NRA reserves continues to the present (e.g. Milton

Wood NNR) there has been no critical assessment of the effectiveness of management under NRAs. Eidsvik (1980) proposes that "It is not simply a question of hectares protected or a question of the number of areas protected: fundamentally it is a question of management quality. Are the protected areas achieving the objectives for which they were set aside?" In their vigorous promotion of NRAs it appears that the NCC is at least moderately satisfied with their performance.

Past studies of management agreements have been of limited value in assessing the success or otherwise of NRA NNRs. Feist (1978) deals specifically but briefly with NRAs commenting on their useage (for which there are statistics) but not their competency (for which there are not). He documents financial, legal and practical constraints but concludes that management agreements (sensu lato) "...have an important role to play..." in preserving features of the rural heritage. The Sandford Report (HMSO, 1974) deals primarily with management agreements in relation to National Parks in England and Wales. The report concluded, in part, that existing powers were insufficient to secure the voluntary conservation of National Parks and other areas and that local authorities be given powers to secure positive covenants to run with the land. Insofar as NRAs invoke primarily negative covenants (Feist, 1978) the same conclusion might be drawn.

In their discussion paper the Countryside Review Committee (1979) expressed concern over the level of protection afforded sites of special scientific interest (SSSI) but there is uncritical acceptance that whether owned or "...managed subject to an agreement" all NNRs receive "real protection". There will be instances where "...the benefits of NNR status..." will be achieved only by acquisition but in general their interpretation of the NCC's policy of acquisition of "...fragile...vulnerable...research...special..." areas is endorsed.

The Countryside Commission (1975), Hookway (1969, 1978, 1980) and Feist (1979) analyse management agreements (including access, landscape and field monument agreements and woodland dedication schemes) and despite some misgivings over technical matters invariably conclude in their favour. None address themselves specifically to NRAs. Nor does Lord Porchester (HMSO, 1977) who offers harsh criticism of the disappointing performance of management agreements in protecting moorland particularly in Exmoor National Park.

Only King and Conroy (1980) refer directly to the performance of NRAs when they opt unequivocally for the purchase of all NNRs by conservation bodies. They argue, with some support from the NCC (1977), that current legislation is "virtually useless" in protecting NRA reserves from agricultural development and afforestation because these operations lie outside planning control.

Publicly the NCC does not commit itself on the issue. For example, the report on conservation and agriculture (NCC, 1977) and the consultative paper on conservation and forestry (NCC, 1979a) do not discuss the performance of NRAs in relation to these sometimes most damaging influences (NCC, 1981a). Yet some NCC staff acknowledge short-falls in the NRA system and reservations are implicit in some recent in-house documents. The Loch Lomond Management Plan (NCC, 1976) in part aims at "...producing optimum nature conservation interest in association with productive land use." Thus "compromises" are necessary which are a "constraint" from the NCC's viewpoint. In relation to the Cairngorms NNR "Policies for the protection and management of the fauna should be subordinated to policies for the conservation of their habitat" (NCC, 1979b) but "The sporting management of the Reserve does not provide favourable conditions for the conservation of habitats..." (NCC, 1981c). Further, most owners are not willing to abandon sporting shooting even if compensated (ibid.)

In contrast, "undoubted success" has attended the management, both in husbandry and in sporting use, of Caerlaverock NNR (Adie, et al., 1974).

Clearly there are conflicting opinions regarding the efficacy of NRAs for nature conservation purposes. And some NRA NNRs would appear to be more successful than others. The main objectives in Part 2 of this study are therefore to:-

a) investigate the characteristics of NRAs and to examine their performance with respect to management.

b) compare the quality of management in NRA and owned reserves with respect to nature conservation values.

With respect to these objectives it is emphasised that the management of the flora and fauna for conservation purposes is the main concern of this study. Recreational, amenity and research responsibilities and objectives are considered only when relevant to the main theme.

In examining the management of a wide range of NNRs, and in compiling data for Part 2 it became clear that several important management problems were common to many reserves. The management of Scots pine (Pinus sylvestris) and birch (Betula spp.) woodlands and operations relating to animal management (including game shooting, pest control and deer management) frequently appeared to be contentious issues. The NCC may also have overlooked certain opportunities to capitalise on the unique status of owned NNRs, particularly in relation to the management of red deer (Cervus elaphus). The objective in Part 3 of this study is to examine in more detail five major problem areas, to identify inconsistencies in reserve management and, where feasible, to suggest alternative strategies with the emphasis on the role of NCC-owned NNRs.

CHAPTER 2

THE RESPONSIBILITY FOR NATURE CONSERVATION IN SCOTLAND

In Scotland six organisations play an important role in the protection and management of selected sites for wild life conservation. The National Trust for Scotland (NTS), Royal Society for the Protection of Birds (RSPB) and Scottish Wildlife Trust (SWT) are voluntary bodies with clearly stated remits to conserve the wildlife interest of the countryside, particularly on their own reserves and properties. The Forestry Commission (FC) is primarily concerned with the economically sound production of timber but since 1974 (earlier for some native Scots pine woodlands) has had a formal policy to maintain the values of scheduled sites i.e. Sites of Special Scientific Interest (SSSIs) notified by the Nature Conservancy Council (NCC). The NCC is the official government organ for nature conservation throughout Britain. The Scottish Division operates from Headquarters in Edinburgh and attempts to fulfil those roles laid down for it by statute in the National Parks and Access to the Countryside Act 1949, the Nature Conservancy Council Act 1973, and the Wildlife and Countryside Act 1981. Local Authorities (LA) were invited, under the 1949 Act, to accept some responsibility for nature conservation in their areas and several authorities have established Local Nature Reserves (LNRs). The Countryside Commission for Scotland (CCS) makes a major contribution to conservation in general. However, it is a non land-owning organisation and its main contribution is in a land-use planning and advisory capacity.

The philosophical and physical contribution that the first six groups make to nature conservation in Scotland is briefly examined in the following sections.

2.1 Conservation Organisations in Scotland

2.1.1 The National Trust for Scotland (NTS).

The NTS was founded in 1931 with a general remit to promote the preservation of places of historic or architectural interest or of natural beauty. All material aspects of Scotland's culture and inheritance as well as its aesthetic, amenity, recreation and scientific values have come to be pertinent "...a much broader view ...than the National Trust itself" (Magnusson, 1978). The "Scottish Trust now leads the world in the wholeness of its approach to environmental management" (Fraser - Darling, The Reith Lectures 1969, in Prentice, 1978) and amongst Scotland's conservation groups the Trust is unique in the breadth of its commitment to environmental conservation.

Implicit in this approach is recognition of the rights of the people who live on the land. Although the Trust has a commitment to manage land "...to promote...the preservation...of (its) natural aspect and features and animal and plant life" (Prentice, 1978) there will sometimes arise a conflict between the furtherance of this objective and the Trust's "...concern for neighbours, for our tenants.." (Wemyss, 1978) and for "...the fragile human communities which now inhabit it (the coastline)" (Grant, 1978).

It is in this explicit commitment to people that the Trust may be more constrained than other conservation groups in manipulating an area to further nature conservation values.

The Trust's properties are usually gifted but sometimes purchased from an endowment fund. However, conservation agreements or covenants

are promoted by the Trust particularly to safeguard sections of the coastline -"Without in any way limiting his ownership, an owner enters into an agreement with the Trust restricting, on conditions agreeable to both parties, the future use of his land" (NTS, 1980). Covenants are usually negative and binding on successors in title (Feist,1978). The terms are flexible and in the long term may prove to be more effective than some NCC-sponsored nature reserve agreements (NRAs) because the initiative lies with the owner. Up to 1981 over 60 such agreements were held over approximately 22,100 ha of land and including 126 km of coastline. (NTS, 1981).

2.1.2. The Royal Society for the Protection of Birds (RSPB). Established in 1889 the RSPB is the largest voluntary conservation body in Europe. The Society's objectives are to acquire land for reserves, to protect rare and threatened species, to investigate offences against the Bird Protection Act, and research, survey and education (RSPB, 1979).

In contrast to the low-key approach of the SWT, acquired sites must be SSSIs and "...preferably (of) National Status grading" (ibid.). Outright purchase is preferred but "...a Lease...or Agreement for at least 21 years with adequate management rights..." such that the nature conservation potential of the site may be exploited (J.Hunt, pers.comm.) is acceptable. In common with the SWT and the NCC the RSPB now regards legally binding management agreements as desirable, although this was not always so. The Society is prepared to compensate landowners for loss of rights, or of potential, but often relies heavily on an owner's altruism in reaching a settlement (ibid.).

In contrast to the other conservation groups in Scotland the RSPB has a specific and unequivocal responsibility to foster birdlife.

(RSPB, 1979). This arbitrary and exclusive interest is now broadening into an ecosystem approach to conservation (J.Hunt, pers.comm.), more akin to that of the SWT and the NCC.

Reserves are generally subject to active management, the policy being one of habitat diversification constrained only by the need to maintain the primary ornithological interest of the site (ibid.). There is a total commitment to maintaining the ornithological values of their reserves: to this end visitors may be discouraged or forbidden. Thus the Society's "List of Scottish Reserves" (RSPB,1981) includes only 19 (of 31) sites where visitors are currently permitted and even on these sites there are frequently restrictions.

2.1.3 The Scottish Wildlife Trust (SWT).

The SWT was founded in 1964 with the objective of reducing the threat that continuing population growth and industrial development presented to the natural history of Scotland. Thus conservation education, in which field the SWT considers that it has been particularly active and responsible (Dr A. Summerville, pers.comm.), has been aimed at fostering a sympathetic awareness of wildlife resources in the population at large. And in seeking to mitigate the potentially undesirable effects of industrial development the Trust's policy has never been to oppose development per se but to site projects and facilities where the threat to wildlife is minimised (SWT, 1976). To this end surveying and recording wildlife, locally and in a national perspective, is part of the Trust's role and again one in which they have been especially active (SWT, 1976; Gwynne, 1979; SWT Annual Reports, 1977-78, 78-79, 79-80).

Although the SWT acknowledges the prime conservation value of SSSIs its acquisition policy has been largely opportunistic

(Dr A. Summerville, pers.comm.) and largely dictated by financial and resource constraints. Thus of the 57 current reserves, only 9 are grade I or II SSSIs and 17 are not scheduled. Only 10 exceed 100 ha. However the Trust is now well established in the conservation field and the larger and more expensive grade I and II sites are within its ambit.

Because of the Trust's deliberate policy to concentrate on those areas under greatest pressure from changing land use "...¾ of the Trust's reserves lie south of the Highland line " (SWT, 1976). In this they echo the NCC's stated concern for lowland sites (NCC, 1977). Only Rahoy Hills and Glen Muick/Lochnagar comprise extensive uplands so typical of NCC and NTS holdings. Sites are purchased outright or secured under management agreements. Agreements secured by an exchange of letters or by "gentlemen's agreement" have often proved unsatisfactory when management for conservation purposes reduces the agricultural potential of a site (Dr A. Summerville, pers. comm.) and currently the SWT insists on an agreement that is sufficiently binding and definitive of SWT rights to permit anticipated management requirements to be implemented (ibid.). Leases are normally avoided (partly because of the difficulty of financing these arrangements) but Roslin Glen, under lease from the Crown Commissioners, is a successful and notable exception.

2.1.4 The Forestry Commission.

Frequent amendments and policy statements modifying the Forestry Acts of 1945 and 1947, in which the Commission's remit was essentially to make good the ravages of two wars, by establishing a forest estate of 2,000,000 ha by 2000 (Forestry Commission, 1980); modified in 1957 whereby "...future objectives should be of a commercial and social nature..." (ibid.) culminated in 1974 with the incorporation

of habitat conservation per se as part of the Forestry Commission's role in the management of the countryside (Forestry Commission, 1974).

The Forestry Commission now gives "...particular attention to those sites where nature conservation has been identified as of special importance" (Forestry Commission, 1979) although in the past a minority of SSSIs including Glencripesdale, Ariundle and Gight have suffered from Forestry Commission activities (R.Scott, pers.comm.; C.F. McNeill, pers.comm.; personal observation). Protection may be in the form of management agreements negotiated with conservation groups e.g. Ryvoan and Inverfarigaig Reserves with the SWT, and part of Loch Maree NNR with the NCC, or leases may be offered over Commission land e.g. Glen Doll in Caenlochan NNR. Listed sites may be disposed of to the NCC for conservation purposes e.g. Strathy Bog NNR and part of Loch Sunart NNR. Other areas of high conservation status may be safeguarded under management plan prescriptions e.g. a saltmarsh complex in Culbin SSSI and the Camghouran birch woods in the Black Wood of Rannoch.

The Forestry Commission has retained management responsibility for most native pinewood remnants within its forests e.g. Glen Affric, Black Wood of Rannoch and Glengarry and is responsible for approving the management plans for areas registered under the Basis III Dedication Scheme (Forestry Commission, 1978). It is in this field of pinewood management that the Forestry Commission is most actively engaged in habitat conservation. Approved schemes aim "...to maintain the existing native pinewoods...increase the area...by planting and natural regeneration...(and)...produce utilisable crops" (ibid.), whilst "...preservation is a better term for the management of the smaller remnants under Forestry Commission management" (Booth, 1977). The larger woodlands including Glen Affric and part of the Black Wood

of Rannoch are actively managed for multiple use purposes including habitat preservation, recreation and amenity, production, wildlife and research (Innes and Seal, 1971; Booth, 1977; MacRae, 1980).

Two Forest Nature Reserves (FNRs) - Glen Nant and Black Wood of Rannoch - have been established by agreement between the Forestry Commission and the NCC (E. Idle, pers.comm.) and a third, Ariundle, by agreement between the Department of Agriculture and Fisheries for Scotland and the NCC (Scott, 1981). These areas, analogous to NNRs but non-statutory, are conjointly managed under plan with conservation the primary objective. This designation is vastly superior to SSSI status with attention clearly focussed on the values of the areas and a written commitment to maintain them (E.Idle, pers.comm.). FNR status is currently being investigated for part of Loch Lomond Woods and for Kielder Head.

2.1.5 Local Authorities (LA).

Under S21 of the National Parks and Access to the Countryside Act 1949 local authorities may, in consultation with the NCC, establish and manage Local Nature Reserves (LNRs). Aberlady Bay LNR was established in 1952 (the first in Britain) but in Scotland only Munlochy Bay LNR, Hightae and Castle Lochs LNR, Eden Estuary LNR and Gladhouse LNR have been added in 30 years. In Angus the Montrose Basin LNR will be declared in 1982. In contrast, in England 55 LNRs (6013 ha) are established, in Wales 10 LNRs (849 ha) (NCC, 1978).

Land acquisition and management and development expenses in LNRs must be paid from the rates support grant. However, approved Country Parks may attract grants for acquisition of land, development of informal out-door facilities, litter collection and ranger services (Countryside Commission for Scotland, 1973). Although primarily for open-air recreation, Country Parks may include SSSIs

as in Culzean and John Muir Country Parks. Provided the situation is suitable Country Park designation may offer a financially attractive alternative to LNR designation, with areas of high conservation value within them protected by indirect means (including access restrictions and zoning).

As an indication of their comparative acceptability to local authorities 11 approved and 11 provisional Country Parks have been established under the Countryside (Scotland) Act 1967 (Countryside Commission for Scotland, 1980).

2.1.6 The Nature Conservancy Council (NCC).

The NCC is the official, government funded agency responsible for promoting conservation of flora, fauna, geological and physiographical features throughout Britain. Under the terms of the National Parks and Access to the Countryside Act 1949 as amended by the Nature Conservancy Council Act 1973 the NCC is responsible for the establishment, maintenance and management of nature reserves; the provision of advice to governmental and non-governmental agencies; dissemination of knowledge about nature conservation, and the support and conduct of research relevant to these functions.

This study is primarily concerned with the maintenance and management of nature reserves. Closely related to this is the NCC's responsibility, under S23 of the above Act of 1949, to notify owners and planning authorities of the existence of SSSIs. In this field the NCC has been exceptionally active: by April 1981 some 3900 SSSIs had been scheduled (NCC, 1981b), more than 915 in Scotland (McCarthy, 1980a). Of these, 735 grade I and II SSSIs - key sites - are listed in the Nature Conservation Review (NCR), some 250 in Scotland (Ratcliffe, 1977). The NCC regards "...the conservation of the

scientific interest..." of these key sites "...as vital to the nation" (NCC, 1980). They "...merit management to nature reserve standards" (NCC, 1981b) and require "...the level of protection provided by National Nature Reserve status or its equivalent" (Countryside Review Committee, 1979). The designation of important sites as NNRs should afford the most reliable protection and by March 1981 169 sites were of NNR status, 56 in Scotland (Table 3.1). Although ownership confers the greatest flexibility for management only 21% of all NNRs, embracing 26% of the land area, are owned by the NCC. The balance are established under lease or by agreement and the involvement of the NCC at the crucial management level is potentially constrained by the owner's requirements. The management of a further 43 grade I and II SSSIs is in part financed by the NCC under S15 of the Countryside Act (NCC, 1981a) whilst about one quarter in total are managed according to advice given by the NCC or by voluntary conservation bodies (NCC, 1977).

It is the NCC's function to impart knowledge and to create conservation awareness; in this capacity the NCC voted 22% of its total expenditure in the 1979-80 year on "General advice and dissemination of knowledge" (NCC, 1981a). In addition to advice and planning assistance limited financial aid may be available to voluntary groups to further conservation projects - in the same year with NCC resources stretched to the limit only £169,000 was so disbursed (ibid.).

2.2 Nature Reserves and Equivalent Areas in Scotland.

The data presented in the following tables is designed to:-

a) establish the role that the NCC plays in the conservation of wildlife habitats in Scotland

b) demonstrate that collectively in all habitats and particularly in open-water and coastal habitats the voluntary groups have major responsibilities

c) demonstrate the extent to which all organisations except the Forestry Commission and NTS depend on agreements with landowners to protect wildlife values

d) demonstrate the different primary interests of the various organisations.

Data relating to the tenure of NNRs, as opposed to habitats, is presented in Table 3.1.

2.2.1 Habitats as the Basic Management Unit.

The conservation of "...the biological resources of the country...can only be achieved by maintaining habitats, which in turn implies proper management" (NCC, 1977). The successful management of a reserve is therefore dependent on the adequate management of its different habitats and henceforth the habitat is regarded as the fundamental unit of management. This approach is of particular value in studying the management of reserves which may, as in the Cairngorms and Inverpolly NNRs, embrace several diverse habitats under different ownerships.

The seven habitats recognised by Ratcliffe (1977) have "...proved to be a practical and convenient subdivision into classes of the first rank." With minor alterations they have been adopted for this study. Ratcliffe's "Woodland" habitat has been subdivided into "Scots pine" (Pinus sylvestris) and "other" woodland habitats. The latter comprises mainly birch (Betula spp.) with some oakwood (Quercus spp.) and minor areas of coniferous plantation other than Scots pine. In ecological requirements, in distribution, habitat and associated fauna and flora there are significant differences between Scots pine

and birch. Since both are well represented in NNRs in Scotland it is apposite to distinguish between the two. There are only three scheduled grade 1 and 2 lowland grassland/heath/scrub habitats in Scotland (ibid.) and this habitat, along with dunes, bird breeding islands and cliff systems, shingle banks, beaches and rocky coast is included in Ratcliffe's already heterogeneous "Coastal" habitat. The other habitat classes used in this study are "Open Water" (including complementary wetlands), "Peatlands", and "Uplands" (comprising the upland grassland/heathland habitat of Ratcliffe).

2.2.2 Guidelines to the Classification.

a) In the following tables all NNRs, all SSSIs (or parts thereof) under the care of the RSPB, SWT, or NTS, all LNRs and all FNRs are included. Country Parks, National Park Direction Areas and SSSIs in general may provide less rigorous protection of conservation values and the two former designations do not always meet the criteria of scientific importance necessary for NNR or SSSI status.

b) Grade 1 and 2 SSSIs are, except as in c) below, classified according to their designation in the NCR (Ratcliffe, 1977); grade 3 and 4 SSSIs are classified according to their predominant habitat types.

c) Many NNRs and SSSIs contain areas of subsidiary habitat which is not scheduled in its own right. "In the present system, the whole of a site is covered by its grading..." (ibid.). Significant areas of subsidiary habitat (except peatlands) have therefore been identified and are included in the tables under the relevant habitat type e.g. woodland in Muir of Dinnet NNR, coastal habitat in Inverpolly NNR and Fetlar Reserve, uplands in Strathfarrar NNR and Glen Tanar NNR, some unscheduled open water habitat in Cairngorms NNR.

d) It proved difficult to consistently identify peatlands within uplands. Thus in both the NCR, and in this classification, peatlands "...are well represented within upland grassland and heath sites" (ibid.). Only those areas scheduled as peatlands in the NCR e.g. Boat Bay and Rannoch Moor NNR, or areas notified for their peatland values e.g. Gualin NNR are included as peatlands in the tables.

e) Inevitably, reliable figures for the areas of many habitats were not available. Area estimates for these habitats were made on maps with scales ranging from 1:5000 to 1:250,000 and on aerial photographs with scales between 1:10,000 and 1:26,000 using dot grids with from 4 to 100 dots/cm^2. The precision therefore varies as does the accuracy with which I was able to define some of the smaller habitats.

f) NTS land including Ben Lawers, St. Kilda, Torridon and Corrieshalloch and Forestry Commission land including Glen Doll and Loch Maree woodlands managed under lease or agreement by the NCC is included in the NCC tallies.

g) Data on areas of habitat types and on tenure presented in Tables 2.1 to 2.7 is derived from Appendices 1A to 1C except that detailed data for RSPB, SWT, NTS areas is confidential to these organisations.

2.2.3 Total Formal Reserve Areas by Habitat.

Table 2.1 shows that 75.2% of all formal conservation areas are managed by the NCC. The NCC has a greater areal responsibility than all other groups combined for all habitats except open waters. Uplands comprise 72.4% (68,308 ha) of the NCC's holdings with 64.0% (43,749 ha) in Rhum, Inverpolly and Cairngorms NNRs. The NCC manages about 22 times

as much peatland, 4 times as much woodland, and 3.7 times as much upland habitat as the other groups combined. Compared to local authorities, the SWT and the RSPB, the NCC has devoted relatively little of its resources to open water habitats. On the mainland, for example, only Loch Leven and Caerlaverock NNRs are of major significance for wildlife although a range of other smaller water bodies are managed by the NCC. Relative to grade 1 sites there is an imbalance in the excess of upland habitat and a paucity of peatland and open water habitat managed by the NCC as NNR. Only the properties of the SWT more closely reflect the existing distribution of habitats of scheduled conservation status.

Some 83% of the total area of LNRs is open water habitat. They contribute substantially to the security of this habitat and especially those areas used extensively by waterfowl and waders in the southern parts of Scotland.

The SWT manages a slightly smaller total resource than the RSPB or the NTS but, in fulfilment of its holistic concept of conservation, has the most balanced portfolio of interests. Proportionately it administers as much woodland as the NCC and it is the only group that has a balanced representation of upland habitat. Adequate resources have been allocated to open water and coastal habitats. Scots pine and peatland habitats are under-represented. This stems in part from their policy of acquiring, as first priority, threatened habitat in the lowlands (SWT, 1976).

The RSPB'S past policy is reflected in their predominantly coastal and open water sites of ornithological value. Some 56.8% of their properties are in this category and even their most significant woodland is associated with open water habitat of ornithological importance at Loch Garten.

Administering authority	Habitat Type						
	Uplands	Woodlands		Peatlands	Coastal	Open Water	TOTALS (and % of GRAND TOTAL)
		Scots pine	Other				
Forestry Commission 1 (FNRs)		649(83.2)	131(16.8)				780(0.6)
Local Authorities 2 (LNRs)		24(1.3)	41(2.3)		238(13.3)	1480(83.0)	1783(1.4)
National Trust for Scotland	9726(86.9)		18(0.2)		1099(9.8)	343(3.1)	11186(8.9)
Nature Conservancy Council (NNRs)	68308(72.4)	5284(5.6)	2000(2.1)	3739(4.0)	11477(12.2)	3509(3.7)	94317(75.2)
Scottish Wildlife Trust	4845(60.3)	200(2.5)	431(5.4)	173(2.2)	775(9.6)	1604(20.0)	8028(6.4)
Royal Society for the Protection of Birds	3695(39.9)	198(2.1)	109(1.2)		3813(41.1)	1453(15.7)	9268(7.4)
TOTALS	86574	6355	2730	3912	17402	8389	
GRAND TOTAL							125362
% of GRAND TOTAL	69.1	5.1	2.2	3.1	13.9	6.7	
All Grade 1 SSSIs 3	61.6	8.5		11.3	11.6	7.0	

Table 2.1 Formal conservation areas (ha) in Nature Reserves and equivalent areas in Scotland by habitat types. Percentage of row totals in brackets. Areas correct to Nov. 1981 for Local authorities, NCC, NTS; to April 1981 for other authorities. For guidelines to the classification see Pt 1; 2.2.2.

Notes: 1. 'Other' woodland includes 47 ha of oakwood in Ariundle FNR owned by the Department of Agriculture and Fisheries, Scotland.
2. The proposed Montrose Basin LNR is not included.
3. Row shows the proportions by habitat, of all grade 1 SSSIs in Scotland included in Ratcliffe (1977). Adapted from McCarthy (1980a) who records that "An analysis of other sites (grades 2 and 3) shows that these proportions are maintained..."

Uplands comprise 86.9% (9726 ha) of the scheduled property of the NTS. This excludes 3506 ha of uplands owned by the Trust but managed by the NCC. A further 15290 ha of uplands at Kintail, Balmacara, Glencoe, Falls of Glomach and Torridon is of additional but unscheduled value to wildlife. The NTS is virtually without woodland of scheduled conservation value but policy woodlands (including those at Culzean and Balmacara) and sites such as Dollar Glen, The Hermitage and the Scots pine plantation on Shieldaig Island (established about 1850) are of at least local significance. The Trust has important coastal properties including St. Abbs Head and Fair Isle but, like the NCC, few open water sites.

Although there is informal collaboration between all these groups there is no overall conservation strategy. It is therefore surprising that, despite the imbalance of habitats within some groups, the overall proportions of formally reserved habitat reflect so closely the relative areas of those habitats of recognised conservation value existing today. The only serious discrepancy is in the apparently small proportion of peatland in reserved areas. However as in 2.2.2. considerable unscheduled peatland is included in the upland habitat and identification of this component would substantially restore the balance.

2.2.4 Formal Reserve Areas Showing Tenure of Habitats.

Apart from the NTS, which has freehold title to all the areas included in these tables, the conservation groups have made extensive use of agreements and leases with owners to protect land with high conservation status. The NCC is no exception as the following tables demonstrate.

2.2.4.1 Uplands. The NCC administers 78.9% of the area of this

Tenure	Administering Authority					
	FC	LA	NTS	NCC	SWT	RSPB	TOTALS (and % of GRAND TOTAL)
Owned			9276	20680	753	1062	32221 (37.3)
Agreement				47325	4092	911	52328 (60.4)
Lease				303	0	1722	2025 (2.3)
TOTALS			9726	68308	4845	3695	
GRAND TOTAL							86574
% Owned			100	30.3	15.5	28.7	
% of GRAND TOTAL			11.2	78.9	5.6	4.3	

Table 2.2 Areas (ha) of Upland habitat, by tenure, in Nature Reserves and equivalent areas in Scotland. Abbreviations:- FC - Forestry Commission; LA - Local Authority; NTS - National Trust for Scotland; NCC - Nature Conservancy Council; SWT - Scottish Wildlife Trust; RSPB - Royal Society for the Protection of Birds.

habitat included in formal reserves. (Table 2.2). The extensive uplands in Rhum NNR and Beinn Eighe NNR contribute massively to the 30.3% (20680 ha) of owned habitat. Despite the wholly owned NTS properties, however, 62.7% of the total resource is still secured by lease or agreement. Because of their large holdings and significant areas under ownership the NCC and NTS are primarily responsible for conserving this habitat.

2.2.4.2 Scots pine woodlands. Table 2.3 demonstrates that only the NCC and the Forestry Commission own significant areas of native pinewoods. Because it represents a valuable and appreciating capital asset frequently beset by complex management issues owners may be understandably reluctant to cede significant rights of management to the NCC. Despite this 71.7% of the resource and 82.8% of the NCC's holdings are secured by agreements, some of which are widely held to be unsatisfactory from a conservation aspect because of the multiple

Tenure	Administering Authority						
	FC	LA	NTS	NCC	SWT	RSPB	TOTALS (and % of GRAND TOTAL)
Owned	649			910		198	1757 (28.3)
Agreement				4374	80		4454 (71.7)
Lease							
TOTALS	649			5284	80	198	
GRAND TOTAL							6211
% Owned	100			17.2	0	100	
% of GRAND TOTAL	10.5			85.1	1.2	3.2	

Table 2.3 Areas (ha) of Scots pine Woodland habitat, by tenure, in Nature Reserves and equivalent areas in Scotland. Abbreviations as in Table 2.2
Notes: 1. Native pinewoods owned by the FC but not declared as FNRs are not included.
2. There is an additional 24 ha of uniform plantation woodland in Gladhouse LNR (LA) and 120 ha in Loch Fleet Reserve (SWT).

values that are accommodated. Conservation groups (including the NCC) rarely have the finances to purchase significant areas of pinewood and only 910 ha (17.2%) of the NCC's holdings are owned. The importance of the Forestry Commission's role is thrown into sharp relief: major additional holdings adjacent to the Black Wood of Rannoch FNR and in the native pinewood section of Glen Affric Forest (819 ha) and responsibility for management in 12 other native pinewoods (Booth, 1977) complement the NCC's limited role in conserving this habitat.

2.2.4.3 Other woodlands. From Table 2.4 the NCC administers 2000 ha (73.3%) of the mainly hardwood resource but only 22.6% of this is owned. Despite its low commercial value the total area of this resource (2730 ha) is only 44% of the area of native pinewood managed for

Tenure	Administering Authority						
	FC	LA	NTS	NCC	SWT	RSPB	TOTALS (and % of GRAND TOTAL)
Owned	131	0	18	452	35	22	658 (24.1)
Agreement		41		1537	377	87	2042 (74.8)
Lease				11	19		30 (1.1)
TOTALS	131	41	18	2000	431	109	
GRAND TOTAL							2730
% Owned	100		100	22.6	8.1	20.2	
% of GRAND TOTAL	4.8	1.5	0.6	73.3	15.8	4.0	

Table 2.4 Areas (ha) of "Other" Woodland habitat, by tenure, in Nature Reserves and equivalent areas in Scotland. For convenience 47 ha in Ariundle FNR owned by Department of Agriculture and Fisheries, Scotland, is included in FC total. Abbreviations as in Table 2.2

conservation. With about 11425 ha in 63 separate woodlands nominated as grade 1 and 2 SSSIs by Ratcliffe (1977) this habitat seems under-represented. The SWT holds 431 ha (15.8%) of the total but 91.9% of this is secured by lease or agreement. Only the coastal habitat has a smaller proportion of the total area secured by ownership.

2.2.4.4 Peatlands. This is the only habitat in which the owned area exceeds that held under other tenures. Largely because of the NCC's ownership of Rannoch Moor (1499 ha) and Claish Moss (563 ha) 54.1% of the resource and 55.0% of the NCC's holdings are owned (Table 2.5). Apart from the SWT's small but valuable interest in 7 mosses conservation and protection of this habitat is entirely the responsibility of the NCC. However, unscheduled "peatland" occurs on most Highland reserves and under a variety of tenures.

Tenure	Administering Authority						
	FC	LA	NTS	NCC	SWT	RSPB	TOTALS (and % of GRAND TOTAL)
Owned				2055	61		2116 (54.1)
Agreement				1444	112		1556 (39.8)
Lease				240			240 (6.1)
TOTALS				3739	173		
GRAND TOTAL							3912
% Owned				55.0	35.3		
% of GRAND TOTAL				95.6	4.4		

Table 2.5 Areas (ha) of Peatland habitat, by tenure, in Nature Reserves and equivalent areas in Scotland (see 2.2.2). Abbreviations as in Table 2.2.

2.2.4.5 Coastal habitat. With management responsibilities over 11477 ha of coastal habitat the NCC has stewardship over 65.9% of the total resource (Table 2.6). Caerlaverock NNR (5502 ha) comprises

Tenure	Administering Authority						
	FC	LA	NTS	NCC	SWT	RSPB	TOTALS (and % of GRAND TOTAL)
Owned			1099	507	20	541	2167 (12.5)
Agreement		238		8467	755	1208	10668 (61.3)
Lease				2503		2064	4567 (26.2)
TOTALS		238	1099	11477	775	3813	
GRAND TOTAL							17402
% Owned		0	100	4.4	2.6	14.2	
% of GRAND TOTAL		1.4	6.3	65.9	4.5	21.9	

Table 2.6 Areas (ha) of Coastal habitat, by tenure, in Nature Reserves and equivalent areas in Scotland. Abbreviations as in Table 2.2.

64.9% of the NCC's holding. Only 4.4% of the Council's property is owned. With its interest in birdlife the RSPB has important coastal reserves and although only 14.2% of its area is owned (541 ha) it, along with the NTS (1099 ha) has more coastal habitat under ownership than the NCC. Some 87.5% of this resource is managed under lease or by agreement, a higher proportion than for any other habitat.

2.2.4.6 Open waters. The 3 voluntary organisations combined hold about the same area of this habitat as the NCC (Table 2.7).

Tenure	Administering Authority					
	FC	LA	NTS	NCC	SWT	RSPB	TOTALS (and % of GRAND TOTAL)
Owned		304	343	480	741	485	2353 (28.1)
Agreement		1176		3029	843	147	5195 (61.9)
Lease					20	821	841 (10.0)
TOTALS		1480	343	3509	1604	1453	
GRAND TOTAL							8389
% Owned		0	100	13.7	46.2	33.4	
% of GRAND TOTAL		17.6	4.1	41.8	19.1	17.3	

Table 2.7 Areas (ha) of Open Water habitat, by tenure, in Nature Reserves and equivalent areas in Scotland. Abbreviations as in Table 2.2.

However, they own 46.1% (1569 ha) of their combined resource, vastly more than the NCC's 13.7% (480 ha). The SWT (741 ha) and RSPB (485 ha) individually own more habitat than the NCC. Local authorities have also concentrated on this habitat which makes up 83.0% of their combined total resource. Together they manage a substantial 17.6% of the total open water habitat, one fifth of which is owned. It is in

this habitat that the NCC's interests are at their most tenuous.

2.2.5 Summary of the NCC's Role.

In the mainland terrestrial habitats i.e. woodlands, peatlands and uplands the amount of land administered by the NCC in the conservation interest (79,331 ha) dwarfs that of all other groups, singly and combined (20,216 ha). The NCC manages 78.9% of uplands, 86.3% of woodland and 95.6% of identified and scheduled peatlands.

In the coastal and open water habitats the NCC plays a relatively less important role. In the coastal habitat the NTS and RSPB together own 1640 ha, more than three times the land area owned by the NCC (507 ha). Thus although the NCC's coastal interests are substantial at 11,477 ha (65.9% of the total resource) only the alarmingly low proportion of 4.4% is owned. There is a slightly better balance between ownership at 13.7% and agreement at 86.3% for the 3509 ha of open water habitat managed by the NCC. The SWT and RSPB each owns a larger area of habitat than the NCC and with the NTS own more than three times the area owned by the NCC. This is the only habitat over which the Council might be said to have ceded major responsibility for the conservation of a habitat to the voluntary organisations.

Of the total area of land administered by the NCC as NNR (94,317 ha) only 26.6% (25,084 ha) is owned. If the extensive upland habitat is excluded the total resource shrinks to 26,009 ha of which 16.9% (4409 ha) is owned.

Similarly, the other organisations combined administer 31,054 ha of which twice as much - 51.1% (15,884 ha) - is owned. If the upland habitat is excluded the resource stands at 12,788 ha of which 34.0% (4343 ha) is owned.

The NCC is clearly the most important conservation force in Scotland in all but the open water habitat. The proportions of habitats included in its reserves are well balanced and approximate the distribution by area of habitats of conservation status in Scotland (Table 2.1). But only one quarter of the areas are secured by ownership (one sixth if uplands are excluded) and in this the Council is potentially more constrained than the other organisations with one half and one third respectively of their properties owned. The implementation of conservation-orientated management practices which in some cases may reduce the earning potential of the property, or result in inconveniences, is clearly dependent to a disturbing degree on the co-operation of owners. The Council's requirements are therefore vulnerable to changes in ownership and to changes in estate staff and tenants, to market forces, to changes in land-use patterns and to the whim of owners.

CHAPTER 3

THE NATURE CONSERVANCY COUNCIL AND ITS CONSERVATION STRATEGY

In Chapter 2 it has been shown that the NCC is the most important conservation body in Scotland. Its responsibilities do not end with the selection and management of NNRs although these are the primary conservation tools. The relative importance of NNRs is established by considering the NCC's conservation strategy, and their second tier of site protection - SSSIs (sections 3.1 and 3.2 respectively) whilst NNRs and NRAs are discussed in section 3.3.

3.1 The 'Key Site' Philosophy

Historically the NCC has adopted a two-tier system in seeking to conserve selected sites of high conservation status. Within the limits of their resources the most important, the most threatened and the highest priority sites have been declared NNRs. Initially, at least, there was also an element of opportunism as in the purchase of Beinn Eighe NNR in 1951. By Nov. 1981 there were 169 NNRs in Britain including 56 in Scotland. Within them nature conservation is ostensibly the dominant land-use but rarely is it the only use.

Sites of Special Scientific Interest (SSSI) are the second tier of site protection. Grade 1 and 2 sites are of international or national importance, grade 3 and 4 sites are of regional and local importance respectively. There are over 3900 SSSI in Britain, over 915 in Scotland (NCC 1981b, McCarthy, 1980b). With NNRs (1.2%) they cover 8.0% of the land area of Scotland and 5.7% of the area of Britain.

SSSI are not the subject of this study but some knowledge of their role will highlight the significance of NNRs to nature conservation.

In seeking to maintain the extant wildlife of Britain the NCC have adopted the 'key site' strategy promulgated in the early Government white papers on conservation (HMSO, 1947,1947a) and endorsed, for example by Ratcliffe (1977) in his Nature Conservation Review (NCR). Under this strategy "The most important sites are selected as biological SSSI. These if managed to retain their conservation value will provide, together with ... NNRs a basis for maintaining the present diversity of wild animals and plants in Great Britain" (NCC,1981b). This the NCC (1979) regards as "...vital to the nation" and is the philosophy of the key site strategy.

The adequacy of such a strategy on its own has been questioned by authors such as Ratcliffe (1977), King and Conroy (1980), Bachell (1981), Goode (1981) who point to spectacular and well documented mainly post-war changes in land use and land management which have caused great losses in traditional wildlife over the spectrum of habitats e.g. Moore, 1962; King and Conroy, 1980; Bunce et al., 1980; NCC, 1979; House of Lords Select Committee on Science and Technology, 1980; Langdale-Brown et al., 1980; Goode, 1981; Beebee, 1977, 1980; Rackham, 1980. Such changes affect not only the viability of SSSI which depend on unprotected buffer areas for maintenance and replenishment of their essential features but the "wider countryside" (NCC, 1977; King and Conroy, 1980) with its undefined but tangible wildlife values. The principles of island biogeography also argue against too much reliance on a key site strategy. For example Moore and Hooper (1975) note that "...it is possible that genetic drift, inbreeding, instability and species extinction at site level may be changing reserves in a way that would be expected on an isolated island." For example,

as woodlands became fragmented the number of species declined: a reduction to 1/10 of the original size halved the number of species and individual species were represented in progressively fewer woods.

To meet these objections the NCC has moved to strengthen the wildlife resource base. The criteria for selecting biological SSSI have been revised so that within a framework of approximately 2500 square km units the best example of each of seven habitat types (or as many as occur) are scheduled as SSSI. Additional provisions ensure that, for example, rare or widely dispersed species or important assemblages of animals are not overlooked (NCC, 1981a, 1981b). This rationalisation now ensures that a site, relatively undistinguished by national standards but essential in a regional context, is accorded statutory recognition.

Further, the Council has based its case for a more viable role in the management of the countryside on a rural strategy which would constrain the actions of some land-managing government departments and encourage landowners to improve yields rather than to develop wildlife habitats with potentially higher agricultural productivity (NCC, 1977). The NCC also seeks to improve wildlife awareness in other government departments and through them to reach a wider audience of landowners (ibid.)

The Council clearly believes that political and legislative initiatives are necessary to carry out this role. Hookway (1980) observed that in our 1980's society the "...conservation ethic...(is)...part of the values of a new generation" and perhaps new generation legislation and new generation action is required for conservation to achieve its legitimate status.

3.2 The Security of Sites of Special Scientific Interest.

Under the National Parks and Access to the Countryside Act 1949 as

amended by the Nature Conservancy Council Act 1973 the NCC is obligated to identify SSSI and to inform local authorities, and by a subsequent Ministerial instruction, owners, of their existence. In Scotland the Town and Country Planning (General Development Scotland) ~~Act~~ Order 1971 (there is a parallel order for England and Wales) obliges local authorities to consult with and take into account the views of the NCC when considering applications for development of SSSI. The decision as to whether the development should or should not proceed, however, rests strictly with the authority concerned. The NCC has a subsequent obligatory advisory role, and often presents its case for conservation at planning enquiries.

Forestry and agricultural operations have been repeatedly identified as the main causes of habitat changes inimical to traditional wildlife values e.g. HMSO, 1977; NCC, 1977, 1982; King and Conroy, 1980; Langdale-Brown et al., 1980; but these operations do not constitute 'development' within the meaning of the Town and Country Planning Act 1971 under which local authorities operate. These and other operations do cause losses to SSSI. According to the NCC (1977) about 4% of all SSSI are seriously damaged each year although a subsequent publication (NCC, 1981a) puts the loss over an approximately 10 year period at about 7%. An assessment of damage on 443 randomly chosen biological SSSI in 1980 showed that a minimum of 13% had suffered damage to their wildlife values in that year, and that damage was due mainly to agricultural improvements and the cessation of traditional agricultural practices (NCC, 1982). Locally the losses can be spectacular with damage recorded to 20 of 62 SSSI in Dorset in 1980 alone (ibid.) In four counties in southern England "...70 SSSI ($^3/_4$ of the total in the region) are under threat" (King and Conroy, 1980) whilst over the whole country 50 out of 120 nationally important grassland sites listed in Ratcliffe

(1977) have suffered appreciable loss of scientific interest over a 10 year period (Goode, 1981). Studying SSSI in S.W. Scotland, Oldham (1974) found sites subject to tipping, quarries used as County Council dumps, woodland SSSI adjoining new housing developments, a caravan park erected on one site and a moss ploughed and planted by the Forestry Commission.

McCarthy (1980b) states that "Site selection must also take account of the feasibility of protection and management..." although clearly this has not been a significant factor in identifying SSSI to date. Thus with no powers to impose conservation oriented changes in management of SSSI or even to ensure that traditional types of land use are maintained the protection of SSSI is essentially dependent on the goodwill of the farming community (NCC, 1977; McCarthy, 1980a; NCC, 1981b). Furthermore McCarthy (1980a) sees no long-term change in the role that land-owners play in striking the "...balance between trusteeship and utilisation."

Measures have been adopted to increase the security of SSSI. Under S.15 of the Countryside Act 1968 the NCC can enter into legal management agreements with owners for the protection of the scientific interest of SSSI ('M-Schemes'). A small number of SSSI - 70 in total and covering some 2500 ha (NCC, 1982) - are administered in this way. Compensatory payments are severely limited by the funds granted to the NCC for this purpose (McCarthy, 1980a) although the NCC is anxious to promote these agreements (NCC, 1977). In addition, areas of outstanding scientific interest may be exempted from Capital Transfer Tax (under the Finance Act 1977) if managed for the public benefit and the NCC considers that this in concert with widespread 'M-Schemes' "...together should provide adequate incentives to conserve SSSI" (NCC, 1977). But Feist (1978) documents the initially disappointing response to

these 'M-Schemes' and indicates that inadequate compensation was one probable cause. He also records that they rely heavily on the altruism of owners and that they are secondary to NRAs in the allocation of funds and resources. Ominously, Lloyd (1977) states "It is unrealistic to expect that public agencies will ever conclude agreements on a large scale..." because of the continuing financial commitment to service them, the difficulty of justifying payment that "...more than compensates for restrictions imposed..." and "...perhaps most importantly...there is a resistance amongst most landowners to long-term legally binding commitments over land management." The Countryside Review Committee (1979) too is dubious about the efficacy of SSSI designation, M-Schemes and tax relief calling them "...an incomplete system of protection in the absence of better control over activities within the sites themselves..."

In summary the SSSI system has been pursued by the NCC with vigour, and with increased effort in promoting conservation - aligned management of the wider countryside, the problems are of a practical rather than philosophical nature. The present level of financing and of authority in land-use issues would seem to be incompatible with the statutory responsibilities of the NCC. And the level of protection currently available to carefully chosen sites of national and international importance is highly inappropriate.

3.3 National Nature Reserves.

3.3.1 The Status of National Nature Reserves : Nature Reserve Agreements.

In contrast to SSSI, NNRs are, in theory, held under such 'conditions and control' that the study of features of the reserve is possible and/or protection of the flora and fauna is assured and/or geological and physiographic features are preserved (HMSO, 1949; HMSO, 1973).

In statutory terms then, the principal conservation features of NNRs are protected and the degree of security is popularly considered to be high. Thus in their discussion paper on conservation the Countryside Review Committee (1979) notes that NNR status is given only when there is an assurance that the nature conservation interest will be protected as a primary objective of management and that all NNRs receive "real protection". Nicholson (1971) remarks that management in NNRs (especially if owned) can be directed uncompromisingly towards the maintenance of selected natural features whilst the IUCN describes Category 4 sites, under which 13 NNRs in Scotland are listed (IUCN, 1980) as areas where the protection of nature rather than the production of harvestable renewable resources is the primary purpose of management (IUCN, 1978, 1980).

However, under the National Parks and Access to the Countryside Act 1949 the NCC was empowered to negotiate agreements over land to secure its nature conservation interest and most NNRs in Britain have been established in this way (Table 3.1). Covenants, usually negative to run with the land (Feist, 1978) and usually in return for some form of compensation, establish management policy for the sites. Known as nature reserve agreements when applied specifically to national nature reserves these covenants give the NCC the same statutory powers as obtain on nature reserves as defined under the Act (ibid.) But productive land is frequently included in NRA reserves and conflicts arise between production and conservation objectives. Subsequent "constraints" on management for conservation purposes e.g. NCC, 1976, 1981c, can cause severe dislocations in the management of some reserves.

Undoubtedly because of this the IUCN (1978) does not recognise the production of protein from wildlife, sport hunting and fishing as legitimate conservation objectives in nature conservation reserves

and there appears to be a fundamental conflict of values in the incorporation of Scottish NNRs in this category.

Nevertheless, NRAs have proven acceptable to the NCC in establishing some level of involvement in areas of high conservation status. Table 3.1 shows that 44 out of 56 NNRs in Scotland (including 70% of the land area) are at least in part administered under NRAs. (Complementary data relating to habitats are contained in section 2.2.4 and in Tables 2.2 to 2.7). Proportionately, almost 2½ times as many reserves in Scotland (79%) are at least in part secured under NRA as in England and Wales (33%). And, in proportion, almost twice the area is involved (70% and 40% respectively). The use of NRAs as a conservation tool is therefore particularly prevalent in Scotland.

Country	No. of Reserves	Area (ha) of NNRs by tenure		
		O	L	NRA
Scotland	56	25084	3057	66176
England	82	7368	9729	11577
Wales	31	1878	4202	3644
Total	169	34330	16988	81397

		Number of NNRs by tenure						
		O	L	NRA	O/L	O/NRA	L/NRA	O/L/NRA
Scotland	56	8	4	30	1	9	3	1
England	82	23	24	16	5	4	3	7
Wales	31	5	11	6	7	-	-	2
Total	169	36	39	52	13	13	6	10

Table 3.1 Area and number of NNRs by tenure. Data for Scotland to Nov. 1981, for England and Wales to March 1981. O = Owned, L = Lease, NRA = Nature Reserve Agreement. Sources : NCC, 1981a; Author.

3.3.2 The Security of National Nature Reserves.

Damage to NNRs does occur and the wildlife values within NNRs may be degraded or come under increased pressure. For example, King and Conroy (1980) claim that 12 NNRs are under imminent threat from development, and Table 3.2 lists some incidents in my sample of Scottish NNRs. Of the 19 reserves and sections established under NRAs 15 have suffered some physical damage or pollution with a minimum of 26 separate incidents. Public authorities acting under public works acts have responsibility for 9 incidents, 17 result from deliberate intervention by owners or their agents. Road development in Glen Einich (Plate 3.1) and into the Moine Mhor wilderness, draining of the Inchnadamph plateau peatland (Stronchrubie Flat - Plate 3.2) and reclamation of the St. Cyrus salt marsh are among the most unsympathetic developments although each may be justifiable in terms of increased productivity.

There have been 8 separate incidents in the 4 owned areas. Three of the four major incidents in Beinn Eighe NNR result from public authority actions and the drain at Tentsmuir Point NNR was unsuccessfully opposed by the NCC in 1957.

Of the total of 23 reserves and sections all but 5 have suffered some damage and two of these - Kirkconnell Flow NNR and the open water section of Rannoch Moor NNR - have been subject to recent proposals for exploitation.

These observations demonstrate that:-

a) irrespective of tenure and regardless of statutory protection NNRs have been liable to development and/or exploitation.

b) public authorities have been responsible for 35% of all the violations.

c) even in Scotland with its relatively minor population pressures and large areas of uplands of low productivity NNR

Reserve / Section	Tenure	Damage due to	Remarks
CAENLOCHAN			
Invercauld	NRA	Skiing development	(1) Tracked vehicle to summit of Glas Maol on weekends, 1980 (Nethersole-Thompson and Watson, 1981). Proliferation of tracking and ski equipment, litter, along NNR boundary. Disturbance and noise pollution.
Tulchan	NRA	Roading	(1) Blasting and road construction in Caenlochan Glen, circa 1977.
CAERLAVEROCK	NRA	nil	But owner retains right to ditching, draining, flood banking, sluices "... without the consent and approval of the Conservancy ...".
CAIRNGORMS			
Glen Feshie	NRA	Roading Forestry	(1) Re-alignment and development of vehicle track up Glen Feshie resulting in a scar "so distressingly ugly that it almost amounts to vandalism" (Nethersole-Thompson and Watson, 1981). (2) Opening up of Moine Mhor barrens with 12 km of track, circa 1970. (3) 140 ha mixed coniferous plantation (commercial) established 1967. (4) 70 ha of Scots pine plantation (commercial) to be established in 1981-82.
Rothiemurchus	NRA	Roading Water exploration	(1) Extensive re-alignment of Glen Einich track circa 1960 (2.3 km of new track) further upgraded circa 1975 (Plate 3.1). (2) Underground pipeline and surge-chamber constructed Glen Einich circa 1975 for Aviemore water supply.
Invereshie/ Inshriach	Owned	Roading	(1) Maintenance of miscellaneous old logging tracks. (2) Construction of substantial concrete bridge over Allt Ruadh in 1959 and possible construction of 700 m length of loop road at head of Allt Ruadh logging track.
CRAIGELLACHIE	NRA	Roading	(1) Tracks developed through woodland, in part associated with underground pipeline and surge chamber. (2) Net loss of approximately 2 ha of woodland/wetland and part Lock Puladdern due to motorway construction 1979/80.
INCHNADAMPH	NRA	Drainage Fisheries	(1) Drastic mutilation of about 150 ha of peatland in 1975/76. Drainage channels about 35 cm deep at 30 m intervals disect the bulk of this previously undisturbed plateau peatland (Plate 3.2). (2) Hatchery established on Allt nan Uamh 1978/79 on south-west boundary of the Reserve.

Table 3.2 Damage to sample NNRs since declaration. List may not be complete. Table includes only man-induced physical changes but not changes due to, for example, modification of stocking rates and shooting pressure.

Table 3.2 continued

INVERNAVER			
East section	NRA	Power reticulation	(1) Transmission line with double line of poles bisects reserve. Erected 1973.
West section	NRA		
INVERPOLLY			
Eisgbrachaidh	NRA	Roading Horticulture	(1) Re-alignment/upgrading of extension to A837 circa 1965 (bisects section). (2) Small area (< 2 ha) of exotic conifers established including a few trees on Eilean Mor.
Polly	NRA	Fisheries	(1) Hatchery (Plate 3.3) on River Polly (started circa 1970). (2) Holding pens on Loch na Dail (1980) with servicing track pushed down to shore of loch.
Drumrunie	NRA	nil	But hatchery established on Loch Veyatie (1978). Although outside the NNR hatchery discharges into the loch, half of which lies within the NNR.
KIRKCONNELL FLOW	NRA	nil	But recently under threat as owner expressed (legitimate) wish to pursue an afforestation programme including replanting with Sitka spruce (Plate 3.4).
MORRONE BIRKWOODS	NRA	Water rights	(1) Vehicle access to pre-existing water supply plant (for maintenance) causes minor surface damage and tracking in vicinity of plant.
MOUND ALDERWOODS			
North section	NRA	Power reticulation	(1) 135 kv transmission line erected 1967-70 bisects reserve. Entailed cutting a 40 m wide swathe through alderwoods.
South section	NRA		
RASSAL ASHWOODS	NRA	nil	
ST CYRUS			
Centre section	NRA	Tracking Agricultural development	(1) The frequent and extensive mutilations to slack and dune that occurred when the area was not regularly wardened have now largely ceased though occasional transgressions continue. (2) About 8 ha of salt marsh at south end reserve reclaimed and developed to arable land in 1974-75 by local farmer.
North/south sections	NRA		

Table 3.2 continued

BEINN EIGHE	Owned	Forestry Roading Power reticulation	(1) Total of 121 ha of commercial plantation (mixed conifer species) established by Forestry Commission 1959-70 in Glen Torridon. (2) Major upgrading and re-alignment of A832 caused loss of about 1 ha of woodland in 1971/72. (3) Power transmission line through Scots pine woodland caused loss of additional 3.5 ha. (4) Stab track and helicopter pad developed Glen Torridon plantation circa 1978. (5) Impoundment and pipeline for Kinlochewe water supply constructed Allt a' Chuirn in 1965.
RANNOCH MOOR	Owned	nil	
TENTSMUIR POINT	Owned	Drainage	(1) Drain constructed along western boundary of reserve by Forestry Commission in 1957.

designation has proved ineffective in totally protecting chosen sites from simple physical damage (as distinct from the more subtle effects of manipulating biological components).

NNRs held under NRAs have been, and will continue to be, legitimately exploited for non-conservation purposes with adulteration of reserve values. Such incidents comprise 68% of all actions in NRA areas. Bachell (1981) argues that if one of the partners is of incontestably superior status in the negotiation of agreements then no realistic compromise is feasible. With limited resources available for compensatory payments (NCC, 1980), a financial inability (and a reluctance) to use their powers of compulsory purchase (ibid.) and the fact that compromises must be voluntarily undertaken by landowners puts the NCC in a weak bargaining position. This result would appear to confirm that situation.

In summary, NRAs are of fundamental importance to the NCC's conservation system in Scotland. However, the negotiated level of control over important management inputs may be minimal (see 5.2) and problems such as those outlined above may result. In the following chapters some NRAs and aspects of their performance are more closely examined.

Plate 3.1 Poorly aligned actively eroding track in Glen Einich, Cairngorms NNR. Constructed circa 1960, upgraded circa 1975.

Plate 3.2 Drainage channels about 35cm deep at approximately 30 m intervals disturbing the previously unmodified peatland profiles of the Stronchrubie Flat, Inchnadamph NNR. Constructed 1975/76.

Plate 3.3 Hatchery complex on the River Polly, Inverpolly NNR. Started circa 1970 and supplemented in 1980 by holding pens constructed on Loch na Dail (also within the reserve).

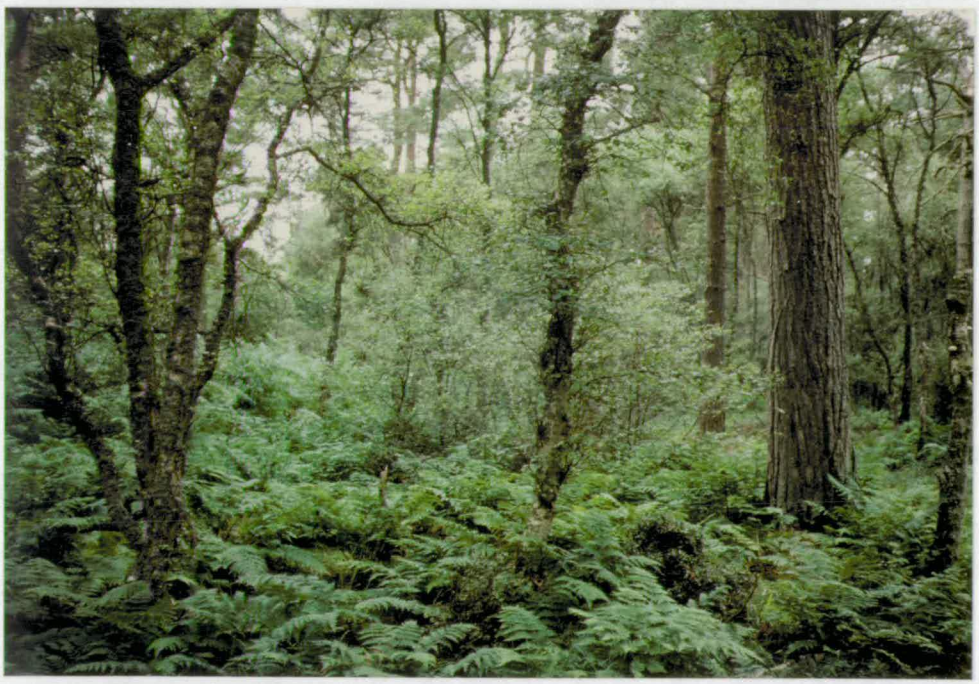


Plate 3.4 Scots pine and hardwood woodland in Kirkconnell Flow NNR threatened by afforestation proposals. Tree and shrub species include Scots pine, birch (Betula pubescens), hazel (Corylus avellana), oak (Quercus petraea), holly (Ilex aquifolium), alder (Alnus glutinosa).

PART TWO

THE PERFORMANCE OF NATURE RESERVE AGREEMENTS IN NATURE CONSERVATION

CHAPTER 4

METHODS AND TERMINOLOGY

Part 2 of this study is based on an analysis of the management characteristics of sample reserves and the following methodology and terminology is relevant.

4.1 The Sample.

Measurements of the changes in the management of the flora and fauna in NNRs since they were established provide the data for this part of the study. Because it takes time to formulate and approve management plans and to implement proposed changes, conservation-oriented innovations are not usually synchronous with declaration dates. For example, by 1980 only three of 18 post-1970 NNRs were being managed under completed management plans. Important changes in management practices are impracticable without an overall plan, particularly when non-NCC personnel are involved. I therefore chose my sample from NNRs declared before 1970. Most of these reserves were being managed under plan and I considered that 10 years (this study started in 1980) provided sufficient time to implement management changes where required. The single exception was Morrone Birkwood NNR (declared in 1972) which I included because of its unique woodland and challenging management problems.

NNRs in the following categories a) to e) were excised from the list of pre-1970 sample reserves.

a) very small reserves (<13 ha) protecting relict patches of woodland.

b) all non-mainland reserves (because of difficulty of access).

c) all open water reserves. Open water habitat within terrestrial reserves was ignored. Open water NNRs are extremely variable and are not generally subject to the same management operations that characterise terrestrial ecosystems. They would therefore require separate measurement methods and analysis.

e) leased reserves and parts of reserves, and reserves that were less than 75% owned or 75% NRA (mixed tenures could lead to difficulties in the interpretation of results).

The huge Cairngorms NNR was sub-sampled with the three areas under different ownership on Speyside being included i.e. Glen Feshie, Rothiemurchus and Invereshie/Inshriach. The small post-1970 additions to Beinn Eighe and Caerlaverock NNRs were ignored as was the 15 ha owned by the NCC in Inverpolly NNR. In contrast to all other reserves, Glen Roy NNR was selected entirely for its geological rather than biological values, and is excluded from the sample.

My sample comprises 15 mainland terrestrial NNRs declared between 1951 and 1972 (Table 4.1). They total 45,154 ha - 48% of the NNR area in Scotland. The sample of owned reserves comprises 36% of the area of owned NNRs in Scotland (62% if Rhum NNR is excluded), and 55% of the area of NRA reserves is included in the sample. The 15 reserves comprise 75% of the 20 NCC-owned or NRA mainland terrestrial reserves at least part declared prior to 1970. There are 19 separate agreements covering the 12 NRA reserves included in the sample. All but 5 of the agreements expire by the end of 1987 (Table 4.1). Throughout Scotland 39 NRAs expire before the end of 1992. The results of this study may therefore be relevant, in the short term, to the renewal of a significant number of NRAs.

The location of the 15 sample NNRs is shown in Fig. 4.1.

NRA Reserves	Number	Section	Habitat	Year NRA Expires
Caenlochan	01	Invercauld	Peatland	1986
"	02	Tulchan	Upland	1986
Caerlaverock	03		Coastal	1982
Cairngorms	04	Glen Feshie	Upland	1987
"	05	"	Woodland	1987
"	06	Rothiemurchus	Upland	1984
"	07	"	Woodland	1984
Craigellachie	08		Woodland	1983
Inchnadamph	09		Upland	1981
Invernaver	10	East	Coastal	1984
"	11	West	Coastal	1985
Inverpolly	12	Polly	Upland	1986
"	13	"	Woodland	1986
"	14	"	Peatland	1986
"	15	Eisgbrachaidh	Upland	1986
"	16	"	Woodland	1986
"	17	Drumrunie	Upland	1986
"	18	"	Woodland	1986
Kirkconnell Flow	19		Peatland	1984
Morrone Birkwoods	20		Upland	1997
"	21		Woodland	1997
Mound Alderwoods	22	North	Woodland	1991
"	23	South	Woodland	1991
Rassal Ashwoods	24		Woodland	2955
St. Cyrus	25	North/South	Coastal	1987
"	26	Central	Coastal	1987
Owned Reserves				
Beinn Eighe	27		Upland	
"	28		Woodland	
Cairngorms	29	Invereshie/	Upland	
"	30	Inshriach	Woodland	
Rannoch Moor	31		Peatland	
Tentsmuir Point	32		Coastal	

Table 4.1 Sample NNRs by tenure showing sections, habitats and year of expiry of NRA where relevant. See text for definition of terms.

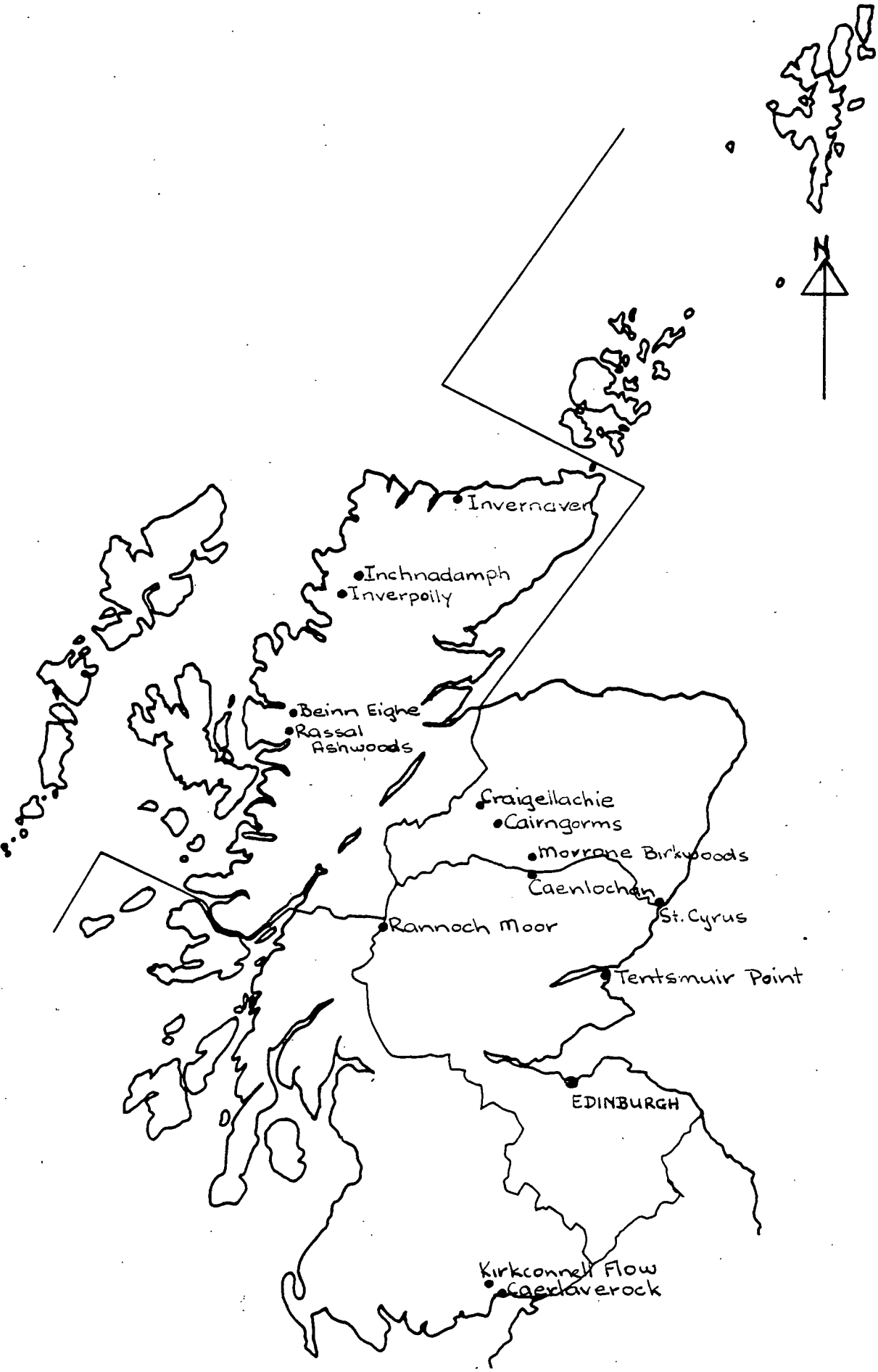


Fig. 4.1 Map of Scotland showing location of the 15 sample NNRs. Scale 1:2,700,000

4.2 Definition of Terms.

4.2.1 Habitats.

As in 2.2.1 the habitat is regarded as the fundamental unit of management. Each sample NNR was divided into its constituent habitats according to their descriptions in the Nature Conservation Review (Ratcliffe, 1977) except that the small, complex Invernaver NNR was assessed only as coastal habitat (where the primary interest lies).

4.2.2 Sections.

Six NNRs are under multiple ownership (Table 4.1). A section is that part of a NNR owned by an individual, a company or group i.e. subject to a common authority for management.

4.2.3 Habitat-sections.

A section may include one or more habitats or part-habitats. In measuring the quality of management each habitat within each section is assessed separately. Inchnadamph NNR (one owner, one habitat) has one habitat-section; Inverpolly NNR (three owners, three habitats) has seven habitat-sections.

4.3 Measurement of Quality of Management.

Each habitat-section was scored for conservation-oriented changes in management, or for maintaining the status quo, according to the management inputs and rating criteria in App. 2A - Management Rating Form - and App. 2B - Criteria Scoring Guide. This system of assessment is closely modelled on the method developed by Helliwell (1969, 1971a) where each of a series of independent variables (the management inputs) are scored according to several relevant and inter-dependent variables (the rating criteria). Scores for the rating criteria were awarded in relation to the general objectives of management. These terms are

discussed below.

4.3.1 Management Objectives.

The objectives in some management plans are very detailed e.g. Rannoch Moor NNR, but most are couched in broad terms. Because of the wide variation in the treatment and expression of objectives it was necessary to produce a reference list of objectives to provide a common baseline. The following is a cross-section of reserve objectives culled from management plans.

1. to preserve the quality, species diversity and range of habitats of the site
2. to provide specific protection for selected species/ communities
3. to rehabilitate, perpetuate and, where threatened, expand native communities
4. to encourage naturalness and to reduce unscientific/ uncontrolled exploitation of wildlife populations.

Each habitat-section was assessed with reference to the above general objectives but prime reference was to specific objectives contained in the management plans, where they existed, and the NRAs/AMPs.

4.3.2 Management Inputs (App. 2A).

Each of the 32 habitat-sections in the sample was scored for the 20 management inputs in App. 2A. With the exception of inputs 13, 16, 17, 18 they are the same operations, controls and requirements that the NCC has identified as pertinent to the management of NNRs and has incorporated in policy statements or specific requirements in all NRAs/AMPs (c f. Feist, 1978, App B).

4.3.3 Rating Criteria (App. 2B).

Associated with each management input are six rating criteria. The

three on the left hand side (LHS) of the table are related, some in a more general way than others, to the improvement of the habitat for nature conservation; those on the right hand side (RHS) are related to a deterioration in quality and in most cases are complementary, in a negative way, to the LHS criteria. The terms are self-explanatory and although there could be argument over selected criteria in specific circumstances they do provide standards for managing man-modified ecosystems in accordance with the above objectives.

4.3.4 Criteria Scores (refer App. 2A and 2B).

The rating criteria in the Management Rating Score Sheet were scored 1, 2, 3, 4, or 5 according to the rules below.

a) If any or all of the criteria for the management input under consideration were not relevant to any past or present operation on the reserve then these criteria were scored 2. This is a positive score and indicates that under the NCC's administration no unfavourable developments have occurred. The criteria are also scored 2 if the status quo for the management input has been maintained and the status quo does not conflict with the reserve objectives as stated in the management plan.

b) If the status quo has been maintained and the situation does conflict with the objectives of management the criteria are scored 1. If action has been taken to resolve the conflict according to the criteria then relevant criteria may be scored 3, 4 or 5 as in c).

c) A criterion may be scored 3, 4 or 5 only when there has been a change in the management of an input on the site since it was declared as a NNR. Most favourable changes have been implemented by the NCC and often involve reductions in, or abolition of, generalised pest control and conservation-oriented changes in gamebird and waterfowl shooting, muirburn, grazing, plant protection and wardening. Unfavourable changes

score negative values of 3, 4, 5 (RHS of Management Rating Score Sheet) and may result from new roading, commercial afforestation and increases in browsing pressure.

To improve the objectivity and consistency of my observations any change in the status quo corresponding to the rating criteria on either side of the Management Rating Score Sheet was scored according to the Criteria Scoring Guide (App. 2B). As above the positive values relate to improvements, the negative values to deteriorations, in conservation values relative to the reserve objectives. Thus ±3, ±4 and ±5 record marginal, significant and extreme changes for the rating criteria respectively.

It was not feasible to separately identify the effects of wardening within sections for large reserves (>1000 ha) or between sections for small reserves (<1000 ha). For scoring wardening (input 19) in large reserves the section tally for man-days was allocated to each habitat-section (if there were two or more) and for small reserves each section was allocated the total man-days on the basis that wardening applicable to part of a small reserve was applicable to the whole.

Although the management inputs were carefully selected for their wide applicability to a range of habitats occasionally one, rarely two, of the inputs were not relevant or potentially relevant to a habitat-section. In these very few cases it was assumed that the status quo would have been maintained, and a score of 2 allocated.

4.4 Preparation and Field Work.

Before my first visit to any reserve, two to three days were spent studying the NRA/AMP, the management plan, and relevant literature. Each reserve was visited at least once, and up to four times. From

one to 15 days were spent on field work in each NNR. Except for Rassal Ashwoods NNR my first visit to a reserve was in the company of the warden(s) or staff responsible for the reserve. If, after my visit, there was any reasonable doubt as to how a management input should be scored I contacted owners, past wardens, tenants, gamekeepers, factors, honorary wardens, other NCC staff or any other individuals whom I thought could usefully comment. My records are therefore as comprehensive as can be reasonably expected but undoubtedly misinterpretations have occurred. It was not always possible, for example, to establish with certainty how a reserve was managed up to 30 years ago particularly when it had been wardened for only part of the time.

Visits to 16 non-sample NNRs have provided additional perspective for my observations. Issues arising from these visits are discussed where pertinent.

4.5 Analysis of Results.

There were too few deteriorations in management relative to conservation interests (negative scores) to justify any independent statistical analysis and they are not considered in the following analyses. However, all inputs for which a deterioration in values was recorded (other than of a minor nature) are specifically mentioned in the following chapters. Most negative scores related to roading development and to continued heavy browsing and grazing in woodlands.

The combined score for each input in each of the 32 habitat-sections was calculated by multiplying together the scores for each of the three criteria after the method of Helliwell (1969, 1971a) The range of scores was from 1 (1^3) to 125 (5^3). These data are shown in App. 2C.

Scores of 3, 4 and 5 could only be allocated if there was a change

in management relative to an input on the reserve: hence some habitat-sections had the potential to score more highly than others, because there were more changes, and no direct comparison is possible between the combined scores for management inputs for different habitat-sections. To overcome this difficulty the combined score for each input is expressed as a percentage of the potential score for each input. This derived score is called the input management score (see below). Criteria that are scored 2 - the status quo - can never be scored higher than 2. Criteria that are scored 1, 3, 4 or 5 all have the potential to be scored 5 under active conservation-oriented management (a score of 1 implies a situation requiring active management in the interests of furthering or maintaining the reserves values). The potential score for any management input is therefore the product of the maximum criteria scores. Where the three criteria are scored 1, 3, 4 or 5 the potential score is 125, with one score of 2 the potential score is 50 (2 x 5 x 5), with two scores of 2 the potential score is 20 (2 x 2 x 5) and with three scores of 2 the potential score is 8 (2 x 2 x 2).

$$\text{Thus the "input management score"} = \frac{\text{combined score for input}}{\text{potential score for input}} \times 100$$

To calculate a value representing the overall quality of management for nature conservation for each of the 32 habitat-sections, the combined scores for the 20 management inputs were summed and the total expressed as a percentage of the sum of the potential scores. This value is called the habitat management score. The habitat management scores, with the data from which they are derived, are shown in App. 2E. Input management scores are shown in App. 2D.

The input management and habitat management scores are ordinal variables for which it is not possible to make comparative statements

about the intervals between members. Thus nonparametric statistics have been used to analyse the data in the following two chapters. The main tests used are the Mann-Whitney U Test (where n_1 and n_2 <20), the Wilcoxon rank sum test (where n_1 or n_2 >20), Spearman's rank correlation test and the Kruskal-Wallis one way analysis of variance (Ferguson, 1966; Siegel, 1956).

Finally, it must be emphasised that because of the superficial nature of this assessment the results cannot be used with confidence to distinguish between habitat-sections or reserves which have similar scores. However, it does satisfactorily distinguish between those sites which lie at the extremes of the management scale.

CHAPTER 5

NRAs, COMPENSATION AND WARDENING IN THE MANAGEMENT OF NRA RESERVES

5.1 Method for Scoring the NCC's Management Interest in NRAs.

The NCC's degree of control over each of the 20 management inputs (see 4.3.2; App. 2A) as determined by the terms of the relevant NRA and agreed management policy (AMP) was scored on a scale of 0 to 5 for each reserve or section (for subsequent references to 'reserves' in this chapter read 'reserves or sections').

0. Input entirely under the control of the owner or a third party.
1. Input to be protected from...or maintained "so far as is practicable".
2. Owner/agent to "consult" NCC, "seek prior consent" or "agree on areas to be affected" before modifying/implementing input.
3. NCC has first option to purchase input or invoke a prohibition order[1] if a deterioration in the input is threatened.
4. Mutual agreement reached over the implementation of input.
5. Input entirely controlled by the NCC.

If an input was not specifically mentioned in the NRA or AMP it was scored 0 unless clearly covered by a general clause which scored it higher than 0. The terminology used in the NRA or AMP determines if

[1] prohibition order: By prior agreement the NCC may issue a prohibition order over the proposed exploitation of nominated resources. In so doing it is required to compensate the owner for income foregone in not implementing the proposed action.

an input may be scored 1, 2, 3 (as above). Score 4 is often used for muirburn whereby formal agreement is reached over the annual extent and location of burns. In theory the ability to circumvent undesirable actions by a right of purchase or prohibition order is a powerful tool. But the option has been exercised only once - in Kirkconnell Flow NNR to secure a portion of the tree crop - and the more practicable option of mutual agreement has been rated more highly. Score 5 is frequently recorded for two inputs - wardening (19) and literature (20) - that do not directly affect the biology of the reserves.

If two authorities have control over a management input in different areas the score relevant to the largest area is recorded. For example, in Caerlaverock NNR the owner retains shooting rights over part of the reserve but authority for control over a larger area is delegated to the NCC and the input scored 5.

In other cases interpretation of the NRAs and AMPs was literal and care was taken to ensure that detail in different agreements was interpreted in a consistent manner. Mr. J. Mottram assisted in this field.

5.2 Formal NCC Involvement in Management.

5.2.1 The NCC's Negotiated Level of Control over Management Inputs.

Table 5.1 shows that the NCC has secured only a low and relatively constant level of control over most management inputs in the different reserves. Although there is a 'model' format to which NRAs and AMPs conform (Feist, 1978, App.B; J.Mottram, pers.comm.) the NCC might be expected to negotiate agreements in which the level of control over particular inputs was concommitant with the special values to be protected in the reserve. In general this is not so but there are

Score	Management Inputs																			
	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
0	6	1	19	18	18	18	19	18	19	4	5		18	12				18		
1	7	1		1								4								
2	4	7								15	14	2	1	6						
3		10																		
4	2											13			18	19	19		2	
5					1	1		1						1	1			1	17	19
Σ scores	23	45	0	1	5	5	0	5	0	30	28	60	2	17	77	76	76	5	93	95

Table 5.1 Frequency of scores (0 to 5) showing degree of NCC control over management inputs (see 4.3.2 and App. 2A for key) for the 19 reserves/sections according to specifications in NRAs/AMPs.

several exceptions. Thus, under permit from the owner the NCC controls public access and bird shooting over much of the merse in Caerlaverock NNR. The Council has similarly unique rights over deer management in the Glen Feshie section of Cairngorms NNR including "...the exclusive right of management of the deer stock" (Glen Feshie AMP). However the concession is akin to a prohibition order in that any loss of benefits or income resulting from NCC manipulations is to be compensated for: consequently the right is not exercised. In Kirkconnell Flow NNR the NCC has secured specific and relevant rights over drainage and in Rassal Ashwoods NNR the Council has the specific right to reintroduce species native to the site.

By my definition the NCC has secured a significant degree of control over six management inputs (Table 5.1) - muirburn (12), the

establishment of new species (15), vegetation manipulation (16), secure rare/threatened/local species or communities (17), wardening (19) and literature (20) but apart from muirburn and, locally, vegetation manipulation they are low impact inputs in terms of habitat manipulation. Furthermore inputs 15, 16 and 17 are scored 4 under NRA general policy statements (except input 15 for Rassal Ashwoods NNR) on the reasonable assumption that failure to agree on beneficial action for such fundamental issues would wholly defeat the purpose of the reserve. For the remaining inputs the NCC has at best obtained a consult concession e.g. over the use of fertilisers (10) and pesticides (11) and at worst virtually no formal control at all. Nine inputs are controlled almost exclusively by the owners and there is a minor level of formal NCC control over the important animal control inputs (05 to 09 inclusive) and over tracking (13).

5.2.2 Total NRA Scores.

Col. 1, Table 5.2 shows the total NRA scores obtained by summing the scores for individual inputs for each reserve/section. The range is from 26 for the two St. Cyrus agreements which are overtly protective of the owners' rights to 48 for the comparatively accommodating Caerlaverock NRA. The NRA covering Kirkconnell Flow NNR and the NRA for Rothiemurchus section of Cairngorms NNR are also comparatively generous in their terms whilst the two Invernaver NRAs strictly limit the NCC's formal rights to manage.

5.3 Section Management Scores for NRA Reserves.

As in the preceding chapter the habitat management scores (see App. 2E, 4.5) represent the overall quality of management for conservation purposes for each of the 32 habitat-sections. Where more than one

habitat-section occurred in a reserve under one ownership or in different sections of a reserve (see Table 4.1) the habitat management scores for the different habitat-sections were averaged so that in Table 5.2 each reserve or section is represented by a single section management score (in a reserve with one habitat-section the habitat, section and reserve management scores are synonymous). This is permissable because there is no significant difference between the scores for habitat-sections in the four habitats (Kruskal-Wallis statistic = 1.72 with 3 degrees of freedom).

Section management scores range from 11.9 for the west section of Invernaver NNR to 69.2 for Caerlaverock NNR (Table 5.2). It is again emphasised that the technique adequately discriminated between the best managed and the most poorly managed groups of reserves or sections but did not result in a spread of scores such that the middle ranking reserves or sections could be separated with confidence. However, all relevant computations are based on the scores as they appear in Table 5.2 and App. 2E.

Spearman's rank correlation coefficient statistic shows that there is no association between the ranked NRA scores and ranked section management scores ($r = 0.047$, $t = 0.285$, d.f. = 17) and indeed the most striking feature is the high section management scores for St. Cyrus and Craigellachie NNRs despite their low NRA scores. Caerlaverock NNR is the top ranked reserve for both measures whilst Caenlochan, Invernaver, Mound Alderwoods NNRs form a low ranking group for section management scores and also have below average NRA scores.

5.4 Compensation.

The total compensation and rate/ha as at April 1981 for all reserves

	1	2	3	4	5
Large Reserves > 1000 ha	NRA Score	Section Management Score	Compensation £ Total	Compensation Rate/ha/ann(p)	Warding Hrs/ha/ann
Caenlochan : Invercauld	34	14.6	15	2.67	.06
Caenlochan : Tulchan	31	20.5	50	1.71	.06
Cairngorms : Glen Feshie	38	36.5	75	0.97	.29
Cairngorms : Rothiemurchus	41	42.5	100	1.70	.30
Inchnadamph	35	23.4	25	1.93	.24
Inverpolly : Drumrunie	34	39.9	90	1.83	.15
Inverpolly : Eisg brachaidh	33	49.5	35	1.75	.37
Inverpolly : Polly	33	44.1	105	2.67	.25
Small Reserves < 1000 ha					
Caerlaverock	48	69.2	0	0	3.40
Craigellachie	31	56.3	.05	.02	5.42
Invernaver : East	28	13.0	15	5.05	.34
Invernaver : West	29	11.9	15	5.91	.34
Kirkconnell Flow	41	18.0	15	9.67	1.86
Morrone Birkwoods	35	32.2	35	15.56	3.20
Mound Alderwoods : North	33	16.1	25	29.76	1.74
Mound Alderwoods : South	32	21.0	.05	.03	1.74
Rassal Ashwoods	34	37.7	5	5.88	1.69
St. Cyrus : North/South	26	64.0	30	54.54	17.48
St. Cyrus : Central	26	59.7	30	81.08	17.48

Table 5.2 Summary of descriptive data, for NRA reserves/sections, used in Chapter 5. See relevant text for derivation of quantities.

is shown in cols. 3 and 4, Table 5.2. No compensation is payable for the merse section of Caerlaverock NNR and a nominal 5p/annum is payable for Craigellachie NNR and the south section of Mound Alderwoods NNR. In May 1981 the annual compensation payable for Morrone Birkwoods NNR was raised from £35 to £350 to become the largest single commitment for these reserves. This was precipitated by the enclosure of more woodland than was originally anticipated but the initial sum of £35 is used in these analyses as it related to the period of assessment. Corresponding rates/ha range from no payment to 81.08p/ha for the central section of St. Cyrus NNR.

There is statistical evidence that the rate of compensation paid for large reserves (>1000 ha) at 1.90p/ha/ann. is less than that paid for small reserves (<1000 ha) at 18.86p/ha/ann. (Table 5.3). If the three small areas for which nil or nominal compensation is payable (Caerlaverock and Craigellachie NNRs and the south section of Mound Alderwoods NNR) are excluded the dissociation increases.

Comparison	rate/ha(pence)	t	df	probability
All sample reserves/sections	$\bar{x}$ large = 1.90 $\bar{x}$ small = 18.86	1.804	17	<0.10
Excluding areas with nil/nominal compensation	$\bar{x}$ large = 1.90 $\bar{x}$ small = 25.93	2.427	14	<0.05

Table 5.3 Comparison of mean rates of compensation for large (>1000 ha) and small (<1000 ha) reserves by t-test.

Separate populations for large and small reserves are therefore recognised and the following analyses, using Spearman's rank correlation coefficient statistic to test for correlations between nominated variables, have been carried out on this basis. The above three reserves

are excluded from the analyses in sections 5.4.1 to 5.4.3 as the owners are clearly motivated by altruistic rather than monetary concerns and their inclusion unfairly biases the results away from the null hypothesis.

The differential between rates of compensation for large and small reserves is insufficient to eliminate the difference between the mean total compensation paid for large (£61.88) and small (£15.46) reserves ($t = 4.04$, $df = 17$, $p < 0.001$).

5.4.1 Compensation and Reserve Area.

The ranked total compensation and rate/ha (cols.3, 4; Table 5.2) were tested for correlation with ranked reserve area (Table 5.4). Within both large and small reserves there is a significant inverse correlation between compensation on a rate/ha basis and reserve area. Within the population of large reserves larger areas still attract significantly more total compensation than smaller areas but for the population of small reserves this positive correlation between total compensation and reserve area is extinguished.

Comparison	population	r	t	df	probability
Rate/ha	large	-0.738	-2.679	6	<0.05
vs area	small	-0.738	-2.679	6	<0.05
Total compen-	large	0.785	3.108	6	<0.05
sation vs area	small	0.533	1.544	6	NS

Table 5.4 Correlation coefficients for compensation vs reserve area for populations of large and small reserves.

5.4.2 Compensation and NRA Scores.

Table 5.5 shows the results of testing for correlations between ranked total compensation and rate/ha and ranked NRA score (cols.3, 4, 1,

Table 5.2). In no case is any correlation established and it is concluded that compensation has been assessed independently of formal management concessions.

Comparison	population	r	t	df	probability
Rate/ha vs NRA score	large	-0.321	-0.830	6	NS
	small	-0.363	-0.954	6	NS
Total compensation vs NRA score	large	0.107	0.264	6	NS
	small	-0.214	-0.536	6	NS

Table 5.5 Correlation coefficients for compensation vs NRA score for populations of large and small reserves.

5.4.3 Compensation and Quality of Reserve Management.

Table 5.6 shows the results of testing for correlations between ranked total compensation and cost/ha and ranked section management scores (cols. 3, 4, 2, Table 5.2). In no case is any correlation established and it is concluded that the total quality of management has not been influenced by the amount or the rate of compensation paid.

Comparison	population	r	t	df	probability
Rate/ha vs section management	large	-0.113	-0.279	6	NS
	small	0.619	1.930	6	NS
Total cost vs section management	large	0.595	1.814	6	NS
	small	0.446	1.223	6	NS

Table 5.6 Correlation coefficients for compensation vs section management for populations of large and small reserves.

5.5 Wardening Intensity.

Wardens provided information on what proportion of their working year (calculated at 235 eight-hour days) was spent on different reserves

or sections, and wardening intensity - a measure of the NCC's physical commitment to a particular reserve - is expressed as warden hours/ha/annum. Because it was impracticable to do otherwise, it has been assumed that wardening effort was spread evenly, on a per ha basis, over the different sections of Caenlochan, Invernaver, Mound Alderwoods and St. Cyrus NNRs. For sections in Cairngorms and Inverpolly NNRs estimates were made of the time spent on the different sections.

On a per ha basis the most intensively wardened small reserve receives 51 and 291 times the attention of the least intensively wardened small and large reserves respectively (col. 5, Table 5.2). It also receives 47 times as much attention as the most intensively wardened large reserve. Predictably there is a significant difference between the mean wardening intensity for small reserves (<1000 ha) at 4.97 hrs/ha/ann and large reserves (>1000 ha) at 0.22 hrs/ha/ann ($t = 2.120$, $df = 17$, $p < 0.05$) and, as for compensation, 'large' and 'small' populations are recognised for the analyses.

Spearman's rank correlation coefficient statistic has been used to test for correlation between nominated variables.

5.5.1 Wardening Intensity and Reserve Area.

The ranked wardening intensity (col. 5, Table 5.2) was tested for correlation with reserve area. No significant correlation exists (Table 5.7).

Comparison	population	r	t	df	probability
Wardening vs reserve area	large	0.423	1.143	6	NS
	small	-0.330	-1.049	9	NS

Table 5.7 Correlation coefficients for wardening intensity vs reserve area for populations of large and small reserves.

5.5.2 Wardening Intensity and Quality of Reserve Management. The ranked wardening intensity was tested for correlation with ranked section management scores (cols 5, 2, Table 5.2).

There is a highly significant level of correlation between wardening intensity and section management scores (Table 5.8) for both large and small reserves. Because there are sound reasons for expecting an improvement in the quality of management with increasing wardening intensity a one-tailed test of significance is used.

Comparison	population	r	t	df	probability
Wardening vs section management	large	0.770	2.956	6	<0.025
	small	0.852	4.886	9	<0.005

Table 5.8 Correlation coefficients for wardening intensity vs section management for populations of large and small reserves (one-tailed test).

5.6 NCC Regions and Quality of Management.

For administrative purposes the NCC divides Scotland into four regions. Each region has a high degree of autonomy in the management of NNRs within its boundaries and it is therefore possible that differences exist in the management of reserves between regions. There is no difference between the habitat management scores in different habitats (see 5.3). Therefore the Kruskal-Wallis one way analysis of variance by ranks was used to test for differences between the habitat management scores for the 26 NRA habitat-sections in the four regions. There were 13 habitat-sections in the north-west region, 9 in the north-east region, 2 in the south-east region and 2 in the south-west region. No significant differences were found (Kruskal-Wallis statistic = 4.952 with 3 degrees of freedom). Habitat management scores are shown in App. 2E.

5.7 Reserve Size and Quality of Management.

The ranked habitat management scores for large (>1000 ha) and small (<1000 ha) NNRs for the 26 NRA habitat-sections were compared using the Mann-Whitney U Test. There is no indication of a disparity in the quality of management between the two classes of reserves ($U = 72$; $n_1 = 12$, $n_2 = 14$).

5.8 Discussion.

Under the terms of the NRAs the NCC has established control over wardening and literature and, through non-specific policy clauses, over three low-impact biological inputs. With minor exceptions control over all major fish and animal populations and artificial, chemical and physical inputs remains with the owners. Thus only exceptionally has the NCC been able to negotiate formal control over the biological components of the reserve ecosystems which dictate the evolution, in some cases the fate, of the special values of the reserves. The general failure to secure adequate controls over domestic grazing, deer management, pest control, sport shooting and roading leads the Council to argue from an intrinsically weak position - almost as supplicant - with little prospect of exerting sufficient pressure to significantly influence land management practices (c f. Bachell, 1981).

It might be expected that the quality of reserve management would reflect the conditions negotiated in the NRAs. However St. Cyrus and Craigellachie NNRs have strikingly high scores for total management despite their below average NRA scores whilst Caenlochan, Invernaver and Mound Alderwoods NNRs have low scores for both variables. Thus two 'voluntary' reserves, one (Caerlaverock NNR) with the highest NRA score, the other (Craigellachie NNR) with a very low score, share the top rankings for management quality with St. Cyrus NNR with the lowest NRA score. Further inconsistencies between management quality

and NRA scores for the other reserves lead to the conclusion that the relative quality of reserve management is unrelated to the conditions of the NRAs. In practical terms, therefore, the NRAs for these reserves seem merely to declare the NCC's legitimate interest in the site as an NNR.

The mean rate of compensation paid for large reserves (>1000 ha) is significantly less than that paid for small reserves. Within each population the rate is inversely correlated with reserve area and only within the population of large reserves do bigger properties attract greater total compensation. With compensation assessed independently of formal management concessions established with owners through NRAs and, further, being unrelated to management quality it must be concluded that in the past compensation has been regarded by the NCC as a gesture designed to provide tangible evidence of the NCC's interest in a site and, in a token fashion, to acknowledge the public's indebtedness to a landowner.

Compensation paid for most of these reserves is trifling. Only St. Cyrus NNR (mean 65p/ha/ann) and, since May 1981, Morrone Birkwoods NNR (156p/ha/ann) have attracted more than 30p/ha/ann. There are some indications that since 1977 the role of compensation in securing concessions may have been taken more seriously. Thus £7200 (180p/ha/ann) is outlayed for Glen Tanar NNR, £2000 (141p/ha/ann) for Muir of Dinnet NNR and £2500 (154p/ha/ann) for Sands of Forvie NNR and some real concessions have been secured. Three small reserves, Glen Nant (£215: 364p/ha/ann), Milton Wood (£50: 263p/ha/ann) and Coille Thocabhaig (£250: 309p/ha/ann) attract even greater rates of compensation. But other post 1977 declarations including Strathfarrar NNR (£100: 0.05p/ha/ann) and Loch a'Mhuilinn NNR (£25: 0.37p/ha/ann) continue the tradition of token payments.

If all owners demanded compensation at a common rate of 150p/ha/ann the NCC in Scotland would be faced with an annual compensation outlay in excess of £100,000 with the prospect of additional compensation for specific privileges and concessions (the NRAs for Muir of Dinnet and Glen Tanar NNRs already make provision for the purchase of sporting rights as they become available). A more rational approach to compensation would be to define the principal conservation features of a reserve, identify the threats to or controls over the development/evolution of these features, and then for the NCC to assume responsibility for the threats or controls by purchasing, at market rates, the relevant rights and authorities.

However, the NCC already anticipates financial problems in the renegotiation of NRAs (NCC, 1980) and Lloyd (1977) warns that high levels of compensation will be difficult to maintain and to justify on a continuing basis. The case for carrying out, on NCC-owned reserves, manipulations that are otherwise likely to demand high levels of compensation (such as drastic reductions in grazing pressure from sheep and/or deer, cessation of pest control and termination of sporting rights) is therefore irrefutably established.

There is a consistently high positive correlation between wardening intensity and the quality of reserve management for both large and small reserves. It could be argued that wardens merely represent the end of a chain-of-command and that even without a warden there may be an effective NCC involvement in management. But with the history of NNRs such as St. Cyrus (the conversion of salt-marsh to arable land and unrestrained burning and tracking) and Morrone Birkwoods (rapid and unchecked disappearance of woodland) when inadequately wardened, and the improvement in management quality of these reserves coincident with the appointment of wardens, it is

unrealistic to divorce management quality from a committed wardening presence.

Wardening effort is unevenly spread between reserves. St. Cyrus NNR receives, per ha, 51 and 291 times the attention of the least intensively wardened small and large reserves respectively, and 47 times the attention of the most intensively wardened large reserve. Caenlochan NNR is sorely neglected. Caenlochan Glen, Coire Fee and Glen Doll support particularly extensive alpine and tall-herb floras (including rare species) and alpine willow scrub remnants (Ratcliffe, 1981) and whilst several other NNRs with similarly valuable floras are heavily wardened (including Ben Lawers, Cairngorms, Morrone Birkwoods, St. Cyrus) Caenlochan NNR is virtually unwardened. With a predictable improvement in conservation values with increased wardening Caenlochan NNR must not much longer remain in limbo. Invernaver, Kirkconnell Flow and Rassal Ashwoods NNRs might also benefit from increased commitment by the NCC. Owned reserves are even more erratically wardened. Rannoch Moor NNR receives a paltry 0.03 hrs/ha/ann, Beinn Eighe NNR 0.99 hrs/ha/ann, Invereshie/Inshriach section of Cairngorms NNR 0.31 hrs/ha/ann and the owned portion of Tentsmuir Point NNR about 11 hrs/ha/ann.

The constant presence of a knowledgeable and committed warden, and his day-to-day interaction with estate staff and neighbours, may generate goodwill amongst owners, tenants and estate staff on a NNR and this is reflected in the results of this study. In the past this goodwill has been prominent in the NCC's case for nature conservation. For example the NCC (1973) record that "...at the end of the day the working of the Agreement is the result of goodwill more than the Agreement itself" whilst Feist (1978) states that "NRAs...rely heavily on the landowner's generosity". In the general context of nature

conservation, "...the goodwill of the farming community..." is essential (NCC, 1977) whilst McCarthy (1980a) considers that landowners are "...the most important trustees of the Nation's heritage of wildlife" and it is necessary to "...maintain good relationships..." with them. But this tacit reliance on the altruism and the goodwill of the landowning community may, despite the best efforts of NCC staff, be increasingly misplaced in an age where private resources have a price but little value; where absentee landlords may have little commitment to the wildlife quality or the appearance of an area (c f. Lloyd, 1977; p 183); where land is commonly administered under the anonymity of corporate responsibility with personal liability (and interest) extinguished, and where land can pass into the hands of foreigners whose personal and cultural mores do not include a traditional land ethic (cf. Leopold, 1966; pp 217-218).

CHAPTER 6

CONSERVATION MANAGEMENT IN NCC-OWNED AND NRA RESERVES

The objective in this chapter is to compare the relative quality of management, for the purposes of nature conservation, in NCC-owned and NRA reserves. The quality of management is estimated from the input management scores (data shown in App. 2D) and there are six NCC-owned and 26 NRA habitat-sections available for the comparison (App. 2D). For the purposes of this comparison the owned section of Cairngorms NNR (3085 ha) is regarded as a separate, owned reserve.

It can be shown that there are no significant differences between input management scores for the same management inputs in the four habitat types for both NRA and NCC-owned reserves. From the data in App. 2D the highest Kruskal-Wallis statistic for NRA habitat-sections is 5.932 for input 13 - vehicle tracking - and for NCC-owned habitat sections is 4.214 for input 08 - deer management. Neither are significant at $p<0.10$ (6.25). For this reason the following comparisons have not been restricted to comparisons between different habitat types but where relevant include all data from each of the 32 habitat-sections within the NCC-owned and NRA reserves.

6.1 Comparisons Between Management Inputs for NCC-Owned and NRA Habitat-Sections.

Table 6.1 shows the results of testing for differences between the same management inputs for NCC-owned and NRA habitat-sections, and

Management Input and Number		N	Wilcoxon Statistic (z)	Probability
Afforestation	01	32	0.382	NS
Peat/mineral exploitation	02	32	0	NS
Fisheries (sporting)	03	32	0.804	NS
Fisheries (commercial)	04	32	1.337	NS
Shooting (game birds)	05	32	1.696 (2.301)	p<0.10 (p<0.05)
Shooting (waterfowl)	06	32	0.912	NS
Pest control	07	32	2.712	p<0.01
Deer management	08	32	0.876 (1.843)	NS (p<0.10)
Domestic grazing	09	32	1.997	p<0.05
Fertiliser use	10	32	0.734	NS
Pesticide use	11	32	1.036	NS
Muirburn	12	32	0.476	NS
Tracking (vehicular)	13	32	0.347	NS
Drainage	14	32	0.267	NS
Establishment new species	15	32	0.029	NS
Vegetation manipulation	16	32	2.022	p<0.05
Secure rare...species	17	32	0.583	NS
Public access	18	32	0.490	NS
Wardening	19	32	1.326 (2.134)	NS (p<0.05)
Literature	20	32	0.513	NS
Overall	1-20	640	3.770	p<0.001

Table 6.1 Differences in management inputs between NCC-owned and NRA reserves by Wilcoxon rank sum test. Values in brackets are comparisons with Rannoch Moor NNR excluded. Data for comparison from App. 2D.

the result of an overall comparison. Comparisons are based on input management scores shown in App. 2D. Examination of the data in App. 2C and 2D shows that Rannoch Moor NNR is scored lower than the other NCC-owned habitat-sections for several management inputs, although the differences are not statistically significant. However, where the scores for Rannoch Moor NNR are lower than the scores for the other NCC-owned NNRs and the comparison is suggestive of a difference between scores for NCC-owned and NRA habitat-sections (inputs 05, 08, 19) a further comparison is made with the Rannoch Moor data excluded.

There are clear indications that in relation to the criteria I have used, the management of grazing and browsing animals, game-birds and pest species is better, in conservation terms, in NCC-owned than in NRA NNRs. Thus there are significant differences between NCC-owned and NRA reserves for gamebird shooting ($p<0.10$, $p<0.05$ with Rannoch Moor data excluded) pest control ($p<0.01$), deer management ($p<0.10$ if Rannoch Moor data is excluded) and domestic grazing ($p<0.05$).

Operations relating to the manipulation of vegetation for conservation purposes (input 16) have been scored higher for NCC-owned than for NRA NNRs ($p<0.05$). If the virtually un-wardened Rannoch Moor NNR is excluded from the comparison, there is an indication that the scores for wardening (input 19) are higher for sample NCC-owned than NRA reserves ($p<0.05$).

When all the input management scores for the 20 management inputs in the six NCC-owned habitat-sections are compared with the input management scores for the 26 NRA habitat-sections, there is a highly significant difference ($p<0.001$) in the way that NCC-owned reserves are managed for conservation purposes relative to NRA reserves.

6.2 Comparative Quality of Management Within NCC-Owned and NRA NNRs.

Overall, and specifically in relation to six of the 20 management inputs NCC-owned NNRs appear better managed than NRA NNRs. However, the data in App. 2C and 2D indicate that NCC-owned NNRs are not always better managed. In Table 6.2 the sample NNRs have been ranked according to their reserve management scores (the sum of the combined scores for each NNR expressed as a percentage of the sum of the potential scores with the data drawn from App. 2E).

NNR	Reserve Management Score	Rank	Kruskal-Wallis Statistic
Beinn Eighe	84.7	16	
Tentsmuir Point	70.5	15	
Caerlaverock	69.2	14	
Cairngorms (owned)	66.0	13	
St. Cyrus	61.9	12	
Craigellachie	56.3	11	
Inverpolly	44.2	10	
Cairngorms (NRA)	39.4	9	
Rassal Ashwoods	37.6	8	
Morrone Birkwoods	32.2	7	
Inchnadamph	23.4	6	
Mound Alderwoods	18.5	5	
Kirkconnell Flow	18.0	4	
Rannoch Moor	17.9	3	
Caenlochan	17.7	2	
Invernaver	12.4	1	
			30.97

Table 6.2 NNRs ranked according to reserve management score (sum of combined scores as a percentage of sum of potential scores - derived from App. 2E). The NCC-owned section of Cairngorms NNR is included as a separate reserve. Comparison between NNRs by Kruskal-Wallis one way analysis of variance for input management scores, N = 640. NCC-owned NNRs are underlined.

A Kruskal-Wallis one way analysis of variance by ranks for the input management scores for each NNR (data from App. 2D) indicates that highly significant differences exist in the quality of management for conservation purposes between the 16 NNRs (Kruskal-Wallis statistic = 30.97, N = 640, K = 16, $p<0.01$).

The NCC-owned Tentsmuir Point and Beinn Eighe NNRs head a group of reserves including two NRA reserves - Caerlaverock and St. Cyrus - and the owned section of Cairngorms NNR all of which have been comparatively well managed, in conservation terms, since they were declared NNRs. The owned section of Cairngorms NNR has been better managed than the NRA sections due mainly to extensive enclosure of regeneration sites and the cessation of pest control operations and shooting of gamebirds. In terms of my management criteria, Rannoch Moor NNR is substantially less well managed than the other owned reserves and probably no better managed than the most poorly managed NRA reserves. The fact that pest control and game shooting continues, that there has been no enclosure or isolation of browse-sensitive plant communities and species and that wardening is minimal contribute largely to its low position in the hierarchy.

6.3 Discussion.

In the conservation terms defined by my scoring criteria NCC-owned NNRs are better managed overall than NRA NNRs although statistically significant differences in management quality are confined to six of the 20 management inputs examined (four if Rannoch Moor NNR is not excluded). Positive management operations relating to other inputs have occurred but were not general enough within either NCC-owned or NRA reserves to produce statistically significant differences,

although they may have been important, in conservation terms, to the NNRs concerned. Some are discussed below. See also Table 3.2 and 3.3.2.

Afforestation (input 01) has been carried out on both NCC-owned (Beinn Eighe) and NRA (Cairngorms) reserves and this issue is discussed in detail in Chapter 8.

Sporting fisheries (input 03) are found on Caerlaverock, Inverpolly, Inchnadamph, and Rannoch Moor NNRs and on each is a low intensity operation. Commercial fisheries (input 04) have been developed and expanded on the River Polly just inside the Inverpolly NNR boundary since 1970 and on Loch na Dail (1980), and on Allt nan Uamh on the south-west boundary of Inchnadamph NNR in 1978/79. Another modern hatchery discharges into the head of Loch Veyatie (part of which lies within Inverpolly NNR). The commercial fisheries on the River Naver (east boundary of Invernaver NNR) and St. Cyrus NNR are long established. Only on St. Cyrus NNR are detrimental effects apparent (random construction of tracks through dunes) and much of this has ceased with intensive and sympathetic wardening. The fishery on Tentsmuir Point NNR is not currently exploited.

Fertilisers (input 10) and pesticides (input 11) have been used on both NCC-owned and NRA reserves, mostly for conservation purposes. For example, poisonous gas has been used on Tentsmuir Point, Caerlaverock and Rassal Ashwoods NNRs to reduce excessive rabbit populations and 2-4-5T has been used to suppress regrowth of Rhododendrum ponticum on Kirkconnell Flow NNR and gorse (Ulex europaeus) on St. Cyrus NNR (on an experimental basis). Ground mineral phosphate has been applied by hand to assist in establishment of planted tree seedlings on difficult sites on Inverpolly and Beinn Eighe NNRs. However, an aerial application of bulk phosphate has been made to the Forestry Commission plantation on Beinn Eighe NNR and bulk lime

has been applied to alluvial flats to increase grazing for displaced red deer in Glen Feshie.

Where relevant, muirburn (input 12) has been rationalised over all NRA NNRs with no more than 10% of the area to be burnt in any one year. On Craigellachie and Morrone Birkwoods NNRs the owners have refrained from burning and regeneration of tree species, outside existing woodland areas, is widespread (see Chapter 10). Muirburn has been proscribed on Beinn Eighe, Tentsmuir Point and the owned section of Cairngorms NNR but continues over a limited area in Rannoch Moor NNR.

Vehicle tracks (input 13) have been developed on Cairngorms, Craigellachie, Caenlochan, Inverpolly and Beinn Eighe NNRs (see Table 3.2). On the other hand considerable lengths of old tracks resulting from wartime felling operations on Beinn Eighe and Cairngorms NNRs, and old tracks on Tentsmuir Point NNR, have been closed off and vegetation permitted to develop.

Extensive deleterious drainage operations have occurred over about 150 ha of the Stronchrubie Flat in Inchnadamph NNR (Plate 3.2). Conversely, existing drains in Kirkconnell Flow, Caerlaverock, Mound Alderwoods and Tentsmuir Point NNRs have been deliberately or inadvertently blocked thus restoring, enhancing or creating wetland communities. As a conservation tool drainage operations have been used to assist establishment of tree seedlings on Beinn Eighe NNR (but see 9.4.3.2, 9.5).

Of three management inputs (15, 16, 17) directly concerned with plant management, only in operations concerned with the manipulation of vegetation for conservation purposes (input 16) are there significant differences between NCC-owned and NRA reserves. These differences result from extensive ground preparation, planting and enclosure on

Beinn Eighe NNR and on the owned section of Cairngorms NNR and from control operations over invading Scots pine and sea buckthorn (Hippophae rhamnoides) on Tentsmuir Point NNR.

If Rannoch Moor NNR is excluded from the comparison, scores for wardening (input 19) are significantly higher for NCC-owned than NRA reserves. Several other NCC-owned or substantially owned NNRs not in the sample and including Rhum, Ben Lawers, Loch Druidibeg, Loch Lomond, Morton Lochs and Taynish are permanently or intensively wardened suggesting that the difference may be maintained for a wider comparison. However, NRA NNRs including Caerlaverock, St. Cyrus and Craigellachie are also intensively wardened and show clear benefits in the quality of management (see 5.5).

There is no measureable difference in the efforts the NCC has made to produce management plans and reserve handbooks or brochures (input 20 - Literature) between NCC-owned and NRA NNRs. The preparation and up-dating of management plans has been neglected for many reserves of both tenures and some further comments are made in Chapter 13.

In both statistical and practical terms the most significant differences in management quality between NCC-owned and NRA reserves are related to animal management (inputs 05 to 09). Only in the shooting of waterfowl (input 06) is there no significant difference. With the exception of Rannoch Moor NNR, gamebird shooting, waterfowling and generalised pest control operations are no longer carried out on owned NNRs whilst at least one of these operations, in most cases all of them, are carried out on all NRA NNRs with the possible exception of Craigellachie NNR. The clear implication is that NRA reserves do not meet the standards set by NCC-owned reserves in these respects. Although red deer management as it relates to this part of the study is measured only by the establishment of control areas and of isolating

browse-sensitive communities, and not by the manipulation of deer numbers to further conservation interests. (see 12.3.2; 12.8) NCC-owned NNRs are still better managed than NRA reserves. It is considered by the author that the way in which these inputs are managed is crucial to the success of the NNR system in Scotland. Thus the regulation of pest and game species is discussed in detail in Chapter 11 and deer management in Chapter 12. Considerable reference to the effects of red deer and of measures taken by the NCC to circumvent these effects is also made in Chapters 9 and 10.

In terms of overall quality of management for conservation purposes the best managed NCC-owned reserves (Beinn Eighe and Tentsmuir Point NNRs) are certainly better managed than the most poorly managed NRA reserves although they are in no clear way superior to Caerlaverock and St. Cyrus NNRs. However, the most ineffectively managed owned reserve - Rannoch Moor - is no better managed than low ranking NRA reserves. Continued sport fishing, the use of cross-country vehicles for deer recovery, continued muirburn to enhance the grouse population for sporting purposes and the continued management of the crucial animal management inputs in the traditional ways are in marked contrast to some of the changes implemented on other NCC-owned NNRs.

Of the remaining NRA reserves, Inverpolly and Cairngorms NNRs have been comparatively well managed and Mound Alderwoods, Kirkconnell Flow, Caenlochan and Invernaver NNRs comparatively poorly managed for conservation purposes.

PART THREE

A CRITIQUE OF SOME MANAGEMENT PROBLEMS IN NATIONAL NATURE RESERVES

CHAPTER 7

INTRODUCTION TO PART THREE

As stated in Chapter 1 one of the objectives of this study was to identify and examine important problem areas in the management of NNRs in Scotland. To a certain extent the problem areas identified themselves: in my early reading and in discussions with NCC staff woodland management, pest control, game shooting and red deer management were invariably topics of contention. I was therefore able to plan the study of these problem areas from the beginning although important considerations including the decline in the condition of hardwood woodlands, the siting of exclosures in Scots pine areas and the extent of the impact of red deer (Cervus elephus) and, to a lesser extent, roe deer (Capreolus capreolus) on reserve floras became apparent only as I visited increasing numbers of reserves.

Data for Part 3 has therefore been collected in several ways. For some problem areas that I had identified before the study proper had begun basic information was collected from structured interviews conducted primarily with reserve wardens but also with other NCC staff, landowners, factors, gamekeepers and tenants whenever possible. Hence, much data relating to pest control, sporting shooting and red deer management was collected in this way according to the proformas in Appendices 3A, 3B and 4 and is presented in the relevant tables in Chapter 11, sections 1 and 2 and in Chapter 12. Much additional data on red deer populations and their management was extracted from NCC records at Beinn Eighe and Inverpolly NNRs and from Regional Offices in Edinburgh and Inverness. Mr. L. Stewart of the RDC assisted in the

interpretation on RDC data of red deer populations.

In compiling the information required to accurately answer the questions posed in the management rating proforma (Appendix 1A and Chapters 4 and 6) many additional sources of potential information had to be researched. Thus additional data relating to all the management issues pursued in Part 3 was obtained from NRAs and AMPs, management plans (when available) and drafts thereof, policy statements and guidelines, published papers, unpublished NCC records and species lists and very occasionally from relevant NCC files. I conducted an extensive correspondence, often with knowledgeable non-NCC personnel including reserve owners, managers, gamekeepers, foresters, tenants and factors, in order to clarify certain points or to add to data provided by wardens and other NCC staff. Chapters 8 to 12 all include data from these sources which are acknowledged where relevant.

Finally, the study of aerial photographs and published maps was relevant in a varying degree to all chapters in Part 3 and sections 1, 3 and 4 in Chapter 10 are based almost exclusively on interpretation of aerial photographs.

Aspects of woodland management predominates in three of the five chapters in Part 3 and might appear to have received unnecessary emphasis. However, woodlands form an important part of the reserve ecosystem in nine of the 15 reserves studied and are present in 30 of the 56 current NNRs in Scotland. With few exceptions the long-term stability of the woodlands is threatened by excessive browsing and grazing and in physical and financial terms inputs into woodland management in reserves on which woodland occurs is frequently high in comparison with other habitat types present. In a country like Scotland, which has been largely denuded of native forest ecosystems, the management of the fragments that remain is an acid test of the

efficacy of the conservation system. The fact that three of the five chapters deal with different aspects of woodland management therefore reflects the relative importance of the habitat type to the NCC and to the conservation system in Scotland.

In addition to the above considerations affecting the choice of subjects in Part 3, analysis of data relating to reserve management in Chapter 6 has shown that the management of four inputs crucial to the evolution of NNRs as conservation areas, and including sport shooting of gamebirds in reserves, pest control and the management of red deer herds, differs significantly between NCC-owned and NRA NNRs. Each of these subjects is therefore examined in Part 3, partly to establish where differences are, partly to determine how improvements might be made in both NCC-owned and NRA reserves, and partly to draw attention to the need to develop even further those management opportunities which are practicable only within NCC-owned reserves.

The problems identified and discussed in Part 3 obviously do not cover the range of management problems to be found in NNRs in Scotland as a whole. Contentious issues such as woodland versus peatland management on Kirkconnell Flow NNR, management of the tern colony and bracken (Pteridium aquilinum) and gorse communities on St. Cyrus NNR, muirburn on a wide range of NNRs in north-east and north-west Scotland and recreational use and development of Cairngorms and Craigellachie NNRs are of major importance. Notwithstanding these examples, however, it is surprising how frequently the dominant theme of reserve management can be reduced to problems concerned with red deer, regulation of pest and game species and woodland management.

In discussing the examples chosen it has not been my intention to apportion blame to individuals and organisations concerned in the

management of the reserves, but to draw attention to some specific problems and inconsistencies - presented essentially in the form of case studies - in the hope that improvements in the conservation status of the reserves can be made.

CHAPTER 8

COMMERCIAL AFFORESTATION IN NNRS

8.1 Extent of Commercial Afforestation

Table 8.1 demonstrates how extensive is the potential for commercial afforestation in the sample NNRs. Even other reserves without a 'right to afforest' clause in the NRA are not secure. For example, the owner of Kirkconnell Flow NNR has expressed a wish to commercialise its woodland despite the NCC's purchase of the mature Scots pine in 1964 to obviate the then same threat. The 'right to afforest' in the three sections of Inverpolly NNR is guaranteed (in Drumrunie 'by arrangement') and over a large part of Eisg brachaidh section non-native species may be used. Some amenity plantings have been made. A nominated portion of the east section of Invernaver NNR is reserved for afforestation. The owner of Morrone Birkwoods NNR has established forest over large areas of upland adjacent to the reserve, has long-term plans to afforest up to the northern boundary (Marren and Batty, 1980) and is 'desirous' of afforesting the heather areas within the NNR (Morrone Birkwoods NRA/AMP). Of the NRA reserves in Table 8.1 only Craigellachie NNR would seem secure from development (H. Blakenay, pers. comm.) whilst of the five sample reserves not in the table only Caerlaverock NNR has a specific presumption against afforestation.

Forestry operations adjacent to Tentsmuir Point and Rannoch Moor NNRs affect both these sites. Tentsmuir Point NNR has been colonised by Scots pine, Sitka spruce (*Picea sitchensis*) and larch (*Larix* sp.) from windblown seed from adjacent plantations. In Rannoch Moor,

Reserves with commercial woodlands

Reserve	Area (ha)	Species	Provenance	Managed by
CAIRNGORMS				
Glen Feshie	170	DF, L, SP, SS	Imported	Owner
	70	SP	Local	
Rothiemurchus	842	SP	Local (natural)	Owner
	20	SP	Imported ?	
BEINN EIGHE	122	SP	Glen Affric	Forestry Commission
		L, LP, SS, NS	Imported	
INCHNADAMPH	2	SS	Imported	Owner

Reserves where rights to afforest are specifically protected in NRAs

Reserve	Action taken
CAIRNGORMS	
Glen Feshie	As above.
Rothiemurchus	Natural regeneration continues, some manipulation of existing crops proposed.
CRAIGELLACHIE	None likely.
INVERPOLLY	
Drumrunie	Nil
Eisgbrachaidh	Amenity plantings with mixed species including non-natives.
Polly	Nil
INVERNAVER	
East section	Nil
MORRONE BIRKWOODS	Nil, but recent afforestation up to W. boundary and owner 'desirous' of planting up open areas within the reserve.

Reserves affected by adjacent commercial afforestation

Reserve	How affected
TENTSMUIR POINT	1) Invasion by CP, LP, SP, SS. 2) Construction of canal and invasion by water-borne seed. 3) Modifications to dune ecosystem including: obliteration of part of original formation, changes in flora and fauna, local development of a new community.
RANNOCH MOOR	1) Local chemical enrichment from phosphatic fertiliser. 2) Enrichment of fauna using NNR. 3) Potential for invasion by Pinus spp. as crops mature. 4) Possibility of use of pesticides. 5) Deer fences cause 'channelling' and locally increased pressure on reserve vegetation in the SE.

Other reserves under threat

Reserve	Threat
KIRKCONNEL FLOW	Owner has expressed a wish to develop the site as a commercial plantation using SS as main crop.

Table 8.1 Sample reserves/sections of which part is currently managed as commercial woodland or is affected by adjacent plantations or is under threat or in which there is a stated presumption for afforestation. The Glen Doll section of Caenlochan NNR (not in sample) is affected in the same way as Rannoch Moor NNR. SP = Scots pine LP = lodgepole pine CP = Corsican pine L = larch SS = Sitka spruce NS = Norway spruce.

Lochan Coire na Meinne and Abhainn Duibhe lie within the catchment of the adjacent plantation and may be affected by over-spray and run-off from aerial spraying and fertilising. Fertilising has already occurred (M. Pearson, pers. comm.) and may continue if profitable (D. Paterson, pers. comm.). New flora and fauna associated with the plantations will intrude into both NNRs but, apart from colonisation by tree species, none is likely to affect the principal values of the reserves.

Of the 15 reserves studied, one has actively managed woodlands, one a woodlot, four have a presumption for forestry, two are affected by adjacent plantations and one is threatened by conversion. As a land use afforestation is feasible on Inchnadamph NNR where almost all the land lies below 400 m and on Rassal Ashwoods NNR. The dunes of St Cyrus NNR and parts of Mound Alderwoods NNR are afforestable. Only Caenlochan NNR is out of contention with virtually no land below 400 m altitude. Large non-sample NNRs held under NRAs and potentially afforestable include parts of Gualin, Ben Lawers, Sands of Forvie, Strathfarrar, Glen Tanar and Muir of Dinnet. The latter three reserves include mature natural woodlands with commercially managed areas in Glen Tanar and Muir of Dinnet.

8.2 Effects of Afforestation

Some of the general effects of large-scale afforestation of uplands with coniferous species at close spacing include the loss of grazing land; loss of 'naturalness' of the site; concentration of the resources of the site in a single species of tree (NCC, 1979a); loss of breeding habitat and feeding territories for moorland birds, e.g. Moss *et al.*, 1979; NCC, 1981a; parallel changes in insect fauna, e.g. Wormell, 1977; elimination of moorland flora under *Picea* species and drastic modification under *Pinus* and *Larix* species (Helliwell, 1971; Hill, 1979; NCC,

1978a; Ovington, 1951) and the sudden disappearance of time-worn vistas and traditional environments. Soil changes may include increasing surface acidification and accelerated podzolisation under conifers and broadly opposite effects under hardwoods, e.g. Miles, 1978, 1981.

For many losses there are compensating benefits including a possible increase in the potential of the site to support deer (R. Rose, pers. comm.), the provision of new habitat which may be colonised by a greater diversity and abundance of birds and small mammals (Helliwell, 1971; Moss et al., 1979; Moss, 1978b; NCC, 1981a; Newton and Moss, 1977) and insects (Wormell, 1977) and increases in biological activity and productivity especially in thinned stands of Pinus and Larix species (Hill, 1979; Moss, 1978a; Williamson, 1969).

Apart from soil changes the main biological effects of a comprehensive afforestation programme lie largely in the creation of new niches and increased wildlife diversity and biological activity mainly at the expense of breeding habitat for upland birds (which may be of high conservation value) and of the flora typical of degraded sites. However, there are strategies that diminish many of the objections to afforestation and preserve the essential desirable features of both moorland and woodland. They are actively promoted by the NCC and the Forestry Commission and include:

- retention of existing scrubland/woodland for structural and species diversity;
- retention of wetlands and atypical habitats for habitat diversity;
- encouragement and utilisation of natural regeneration in preference to planting;
- retention of significant open areas alongside streams and in stands;
- establishment of mixtures of species, especially hardwoods;
- where relevant, planting of native species in preference to non-native species;

- planting hardwoods in preference to Pinus spp. in preference to Picea and Pseudotsuga species;
- maximising the length of edge habitat to increases niches;
- thinning of established stands, especially conifers, to permit understorey development;
- maximising rotation lengths to permit ecosystems to mature;
- harmonising woodlands with topography and existing vegetation.

Main sources for the above are: Forestry Commission, 1975, 1978, 1979, 1979a; Helliwell, 1971; Hill, 1979; Moss et al., 1979; Moss, 1978a, 1978b; NCC, 1978a, 1979a; Newton and Moss, 1977; Williamson, 1969.

8.3 The NCC's Attitude to Afforestation

In their essay on nature conservation and forestry the NCC (1978a) note that "... afforestation ... offers opportunities for enhancing wildlife interest" and that "Woodlands are arguably the most important habitat for nature conservation in Britain ...". They have generally taken a positive view of afforestation notwithstanding that "... forestry is posing an increasingly serious threat to nature conservation ..." (NCC, 1981a) and opposing it only when clearly identifiable values are threatened, e.g. on Arran Northern Mountains SSSI (ibid.) and Mindork Moss SSSI (NCC, 1980).

But major losses to valuable habitats have occurred through afforestation (see 3.2). The NCC is therefore anxious to rationalise the approach to afforestation arguing that although it will "... always increase the diversity of the ecosystem ..." (NCC, 1979a) a sense of balance must be exercised to ensure that the diversity of large-scale habitats is maintained and that where afforestation is undertaken that diversity of species, structure and habitat be encouraged according to the above principles (ibid.).

Substantial commercial plantations have been established in the Cairngorms and Beinn Eighe NNRs. They are not generally managed according to the principles promulgated by the NCC and are the subject of the following case studies.

8.4 Afforestation in Cairngorms NNR: Glen Feshie Estate

In 1967 140 ha of land (D in Fig. 9.1) was enclosed at Coille an Torr "... for afforestation, and after as much ground treatment as possible by plough it has been planted with Scots pine, larch, Douglas fir and Sitka spruce" (NC , 1967). It is a commercial plantation and from a conservation viewpoint there are several salient points. (1) The crop was planted despite native seed-trees being present. (2) Non-native species made up the bulk of the planting stock. (3) No native hardwoods were established. (4) The crop was blanket planted at close spacing. (5) Management will involve the introduction of large numbers of deer to the site (Dulverton, 1980). (6) A timber crop is desired and the life span of the trees will be limited. In concept and execution the exercise was at variance with the above conservation principles (although between 1967 and 1973 the then Nature Conservancy supported planting in the reserve - NCC, 1979b) but in line with the overall plan to develop woodland (NC , 1967).

On the other hand it was part of a considered programme by the Estate to re-afforest much of the Glen (Dulverton, 1971, 1980). With the twin objectives of maintaining the red deer herd which is "... the mainstay of the social life (and) economy ..." of the Estate (Dulverton, 1980), and afforestation, the Estate had little choice but to enclose and plant at a location where natural regeneration is a slow and sometimes uncertain process (Miller and Cummins, 1974; NCC, 1979b, 1981c) even in the absence of deer, e.g. NCC, 1981c; personal observation).

Predictably, when approached with a proposal in 1980 to enclose and naturally regenerate 150 ha of (mainly) moorland (E. Mathew, pers. comm.) including about 115 ha within Glen Feshie (B in Fig. 9.1), the Estate suggested that the land be leased by the NCC to compensate for loss of grazing (planting had already "... been pushed to the limit in relation to the needs of the deer" (Dulverton, 1980)) or that a planted commercial plantation subject to silvicultural treatment and cropping be established (NCC files). Because the NCC is unwilling or unable to compensate, another commercial plantation will be developed on the western edge of the Cairngorms NNR (although some 35 ha will be permitted to naturally regenerate provided 60% of the area is naturally regenerated by 1986).

8.5 Afforestation in Beinn Eighe NNR

In 1958, 89 ha of moorland in Glen Torridon was leased to the Forestry Commission for establishing a mixed conifer plantation (Plate 8.1). This 200-year lease was supplemented in 1969 by the lease of a further 32 ha. The management of the woodland arising is of great importance to the evolution of Beinn Eighe as a NNR.

8.5.1 Choice of Site

The Forestry Commission was invited to examine Beinn Eighe NNR for afforestation purposes (McVean et al., 1957) and identified 89 ha as being suitable. Despite the NCC itself adopting a "... positive programme of tree planting ..." (Boyd and Campbell, 1965) less than one year later this best land was leased to the Commission and NCC plantings relegated to less amenable sites. By 1965 the NCC's stated objective was to re-create "natural-type forest" (ibid.) on the moorland and the 1969 lease is more disturbing in this context.

Although the 121 ha leased is only 7% of the then unwooded

moorland below 300 m altitude it extends over more than 25% of the periphery by taking in only the lowest altitude land (see Fig. 9.2).

8.5.2 Choice of Species

Following their decision, in 1959, to plant rather than naturally regenerate the lower slopes of Beinn Eighe NNR (Boyd and Campbell, 1965) the NCC has, in accordance with their philosophy, exclusively used species native to the site. The terms of the lease, however, permit the introduction of mixed conifers of unspecified provenance. In addition to Scots pine, non-native larch, Sitka spruce, Norway spruce (Picea abies) and lodgepole pine (Pinus contorta) have been introduced. Only for the second and subsequent rotations may the NCC even advise on species. Apart from aerial fertilising in 1979 (H. Brown, pers. comm.) the stands, some over 20 years old, have been largely unmanaged and particularly in the south-west end some Scots pine appears nutrient deficient with very thin crowns.

8.5.3 Spacing

All the Commission's stands in Beinn Eighe NNR are blanket planted at close spacing (2m x 1.5m to 2m x 2m) which leads to rapid canopy closure and, depending on species, from substantial to total suppression of the ground flora (Hill, 1979). Untended coniferous woodland established in this way makes the absolute minimum contribution to biological diversity, e.g. Moss et al., 1979; Williamson, 1969. However, in a contribution to habitat and species diversity the Forestry Commission has planted, throughout much of the plantation, an unusual mixture of Scots pine and lodgepole pine. Each species has been established pure in small rectangular blocks ranging from about 200 m^2 upwards (Plate 8.2). Scots pine has been sited mainly on knolls and ridges, lodgepole pine on intervening areas. The latter has invariably outgrown Scots

pine and has also been planted more extensively. Amongst the Scots pine and lodgepole pine a few small blocks of Sitka spruce (in addition to the main blocks of Sitka spruce which are closer to the road) and even fewer of Norway spruce have been planted. All the spruces in these small blocks have suffered from browsing and because of this have continued to provide small open areas within the woodland (Plate 8.2).

8.5.4 Conservation of Genotype

Frankel (1970) considers that "... evolutionary responsibility predicates that what we regard as our genetic heritage must be preserved for future generations ... as far as possible with the genetic integrity of (the) natural state". The NCC's current policy of using seedlings of local provenance for planting in NNRs (NCC 1979a, 1981c; NCC files; A. Scott, pers. comm.) and their role in formulating conditions for grant-aided planting in native pinewood areas (Forestry Commission, 1978) demonstrates their commitment to preserving extant genotypes.

Faulkner (1977) argues that for Scots pine the scientific, ecological, amenity, and potential production values together make a strong case for preservation of genotypes. Large stands, and those at the extremes of the natural range have priority for preservation (ibid.). Hence he singles out the Loch Maree stands (including Coille na Glas-leitire, Plate 8.3) as a priority area because of their size (about 500 ha in total) and the Shieldaig stand as representing the western-most extent of Scots pine. Identification of genotypes through biochemicals in fact shows the Shieldaig - Loch Maree - West Coulin grouping to be the most distinctive of five discrete genotypes (Forrest, 1980) with probable biochemical affinities with Scots pine in Spain and France. Stands to the south and east more closely resemble trees in northerly Continental areas. With the Shieldaig stand partly burnt in 1974, and susceptible to further fires, and Coille na Glas-leitire at virtually the same longitude and altitude and more adequately protected, it could

reasonably substitute for the damaged Shieldaig stand. Certainly, wartime fellings in Coille na Glas-leitire were extensive but the steep terrain has protected parts of the stand from dysgenic selection for tree quality (Plate 8.3).

Unlike some other significant areas of native pinewoods Coille na Glas-leitire remains remote from mature Scots pine stands of non-local provenance. This long-lived genetic isolation is now threatened by the maturing Commission-planted Scots pine stands in Beinn Eighe NNR and by non-local Scots pine established by the NCC in the 1971-78 period (both of mainly Glen Affric origin).

8.5.5 Amenity and Scenic Considerations

Whilst not a statutory responsibility, scenic and amenity values are important to the NCC. Thus, the deer fence on their newest exclosure (number 16, Fig. 9.2) is up to 80 m from the road and does not dominate the view. The vistas and the feeling of spaciousness so characteristic of the area are maintained. But the coniferous plantations fringing the Kinlochewe - Loch Clair section of the Glen Torridon road are oppressively close to the road and increasingly intruding into the grand views of the quartzite screes and high tops of the Beinn Eighe massif. Because it is the oldest and best developed the Forestry Commission plantation is the most offensive, obscuring the view for over 3 km.

8.6 Discussion

Commercial afforestation is unlikely to be wholly desirable in any NNR. However, in a sparsely wooded area afforestation adds diversity to the ecosystem and undesirable effects can be minimised by conservation-conscious management. Concessions can detract from the quality of a tree crop (by increasing the number of coarse edge trees) and from its productivity (by planting less vigorous species or provenances and

retaining substantial open areas). Unless compensation is paid it is unreasonable to expect owners with land in NNRs to reduce the potential of their crops. Even with the high level of co-operation in Glen Feshie the results have not been entirely satisfactory to either party with the unfortunate, but unavoidable, conflict between the Estate's animal-oriented management and the NCC's desire for priority for range management (Nicholson, 1971). The NCC has been forced to subvert an exciting plan to naturally regenerate the unwooded parts of the western edge of the Cairngorms NNR whilst the Estate pursues its dignified afforestation programme in the only practicable way. With the Estate willingly meeting the extra establishment costs imposed by environmental considerations (Dulverton, 1980) it is unlikely that more satisfactory voluntary concessions will be achieved in other reserves.

It is therefore incumbent upon the NCC to demonstrate that if commercial afforestation is to occur on their own reserves that it is amply justified and, if so, to ensure that conservation requirements are fully implemented. Neither of these conditions are met for the Forestry Commission plantation on Beinn Eighe NNR.

There is, however, one reason why the plantation, in a modified form, might benefit both the NCC and the Commission. Because both organisations recognise the same conservation criteria in relation to improving plantations (Forestry Commission 1979, 1978, 1975; NCC as in 8.2) there is the opportunity to re-develop this plantation, in a fully monitored experiment, as a demonstration-worthy commercial plantation meeting the highest conservation standards. The NCC's "Statement of Policies" (NCC, 1974) does, in fact, envisage the establishment of such "management demonstration areas". That larch, Sitka spruce, Norway spruce and lodgepole pine have been introduced to the site is a fait accompli. But a well conceived, vigorous silvicultural programme of thinning and

respacing aimed at increasing individual tree vigour and creating open canopy conditions, permanent gaps and irregular margins, followed by the establishment of groups of native hardwoods will revitalise the area for wildlife. Edwards and Grayson (1979) have shown that there is unlikely to be any financial gain by respacing the younger stands, but the production of posts and fencing material from older stands will offset some expenses. There may be increased liability to windthrow (ibid.) but the potential benefits in credibility and in increased wildlife values outweigh any risks.

The Scots pine stands pose a different problem. Both Faulkner (1977) and Forrest (1980) imply that the integrity of the extant gene resource on Beinn Eighe NNR is a serious conservation responsibility. In addition Beinn Eighe NNR has been declared a "Biosphere Reserve" under the "Man and Biosphere" programme sponsored by UNESCO and IUCN (IUCN, 1978). If the gene resource is to be conserved in situ the NCC's obligations are therefore clearly defined: The Glen Affric origin Scots pine must be removed before they mature and contaminate seed produced in the native stands. The closest mature native stands are 150 m and 300 m away in Allt a' Chuirn. Some 80% to 90% of Scots pine pollen falls within 400 m of its origin (A. Fletcher, pers. comm.), but still well within range of these stands, and Hadders (1972) found that 2000 m was insufficient to isolate a Scots pine seed orchard. Under suitable wind conditions some pollen would reach the main Coille na Glas-leitire stands several kilometres away, although even the initial density of the pollen cloud would be low from such small stands (Koski, 1975). It would, however, be ample to contaminate, as they mature, the young stands of local origin Scots pine planted by the NCC adjacent to the Forestry Commission block and certainly be sufficient under the influence of the prevailing north-west wind, to contaminate residual native Scots pine

opposite the Forestry Commission plantation and to reach the more substantial West Coulin stands some 1400 m away at the west end of Loch Clair (Plate 8.4).

Fortuitously, the unusual planting pattern adopted in the Forestry Commission plantation facilitates the selective removal of Scots pine whilst leaving intact a woodland habitat. Clearfelling the varying sized blocks of Scots pine would remove the threat of genetic contamination and simultaneously create a mosaic of open areas from 150 m^2 to over 4 ha in extent, similar to the pattern suggested by Fig. 9.3B. Having itself promoted the philosophy of genetic purity in this specific locality through the native pinewoods grant scheme (Forestry Commission, 1978) such a proposal should be acceptable (it covers <25 ha of Scots pine).

In the 1971 to 1978 period the NCC inexplicably abandoned its previous policy of planting only local origin Scots pine on Beinn Eighe NNR, although the original policy of genetic purity is now reinstated (NCC files). My remarks therefore apply to seedlings of Glen Affric origin included in the 127000 Scots pine seedlings planted by the NCC over 145 ha during that period. Seedlings in exclosure 13, and some in exclosure 11, are adjacent to, and within a few metres of, mature native and planted local origin Scots pine respectively. The south-west corner of exclosure 11 is also within 20 m of an outlier of mature Scots pine and within 150 m of the main Scots pine stand in Allt a'Chuirn. However, it is unlikely that significant quantities of pollen will be produced by Scots pine on these sites until at least age 20 (A. Fletcher, pers. comm.). Koski (1975) showed that grafted stock of Scots pine produced very little pollen whilst less than 16 cm dbh and 7 m in height. The replacement programme could therefore be spread over at least 10 years with exclosures 11 (62 ha), 13 (2 ha), 12 (40 ha) and 14 (40 ha) treated consecutively. The ameliorative effect of the existing trees on the ground climate could be used to advantage in establishing the new stock,

and the former removed only when flowering is imminent.

The extensive coniferous plantations adjacent to Beinn Eighe NNR on Coulin Estate (see Fig. 9.2) are of lodgepole pine and Sitka spruce (established since 1966) although some naturally regenerated Scots pine is interspersed through parts of the stands. The native pinewoods grant scheme (Forestry Commission, 1978) provides a financial incentive to establish local origin Scots pine in this locality should it be established in the future, and in fact in Glen Coulin Scots pine raised from seed of local origin is being used to extend the current range of the species (J. Evans, pers. comm.).

Finally, the amenity value of the reserve would be enhanced if, during silvicultural operations, wedge-shaped rides were constructed. With their narrow end towards the road they would preserve, for the length of the rotation, glimpses of the fine vistas currently being obscured.

Plate 8.1 The Forestry Commission's commercial plantation of Scots pine in Beinn Eighe NNR. Most of the trees visible are lodgepole pine but some blocks of Scots pine are discernible as lighter patches, greyish in colour. Coulin Estate plantation of lodgepole pine in foreground.

Plate 8.2 Mixed coniferous woodland in Forestry Commission plantation, Beinn Eighe NNR. Scots pine left rear, lodgepole pine right rear (of approximately 1200 and 1600 m^2 respectively) and heavily browsed Sitka spruce in foreground.

Plate 8.3 Coille na Glas-leitire, Beinn Eighe NNR. Gap in foreground was created by wartime felling of Scots pine. However, the steep and broken terrain prevented dysgenic selection for timber quality over the whole woodland and the original genetic complement has undoubtedly been retained.

Plate 8.4 Part of the West Coulin stand of native Scots pine near Beinn Eighe NNR. This stand is 1400 m from Scots pine of Glen Affric origin in the Forestry Commission plantation and its genetic integrity may be under threat.

CHAPTER 9

THE ESTABLISHMENT AND MANAGEMENT OF SCOTS PINE WOODLAND

The only sample reserves with significant areas of semi-natural Scots pine woodland are Beinn Eighe and Cairngorms NNRs. Both have red deer densities in excess of that which permits natural regeneration in unprotected areas and to extend the range of the existing remnant woodlands the NCC has used deer-proof exclosures. Table 9.1 shows current exclosures on Beinn Eighe NNR and on the Speyside sections of Cairngorms NNR.

Between 1956 and 1960 five small exclosures (0.04 to 3.2 ha) were constructed on the Mar section of Cairngorms NNR (not in sample). All but one have been planted up with Scots pine. In 1963 the NCC had plans to construct a 40 ha exclosure on Mar (NCC, 1967) but although only 95 ha of woodland remains on Mar (E. Matthew, pers. comm.) and there has been no effective regeneration for over 170 years (Steven and Carlisle, 1959) the owner declined to co-operate. In 1980 four small exclosures (0.1 to 3.0 ha) were constructed.

But the bulk of the NCCs mainland re-afforestation programme has taken place on Beinn Eighe NNR and on Invereshie and Glen Feshie sections of Cairngorms NNR and is the subject of this chapter.

9.1 Objectives and Techniques.

In Beinn Eighe NNR the primary purpose of afforestation is to achieve rapid tree coverage of deforested moorland using indigenous species (Boyd and Campbell, 1965) and to encourage expansion of native pine-wood over moorland (NCC, 1977a). By 1957 it was realised that only

by man-assisted methods could the Coille na Glas-leitire be satisfactorily restored and to create the "natural-type forest" desired by the NCC (ibid.; NCC, 1973a, 1975; NCC files) it was decided to adopt conventional commercial afforestation techniques modified "...to meet the special requirements of the Conservancy" (Boyd and Campbell, 1965). This policy is currently in force.

On Cairngorms NNR the objective is "...to re-establish areas of wartime-felled woodland..." (NC , 1967) and to "...encourage the regeneration and extension of the native forest" (NCC, 1981c). Notwithstanding that the natural evolution of plant communities is important (NC , 1967) the practices of re-establishment have fluctuated between planting and natural regeneration. Currently the policy is to encourage natural regeneration to the extent that "Where woodland can regenerate successfully without planting...planting is an undesirable alternative" (NCC, 1981c).

9.2 Siting of Exclosures.

Some exclosures appear to have been sited and built to meet the requirements of the moment rather than as part of a considered programme of land enclosure related to overall reserve management. The building (cost about £4 per m) and maintenance of exclosures is a major and recurring expense and it is opportune to examine the Council's achievements to date. Unfortunately neither reserve operates under a current management plan which details the NCC's long-term aims and methods of re-afforestation.

9.2.1 Cairngorms NNR : Invereshie and Glen Feshie Sections.

The four major exclosures on Invereshie (Table 9.1, Fig 9.1) were of a size (15 to 20 ha) that was, at the time of construction,

Table 9.1 Exclosures in Beinn Eighe NNR and in Rothiemurchus, Invereshie/Inshriach and Glen Feshie sections of Cairngorms NNR. Exclosures are numbered according to H. Brown's records for Beinn Eighe NNR and to Mount (1977) for Cairngorms NNR. Exclosures not mapped by Mount are lettered A to G. Information on exclosures 1, 2, 10, A, C to G was requested from the NCC but was not forthcoming. Data shown was compiled from various sources and is provisional. Unless otherwise noted all stocking rates are calculated on the basis of the whole exclosure being planted up.

Reserve	Exclosure number	Area (ha)	Established	Seedlings planted: Scots pine	Seedlings planted: Hardwoods	Stocking (s p ha)	Equivalent spacing (m)	Purpose (see below)
Beinn Eighe	1	45	1954	—— 4000 ——		3333[1]		2, 3, 4
	2	121*	1959/69	mixed conifers			2.0 x 2.0	5
	3	0.6	1957/71	nil				1, 2, 4
	4	0.1	1958	yes	yes			2, 4
	5	0.4	1959	yes	yes			2, 4
	6	1	1959	yes	yes			2, 4
	7	0.8	1960	yes	yes			2, 4
	8	16	1960/70	20440	2900	1441	2.5 x 3.0	2
	9	19	1964	50100	6660	2921	1.9 x 1.9	2
	10	18	1969	34500	5720	2208	2.0 x 2.4	2
	11	62	1971	36000	11700	769	3.8 x 3.8	2
	12	40	1975	50000	22500	1791	2.5 x 2.4	2
	13	2	1973	1000		500		
	14	40	1976	40000	27200	1680	2.4 x 2.5	2
	15	0.5	1967	500				2, 4
	16	121						2
Cairngorms								
Rothiemurchus	G	0.4	1962	yes				1, 4
	13	0.2	1962					3, 4
	14	0.1	1954					4
Invereshie/	1	18	1959	8000		2500[2]	2.0 x 2.0	2, 3, 4
Inshriach	2	20	1964	17400	300			2, 3
	10	14	1967?	yes	yes			
	A	15	?	yes				2
	B	35	1981	to be naturally regenerated				3

Glen Feshie	B	115*	1981	yes		2500[3]	2.0 x 2.0	3, 5
	C	26*	1972	yes	yes			5
	D	140*	1967	mixed	conifers	2500	2.0 x 2.0	5
	3	5.3	1975	12000	1075	2467	2.0 x 2.0	2
	4	0.8	1975	2270	250	3150	1.8 x 1.8	2
	5	1.8	1975	4800	370	2872	1.9 x 1.9	2
	6	8.0	1975	14000	8730	2841	1.9 x 1.9	2
	E	0.1	1970?	yes	yes			4
	F	1.6	1969?	yes				5

Purpose: 1 = non-grazed control; 2 and 3 = artificial and natural establishment of shrub/tree species respectively; 4 = experimental purposes; 5 = commercial afforestation.

Notes:
1. 1.2 ha only planted.
2. 3.2 ha only planted.
3. Proposed 1981/82, about 35 ha to be naturally regenerated if 60% stocked by 1986, otherwise to be planted.

* Commercial plantations.

Sources: H. Brown, D. Gowans, E. Mathews, D. Morris, pers. comm.; Boyd and Campbell, 1965; Mount, 1977; NCC, 1967, 1977; Ordnance Survey, 1980 (Kingussie, Sheet 35, 1:50000).

considered suitable in terms of manpower, finance and displacement of deer (NC , 1967). They cover the altitudinal range of forestable sites (310 to 540 m) but few site types. Thus they enclose no existing timberline or scrubland zone, nor any part of the extensive wet, previously wooded Inshriach flatlands below 300 m altitude nor any of the steep, rubble-littered, potentially regenerable slopes west of Creag Mhigeachaidh. The current 150 ha exclosure (B in Table 9.1, Fig 9.1) would appear to be of dubious conservation value. Whilst the concept of involving Glen Feshie Estate in naturally regenerating the woodland is laudable the result is unsatisfactory. A meagre 35 ha is guaranteed for natural regeneration (all on Invereshie) with a further 35 ha potentially available in the unlikely event that it is 60% regenerated by 1986 (NCC files). The balance is to be commercially afforested. No site types of high priority for conservation are included in the 'natural' areas whilst if effort was concentrated on enclosing areas owned by the NCC (as was the case until 1974) the following options were available.

Option 1 : run a fence-line from the eastern-most corner of exclosure A to the low saddle (670 m) at the head of Allt nan Cuileach. Thence south-west on the true left of Allt nam Bō and west down the track to exclosure 10 (Fig 9.1). This would enclose some 240 ha of existing Scots pine woodland and naturally regenerable sites below 610 m altitude (which Pears (1967) considers to be the likely maximum timberline under present climatic conditions on the Cairngorms) and 155 ha of uplands (to 742 m altitude), none of which is included in any major exclosure in any mainland NNR in Scotland. It would also include over 3000 m of existing timberline none of which is included in any exclosure, the steep naturally regenerable slopes west of Creag Mhigeachaidh and over 40% of the forestable periphery of Invereshie/

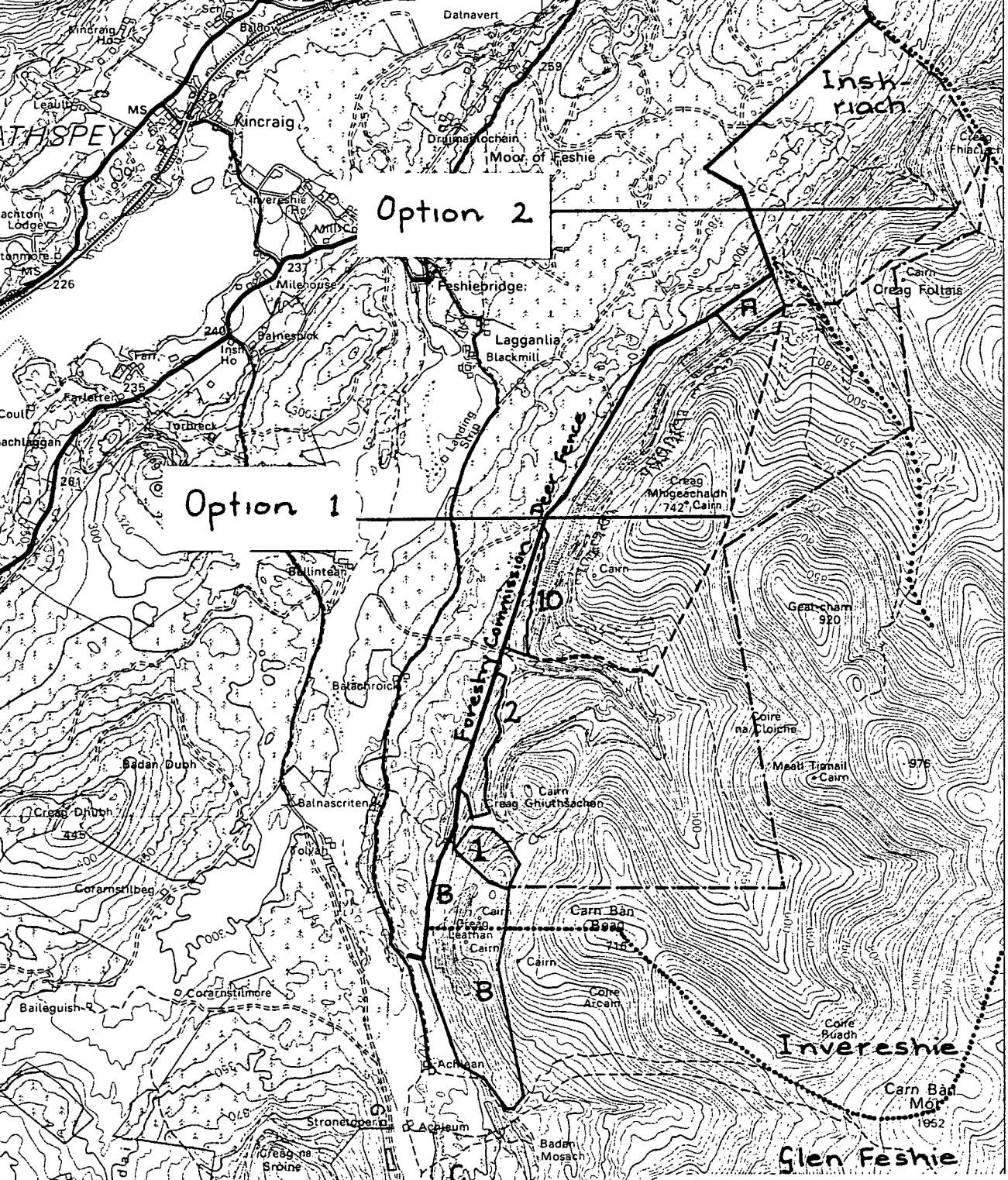


Fig 9.1 Western margin of Cairngorms NNR showing main exclosures, section boundaries and alternative fence-lines.

..... section boundaries

-.-.-.- possible line to enclose land below about 650 m altitude

------ alternatives to exclosure B

Refer to text and Table 9.1 for detail. Exclosures are numbered according to Mount (1977); undescribed exclosures are lettered A to D

Scale 1 : 50,000

Inshriach section. The total length of new fencing required - about 4400 m - is 50% in excess of the 2900 m the NCC was prepared to commit to the Glen Feshie exclosure. However, re-use of some of the 2000 m of fencing that presently contains exclosures 10 and A would have reduced the shortfall and costing could have been spread over two financial years.

Option 2 : run a fence-line along the most convenient route from the eastern-most corner of exclosure A to the Inshriach boundary on Creag Fhiaclach then north-west down the Inshriach boundary to the north-east corner of the Forestry Commission deer fence. This would enclose some 290 ha including the Inshriach flatlands, the whole of the most intact Scots pine woodland along the western margin of the Cairngorms and the unique natural timberline, at its maximum potential altitude of 645 m (Pears, 1968) on Creag Fhiaclach, with its associated fragment of fern-rich juniper shrubland (Pears, 1967) (Plate 9.1). Rare, of great scientific value and unfortunately exploited by red and roe deer to the exclusion of any regeneration or development, it is still, after 27 years of NCC administration, unprotected from browsing and trampling. Ward (1977) considers juniper in the Cairngorms area to be especially important because it supports all the known associated northern insect fauna including three species not known from other parts of Scotland. With Juniperus communis stands at both extremes of its altitudinal range on the Cairngorms NNR on Inshriach the case for protection is strong. The total length of new fencing required to enclose this incontestably superior ecological complex is 3750 m - only 30% more than the NCC was prepared to commit to the Glen Feshie exclosure.

Table 9.2 documents the relative costs of these various options.

Exclosure	Area (ha)	Fencing (m)	Fencing (m)/ha enclosed
B (Fig 9.1)			
a) whole area	150	2900	19
b) areas to be naturally regenerated	70	1450[1]	21
Option 1	395	4400	11
Option 2	290	3750	13

Table 9.2 Cairngorms NNR: Invereshie/Inshriach and Glen Feshie exclosures. Cost of various exclosures in terms of metres of fence per hectare enclosed. Refer to text for description of areas.
Note: 1. Glen Feshie Estate agreed to share the cost of fencing when it became clear that the bulk of the exclosure was to be a commercial plantation.

Clearly there are major differences in the cost-effectiveness (and ecological desirability) of the alternatives, with the Glen Feshie exclosure comparing unfavourably. To extend the argument, much of the Invereshie/Inshriach section of the reserve below 650 m altitude could be completely enclosed by approximately 12 km of fencing (Fig 9.1) at a cost of between eight and nine m of fence per ha enclosed. The precedent for deer fencing on this scale has been established on both Rhum and Beinn Eighe NNRs with over 10,000 m and 22,010 m of NCC fencing respectively. As on these reserves such fencing will ultimately be necessary on Invereshie/Inshriach section to permit the NCC to meet its statutory obligation to protect and enhance the whole flora and fauna of the site.

9.2.2 Beinn Eighe NNR.

The NCC's ambitious re-afforestation programme on Beinn Eighe NNR began in 1954 with the enclosure of 45 ha within the existing woodland.

Largely experimental, it was followed by a series of exclosures which by 1971 saw most of the moorland below 100 m altitude north of Loch Clair enclosed (below 60 m north-west of Kinlochewe). Since 1975 some land up to 300 m altitude has been included in exclosures 12 and 16 (Table 9.1, Fig 9.2).

Including the Forestry Commission exclosure (2 in Fig 9.2) some 29,240 m of deer fence has been constructed to protect 487 ha (60 m of fence per ha enclosed). The NCC has erected 22,010 m of fence around 366 ha at 60 m of fence per ha enclosed. Of this, 12,800 m has been erected since 1969 (enclosing 278 ha with 46 m of fence per ha enclosed). 81% (296 ha) of the land enclosed has been open moorland for re-afforestation in accordance with the NCC's policy objectives. Yet despite the extent of enclosure on Beinn Eighe NNR, important communities still remain unprotected (as below). A comprehensive approach to enclosure would result in a more rational use of funds for fencing with the enclosure of these communities in addition to a much wider range of Scots pine sites some of which are naturally regenerable.

9.2.2.1 Montane dwarf shrub heaths. As in Cairngorms NNR scant effort has been made to protect and enhance, or even to monitor, important plant communities above timberline, although "...preservation of the montane communities..." is a primary object of management (Boyd and Campbell, 1965). Not even fragments of the unusual dwarfed Calluna/Juniperus communis ssp. nana/Arctostaphylos uva-ursi/Herberta borealis or mixed Calluna/Arctuous alpina/Arctostaphylos uva-ursi/Loiseleuria procumbens/Empetrum hermaphroditum communities at 400 to 600 m altitude on north-east slopes (Ratcliffe, 1977) are protected from browsing and trampling by red deer. However, they are now freed from the fires that once ravaged them and largely reduced them to patches between erosion pavement (Poore and McVean, 1957). At least some part of the

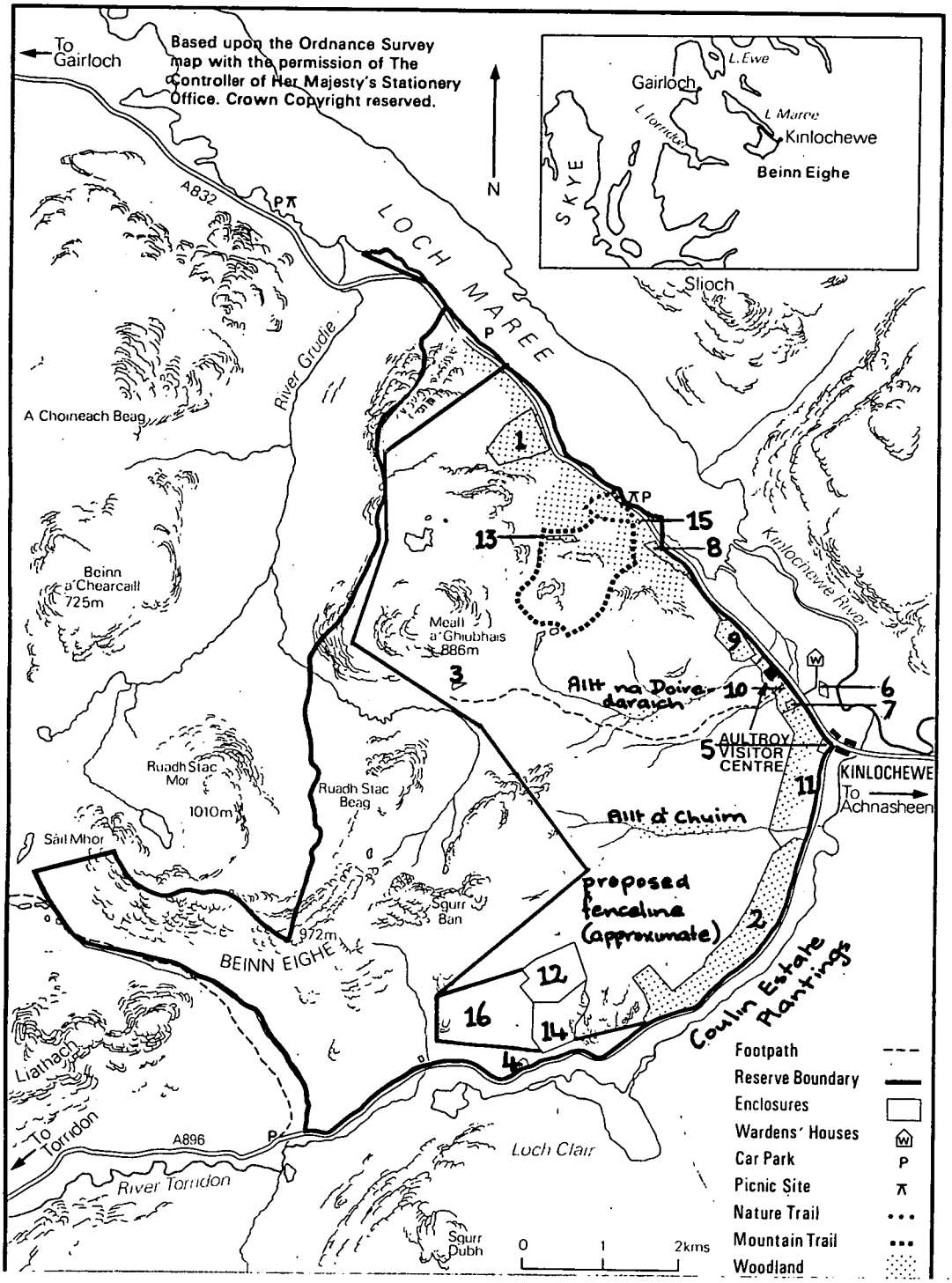


Fig. 9.2 Current exclosures on Beinn Eighe NNR. Numbered according to H. Brown (pers. comm.) and NCC records. Exclosure 2 is leased by the Forestry Commission and has been developed as a commercial plantation. Possible route (diagrammatic) for a deer-proof fence to isolate about 3600 ha (76%) of the reserve from red deer is indicated.

communities justifies enclosure if only to establish the impact of current animal pressure. Uneroded juniper scrub as found below Creag Dubh and Sgurr na Conghair is extremely rare (Boyd and Campbell, 1965) yet the only high altitude exclosure (number 3 in Fig 9.2) is at 490 m altitude and includes only Calluna vulgaris and a Tricophoretum/ herb-rich flush. A predictably vigorous response to the cessation of grazing (Plate 9.2) demonstrates that, like woodlands, upland floral ecosystems are drastically inhibited by current browsing pressures. After only 4 years enclosure the "Recovery of tall herbs (was) proceeding satisfactorily: there has been quite an impressive show of globe flower contrasting with complete absence of flowers outside the fence" (NCC files).

9.2.2.2 Valley woodlands. The two main remnants of valley woodlands in Allt a' Chuirn and Allt na Doire-dairach (Fig 9.2; Plates 9.3, 9.4) are heavily utilised by animals and entirely unprotected. Surviving trees are often scattered and many have thin crowns. Seed is still produced but any seedlings that do establish are decimated by deer. Yet these sites with colluvium, thin soils, ledges, small screes and rock outcrops offer the finest prospects for natural regeneration on Beinn Eighe NNR.

Although admirable commitment is evident in the extension of Scots pine woodland at low altitudes these unique valley woodlands with occasional trees up to 400 m altitude - about the limit for Scots pine in this region (NCC, 1977a) - will disappear under the current management policy. Separate enclosure is out of the question : to enclose Allt na Doire-dairach to about 460 m altitude would require 7 km of deer fence and Allt a' Chuirn 5.5 km. An alternative approach is required.

9.3 A Comprehensive Alternative to Exclosures.

Fortuitously, a combination of topography and existing fencelines permits much of Beinn Eighe to be readily and reasonably securely isolated from the red deer of neighbouring estates.

The complex question of whether or not there should be red deer on Beinn Eighe NNR is discussed in some detail in Chapter 12. However, in relation to the flora of the reserve, and to the NCC's narrower commitments to re-establishing Scots pine woodland, red deer make no positive contribution but their control involves continuing expenditure on fencing and management commitments. There is no valid scientific or ecological reason for encouraging red deer on the reserve and the NCC has already demonstrated its commitment to excluding animals from selected areas.

The fence-line shown diagrammatically in Fig 9.2 extends the concept of exclusion to some 76% of the reserve area and in so doing relieves from grazing those important and threatened communities enumerated above. Communities like these have scant prospect of extensive protection in any other NNR in mainland Scotland. Such a fence would not be permanently and totally deer proof but a vigorously presented control programme to remove infiltrating animals will guarantee the unique conditions that could permit the development of alpine, montane and woodland communities free of overt browsing pressure from red deer.

The total length of fence required is approximately 12 km - slightly over half that already erected on Beinn Eighe and only 11% more than has been constructed since 1971. An indeterminate length of fencing materials - possibly as much as 4000 m - might be salvaged from the inner fences of exclosures 10, 11, 12, 14, 16 and re-used. The fence encloses some 3600 ha of reserve at a cost of 3.5 m of

fenceline per ha enclosed. It would be from 13 to 17 times more efficient in the use of resources than past methods and about 5 times more efficient than ring-fencing, as is mooted in NCC files, the unenclosed 640 ha below 300 m altitude above the existing exclosures.

9.4 Treatment of Exclosures

9.4.1 Species

On both Beinn Eighe and Cairngorms NNRs mixed hardwood species have been planted to diversify the woodland (Table 9.1). Only species that have previously occurred on the sites have been used. On Beinn Eighe exclosures have been treated inconsistently. For example, in exclosures 8 and 9, 12.4% and 11.7% of planted seedlings respectively were hardwoods whilst in exclosures 12 and 14, 31.0% and 40.5% respectively were hardwoods. However, this appears to reflect site type and seedling availability rather than changing policy requirements. Species planted include birch (Betula pubescens), alder (Alnus glutinosa), oak (Quercus petraea), Salix sp, Populus sp, rowan (Sorbus aucuparia), ash (Fraxinus excelsior), birdcherry (Prunus padus), holly (Ilex aquifolium), broom (Saro thamnus scoparius), gorse (Ulex europaeus), hazel (Corylus avellana). In the early 1960s the Anancaun nursery was extended with "Only locally collected seed from Loch Maree district, Coulin and Sheildaig ..." to be used in the nursery (Boyd and Campbell, 1965). However, the demand for large numbers of Scots pine seedlings between 1971 and 1977 saw the importation of Glen Affric stock from Forestry Commission nurseries to make up the shortfall in seedling transplants. Recommendations for the management of this stock are made in Chapter 8.

On Cairngorms NNR hardwoods including Prunus avium, rowan,

Betula pubescens, alder, Salix sp and broom have been planted by the NCC. Scots pine seedlings raised from local seed only have been planted in the Invereshie exclosures but large stocks of Scots pine of dubious provenance have been established adjacent to the reserve (NCC, 1981c) and the genetic purity of the native stands is threatened. However, the native pinewoods grant scheme (Forestry Commission, 1978) now encourages and rewards the use of genetically pure stock.

9.4.2 Spacing and Planting Pattern.

The commercial plantations on Beinn Eighe and Cairngorms NNR have been blanket planted at approximately 2 m x 2 m spacing. This combination is not to be expected for planting in exclosures by the NCC where habitat diversity and wildlife values are of major significance and are promoted by wider spacings, frequent gaps, irregular margins and species admixtures (see 8.2).

9.4.2.1 Cairngorms NNR : Invereshie and Glen Feshie Sections. None of the four large exclosures on Invereshie have been fully planted up, with more than 50% of the area left to naturally regenerate. Planted Scots pine, sometimes with hardwoods, modified by natural mortality on essentially unprepared sites and supplemented by natural regeneration has resulted in a woodland habitat with many conservation features and which locally resembles the pattern of natural regeneration on Rothiemurchus (Plate 9.5). The 1975 exclosures are smaller and are fully planted up (Table 9.1). They are best regarded as nuclei amongst degenerating woodland. Comprehensive site surveys before planting have ensured that the range of species planted are optimally sited (NCC files; D. Gowans, pers. comm.).

9.4.2.2 Beinn Eighe NNR. Exclosures 8, 9, 10, 11, 12, 14 comprise the bulk of the moorland afforestation sites planted up by the NCC prior to 1980. The most striking feature is the originally close-spaced regular planting of many of these sites (Table 9.1; Plate 9.6) although deer-induced mortality has reduced the stocking of hardwoods in most exclosures. Scots pine may naturally develop in dense stands, and there are examples of this structure in Coille na Glas-leitire, but limited efforts have been made to develop planted areas as improved wildlife habitat. Ploughing has been used as the basic method of land preparation and often less than 20% of the plantable area has been left unploughed (Plate 9.7). With close-spaced planting along the ridges (from 1.3 m to 2 m between seedlings) and ridges themselves regularly spaced and frequently too close (usually 2 m to 3.5 m apart) to permit the development of understory floras (even if deer were controlled) the successfully established parts of some exclosures resemble commercial Scots pine woodlands (Plate 9.6).

Although naturally more amenable to sympathetic planting with its scattered residue of old Scots pine and swampy corner, exclosure 8 has been more skilfully restored, in both conception and practice, than any of the other major afforestation blocks. Group planting of Scots pine and birch in open areas (Plate 9.8) contrasts with dense planting of Scots pine (1.3 m x 2 m, 82% survival) at the south end to give a mixed woodland habitat. (This, and the following estimates of survival are based on counts of at least 250 trees along randomly chosen planting lines within each exclosure). A high population of red and roe deer with free access to the exclosure through dismantled fences is preventing the further development of hardwoods, especially rowan.

The bulk of exclosure 9 was successfully planted with Scots pine

at a maximum of 2 m x 2 m spacing (survival 85%). However, along the south-east margin a substantial open area has been retained and a small area of the same sector has been about 50% planted up with groups and lines of Scots pine. The clearings visible from the road mostly represent hardwood plantings amongst which mortality and suppression has been extreme (Herbert, 1982).

The north-west end of exclosure 10 was successfully planted with Scots pine at about 2 m x 2.4 m spacing and has few planned gaps (Plate 9.6) although the trees have not yet closed canopy and much of the ground flora is intact. The south-east end planted up at the same spacing has more gaps, some planned and some resulting from hardwood mortality. Survival of Scots pine is 82% and for hardwoods is variable but generally low.

The wettest 12 ha of exclosure 11 was not planted although attempts have been made to seed in alder. Overall, the block has a low stocking rate (769 s p ha) and many small open areas were retained at planting. Unfortunately red and roe deer have had virtually unrestrained access to this exclosure. Growth of Scots pine has been suppressed by browsing and of the 11,700 hardwood seedlings that were planted those that do survive are mostly no more than sticks. It should be noted that in exclosures 8, 9, 10, 11, 12 and 14 that some rowan seedlings in particular have survived persistent and heavy browsing by red and roe deer and persist as mutilated stumps. If freed from browsing most would respond with vigorous new growth. Some such seedlings in exclosure 8 are over 20 years old and less than 1 m tall. In exclosure 11 reliance on machine preparation of the ground has been carried to an extreme with planting of Scots pine on tractorable wet flats and hollows but virtually no planting on glacial hillocks where natural regeneration would normally occur

(c f. Malcolm, 1976) but where tractors with ploughs cannot conveniently operate (Plate 9.9).

Of the more recently planted exclosures 12 and 14 (post 1975) only in the latter is conservation planning evident. Here about one third of the area is unploughed and unplanted. However, seedlings (60% Scots pine) have been mostly close planted - from 0.6 m to 2.5 m apart in rows with rows from 2 m to 4 m apart - and with 78% survival most of the planted area will be closed canopy woodland within 20 years.

All but about 15% of exclosure 12 has been comprehensively ploughed (Plate 9.7) although part of the ploughed area in the north-west sector remains unplanted. Survival of Scots pine is variable with an average of about 73% in the lower two thirds of the block. In wetter more exposed sites near the top of the block survival is as low as 25%. In exclosures 12 and 14 rowan has proven more persistent than Scots pine and even though sometimes mis-sited on knolls (Plate 9.7) survival is rarely less than 90%. Although comparatively new, and with no established cover for deer, browsing of seedlings by roe deer in exclosures 12 and 14 is already a serious problem with few seedlings completely intact and most rowan grossly mis-shapen.

The beneficial effects for wildlife of altering spacing and planting pattern have not been exploited by the NCC for the Beinn Eighe woodlands. Fig 9.3 shows two hypothetical 20 year old stands with 50% open areas. Fig 9.3 A contains the equivalent of 800 s p ha which is closest to the original stocking rates in the least densely planted exclosures (11 and 13) and resembles the planting pattern used in most exclosures. By the time trees are about 8 m tall little direct light reaches the ground, an effect that is exaggerated as

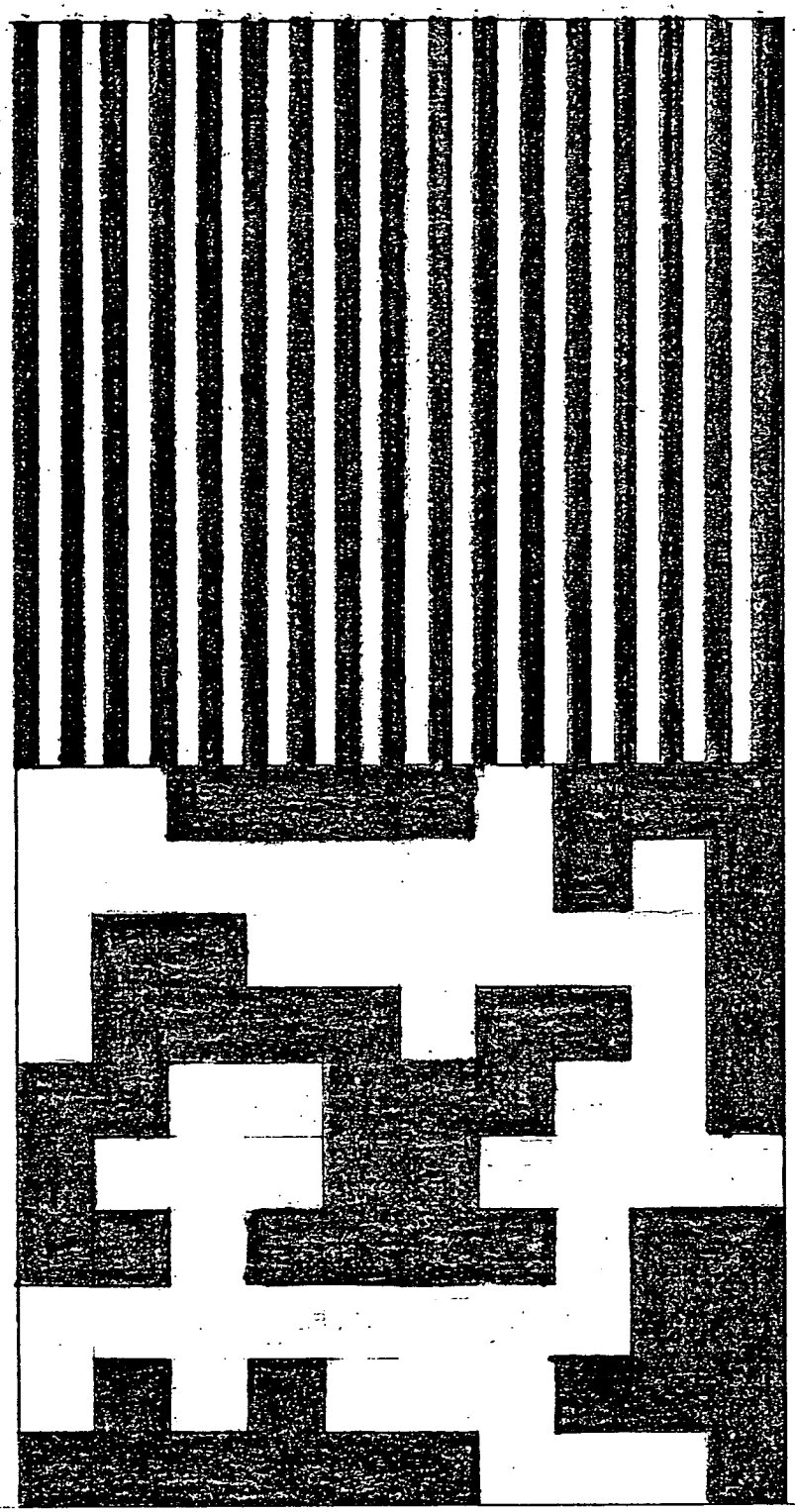


Fig 9.3 Two ways of establishing 50% open areas in planted woodland. Trees are assumed to cover an area 3 m wide by age 20. In 9.3 A rows are 6 m apart, trees 2.2 m apart in rows. This is equivalent to about 800 s p ha and similar to the original stocking in exclosures 11 and 14. In 9.3 B trees are essentially group-planted with the aim of creating a diverse habitat. Spacing within the planted areas is optional but 2.5 m x 2.5 m spacing (1600 s p ha within the planted area, 800 s p ha overall) should provide 100% ground cover by age 20 and may be reduced if openings are required within the stand.

the rows come closer to forming a right angle with the sun's path. Such a pattern has little to recommend it as improved wildlife habitat. Fig 9.3 B represents a similar density of trees covering the same proportion of ground. Such a pattern offers ample shelter from all winds, some parts are constantly fully lit, spaces are extensive enough to be free of shading effects and it provides moorland, woodland and extensive ecotone habitats.

9.4.3 Land Preparation and Fertiliser Use.

9.4.3.1 Cairngorms NNR : Invereshie and Glen Feshie Sections. Screefing to encourage seedling establishment, and burning (2.5 ha in exclosure 2 was burnt under controlled conditions in 1965) have been the only forms of land preparation used by the NCC. The plans to fertilise all seedlings with 50 g of ground mineral phosphate (GMP) in the 1975 Glen Feshie exclosures (NCC records) was not implemented and there is no record of other widespread fertiliser use outside the commercial woodlots. Currently, fertilising is not considered necessary unless it is essential to re-establish forest and scrub vegetation: a policy of minimum inputs consistent with establishing trees is being followed (NCC, 1981c).

9.4.3.2 Beinn Eighe NNR. Deep blanket peat, high rainfall, acid ground conditions and nutrient deficiencies contributed to unacceptably slow natural regeneration of Scots pine (e.g. Boyd and Campbell, 1965; McVean, 1963) on Beinn Eighe. The NCC opted for the proven commercial techniques of ploughing and fertilising as the most feasible short-term method of re-establishing Scots pine woodland on the degraded moorland sites (Boyd and Campbell, 1965), although conservation requirements have proven difficult to optimise under such extensive and machine-dependent techniques.

Although "The effects of draining (ploughing) on the composition of the vegetation of wet peaty habitats are fairly negligible..." (McVean and Lockie, 1969) there is a major inconsistency in the attitude to ancient soil profiles on Cairngorms NNR where, as proposed by Peterken (1977), they are regarded as non-replaceable natural features to be preserved (NCC, 1981c), yet on Beinn Eighe NNR they are being severely modified on all low altitude sites.

One of the principle effects of ploughing is to extend the range of sites on which trees will grow at uniform rates. Thus even though natural regeneration occurs in clusters of more-or-less even aged trees, variations in soil and irregular spacing produces variation within the crop (Innes and Seal, 1971). By ploughing "The original and frequent soil variations are masked..." and this, with the mosaic of plant communities is "...one of the assets of the natural pinewood" (ibid.). This trend to even-ness is exacerbated by the standard application, on Beinn Eighe, of 50 g of GMP per seedling and uniform growth rates in the field then come to characterise the already homogeneous nursery-raised seedlings planted in a regular pattern. The elements of heterogeneity and diversity are progressively suppressed.

9.4.4 Management of Exclosures.

9.4.4.1 Roe Deer Control. Comparatively few of the large number of hardwoods planted in exclosures 9 and 11 (18,360 seedlings in total) appear to have outgrown repeated and persistent browsing by red and roe deer despite rowan's astonishing capacity to repeatedly recover from browsing. Hardwoods in exclosures 8, 9, 10, 11, 12, 14 have been and continue to be, heavily browsed resulting in drastically diminished

growth in all six exclosures and reduced survival in exclosures 8, 9 and 10. The acceptance by management of roe deer within the exclosures is inexplicable in view of high fencing costs to specifically exclude them, the high cost of producing the non-commercial species planted, the closeness of the wardens to the sites for control purposes and the ease with which an adequate level of control is possible in these small exclosures.

Because of the planting pattern and natural regeneration the impact of roe deer on the Invereshie plantings is less readily assessed. However, damage is evident and two animals were gaining entry, or resident, in exclosure 2 in June 1980. Again they selectively damage hardwoods and their continued presence is unacceptable with respect to the NCC's objectives of re-afforestation.

9.4.4.2 Manipulation of existing stands. There has been no attempt to improve the value to wildlife of the earlier plantings of Scots pine in exclosures 9, 10, 12 and, to a lesser extent, 11 despite references in NCC files to the possibility of manipulation. The above sections demonstrate that inter-tree spacings, species mixes and planting patterns in existing exclosures are in urgent need of assessment and reappraisal. Original stocking rates range from 1441 to 2921 s p ha but no modern measurements of survival or pattern have been undertaken. Depending on the Council's ultimate objectives for these (and future) woodlands manipulations including thinning, block-felling, hardwood planting and aggressive animal control may be necessary to meet the Council's own ecological requirements of woodlands. Considerations of genetic purity in Coille na Glas-leitire may dictate extensive replacement of existing Scots pine over a 10 year period (see 8.6).

9.5 Discussion.

On both Cairngorms and Beinn Eighe NNRs the NCC has used deer-proof exclosures to extend the range of Scots pine woodland. But in their planning and siting the managers of both reserves have adopted an expedient approach which has been neither cost-effective nor taken advantage of the opportunity to simultaneously free other important communities from browsing. On Cairngorms NNR the regeneration of shrub and tree flora on the Inshriach flats, on the steep faces west of Creag Mhigeachaidh and about the unique natural timberline and juniper shrubland on Creag Fhiaclach is prevented by the browsing and trampling of red and roe deer. On Beinn Eighe NNR the montane dwarf shrub heaths, Scots pine timberline, valley woodlands and the Scots pine woodland itself all remain unprotected despite the erection of 29,240 m of fencing since 1954. Any further extension of woodland and shrubland on the Invereshie/Inshriach and Glen Feshie sections of Cairngorms NNR and on Beinn Eighe NNR will require more fencing and if woodland ecosystems are to be permitted to develop palatable floras not represented in other reserves because of browsing pressures, then all fences will require to be replaced after about 25 years.

To meet their obligations to protect the whole authentic flora and fauna of the reserves it is clear that a biologically viable and representative portion of each of the reserves must eventually be permanently enclosed against large browsing animals. The NCC's predilection for 'naturalness' and non-intervention becomes difficult to justify when one large mammal, maintained at artificially high levels by neighbours with pecuniary interests in its welfare, comes to dominate all ecosystems in most mainland NNRs. The NCC has proposed radical changes for Cairngorms NNR (NCC, 1979b, 1981c) but practically

these can apply only to the 12% of the reserve - Invereshie/Inshriach section - that the NCC owns. It is here that efforts should logically be maximised, in particular to re-establish Scots pine woodland over its full range and to permit the development of sub-alpine scrub which Watson (1977) regards as "The most remarkable of the absent habitats that could be in the Cairngorms." On Beinn Eighe the current red deer population is regarded as a natural component of the ecosystem and managed to meet "...the demands for stalking, venison and recreational enjoyment..." (NCC, 1973a) as part of the Gairloch Conservation Unit (for further discussion on the role of red deer see Chapter 12). In arguing for active management of Scots pine woodlands Malcolm (1976) comments that "...the forest has degenerated to an extent which makes it highly unlikely that non-intervention, even with protective measures, would ever result in self-restoration" and Gimingham (1975) writes with respect to native pinewoods that "...we should not be too fearful of human intervention". Surely the same comments apply to the other important animal-modified communities of the reserves.

It is proposed that 12 km of deer-proof fence be erected on Beinn Eighe NNR to isolate some 3600 ha (76%) of the reserve from red deer. In addition to fully protecting, for the first time on any reserve, a wide range of floras including the sequence through forest zone, timberlines, montane dwarf shrub heaths, flush grassland, sub-alpine heaths, grass heaths and moss heaths, and from sea level to 900 m altitude, the NCC would be free to pursue its afforestation programme with a degree of freedom over both options and sites that has not been previously envisaged. If, as is understood, it is the intention of the Council to establish woodland up to 300 m altitude

in a strip above the existing planted up strip then approximately the same length of fence - 12 km - is required to ring-fence this area of about 640 ha (or 1060 ha if the currently enclosed area is re-enclosed). Whatever action is taken should, however, be part of a larger scheme which examines the NCC's long-term afforestation and site protection policies for Beinn Eighe NNR.

On Invereshie/Inshriach section of Cairngorms NNR more deer fencing is required but its siting will depend on the Council's long-term management plans for the section. Again, about 12 km of fence would enclose most of the zone below 650 m altitude.

The range of shrub and tree species planted, especially on Beinn Eighe, fairly represents the range of species to be expected to occur naturally on the sites e.g. Durno and McVean, 1959. Only as the unique genetic qualities of Scots pine in Coille na Glas-leitire have been enumerated and described (Faulkner, 1977; Forrest, 1980) have the potential consequences of importing Scots pine seedlings of Glen Affric origin between 1971 and 1978 become clear.

The vigorous afforestation programme of this period has not been paralleled by a similar commitment to silviculture and animal control. Although understandable in a group given to fostering wildlife the Council has partly undone its own good efforts by failing to define for itself a more aggressive role in roe, and to a lesser extent, red deer control. As far as establishing hardwood species is concerned, the exclosures have largely been an expensive failure. Possibly in the newer exclosures hardwoods will be more energetically protected and there remains the opportunity to re-plant in exclosures 9, 10 and 11.

Whilst the NCC has sought to improve conservation standards in woodland design e.g. NCC, 1979a, it has not taken full advantage of its ownership of ~~the~~ Beinn Eighe ~~situation~~. Establishment of Scots pine has been highly

successful using commercial techniques but the early recognised challenge of modifying them "...to meet the special requirements of the Conservancy..." (Boyd and Campbell, 1965) has not been fully met. Most exclosures were regularly planted at close spacings and although there has been an increase in inter-row distances in exclosures 12 and 14, there has been limited innovation in the planting pattern. Further, no practical steps have been taken to improve the distribution of woodland and open areas and to re-establish hardwoods in exclosures 9, 10 and 11. It is suggested that a survey of stock be carried out in the existing exclosures and that a detailed plan for the management of established artificial woodland be drawn up by the NCC.

The lack of detailed site planning and limited ground control of machine operators and planters has resulted in species being mis-sited e.g. rowan on knolls (Plate 9.7) and Scots pine in wetlands (Plate 9.10) in exclosure 12, ecologically and silviculturally undesirable sites being prepared for planting up e.g. peat hags in exclosure 12 (Plate 9.10), ecologically inferior planting sites being prepared at the expense of more desirable natural sites e.g. failure to plant up glacial mounds in exclosure 11 (Plate 9.9), preparation of land far ahead of the NCC's ability to supply seedlings for planting up e.g. north-west corner of exclosure 12 and a general lack of appreciation of the options available for planting up open sites. It might therefore be in the Council's best interests on Beinn Eighe NNR to emulate the detailed site surveys that preceded the small Glen Feshie plantings of 1975. Further, with 366 ha of moorland and open areas now enclosed by the NCC and over 80% planted up or due to be so treated, it is opportune to reappraise the NCC's objectives and methods. As Malcolm (1976) points out Scots pine grows naturally on glacial deposits and raised areas and although such features are

of limited distribution on Beinn Eighe certainly elevated sites could be identified and "The flats and hollows could be left unattended" (ibid.). Within the more extensive planting sites chosen ploughing may be desirable as on peat sites "...the restoration of adequate aeration and vertical drainage..." (ibid.) may be beneficial. But there is the alternative of dispensing with machine preparation. A small trial at Beinn Eighe NNR demonstrated that Dalapon, at 44 kg/ha active ingredient was effective in controlling regrowth of Trichophorum and Molinia on previously burnt sites (J. Miles, pers. comm.). Although burning would be impracticable on a large scale on Beinn Eighe NNR it would be feasible to spot spray with paraquat (as is standard practice in establishing wide spaced Pinus radiata plantations on cultivated grassland in New Zealand) to prepare selected individual planting sites and to follow up by treating regrowth with Dalapon as above. Hand cultivation and fertilising at planting should result in satisfactory planting spots with even higher survival than has been experienced to date.

Like ploughing, the use of fertilisers may be of questionable validity in a purely conservation context. However, having made the decision to artificially re-establish woodland and knowing that fertilising enhances establishment and early growth, there would seem to be little reason for not using it. But its beneficial effects on survival and growth could be used in the same way as judicious site selection and preparation as above - to justify wider initial spacings with fewer planted seedlings. A great deal more time could then be allocated to site selection and actual planting and this, coupled with spot-spraying, may be an economical way of using the NCC's resources.

Plate 9.1 Natural Scots pine timberline with dwarfed, wind-roofed Scots pine to 2m tall, at 645m altitude on Creag Fhiaclach, Cairngorms NNR. Associated fern-rich juniper shrubland in foreground. Browning off of juniper (especially right foreground) and heather (centre) caused by severe weather conditions in late spring, 1981.

Plate 9.2 Exclosure 3, 490m altitude, Beinn Eighe NNR. Built 1957, enlarged 1971. Vigorous response of flush vegetation to cessation of browsing by red deer. Large clumps of palateable Luzula sylvatica are visible within the exclosure. Also visible are seed heads of Angelica sp., Plantago sp., Cirsium sp. amongst Trichophorum-dominated sward. Other flowering species include Trollius europaeus, Galium boreale and Geum rivale. Compare browsed vegetation to left of fence.

Plate 9.3 Remnant Scots pine woodland in Allt a' Chuirn, Beinn Eighe NNR. Deterioration of this already open stand continues (four dead trees are visible at 10 o'clock behind the large crown in foreground) but there is no effective regeneration except on the inaccessible dropover into the burn. No part of this stand is enclosed and protected from browsing.

Plate 9.4 Remnant Scots pine woodland at about 350 m altitude in Allt na Doire-dairach, Beinn Eighe NNR. These comparatively well drained sites with scree, ledges and rocky outcrops offer the best sites for natural regeneration in Beinn Eighe NNR but heavy browsing pressure prevents effective regeneration. Note network of red deer tracks on steep slope above rock outcrop. No part of this woodland is enclosed.

Plate 9.5 Group planted Scots pine, modified by natural mortality on unprepared sites and supplemented by natural regeneration, in exclosure 1, Invereshie section, Cairngorms NNR (on right) bears a marked resemblance to natural regeneration of Scots pine on Rothiemurchus section (left).

Plate 9.6 North-west half of exclosure 10, Beinn Eighe NNR (part exclosure 9 in background). Note close spaced (2 m x 2.4 m) Scots pine with high survival (82%). Gap in foreground was planted with Scots pine and rowan both of which have been severely browsed with many deaths. Animal-induced openings, mainly in hardwood areas, are a feature of exclosures 9, 10 and 11.

Plate 9.7 Ploughing and planting in exclosure 12, Beinn Eighe NNR. Overall planting rate was 1791 s p ha. Inter-row gaps commonly about 3 m and seedlings are frequently at less than 2 m spacing within rows. Main species in Plate is Scots pine but note part of a group of mis-sited rowan on a dry exposed knoll in right foreground.

Plate 9.8 Group planting of Scots pine and birch in open areas amongst residue of old native Scots pine in exclosure 8, Beinn Eighe NNR. Unless changes are made in the management and species composition of existing exclosures this is the only exclosure that can provide a genuine mixed woodland habitat.

Plate 9.9 Exclosure 11, Beinn Eighe NNR. Scots pine seedlings have been row-planted on tractor prepared ground in flat areas and hollows. However, some raised sites (centre) that would naturally be colonised by Scots pine (c f. Malcolm, 1976) have not been planted apparently because they were inconvenient to work with tractors.

Plate 9.10 Exclosure 12, Beinn Eighe NNR. Lack of site planning and ground supervision of machine operators and planters has resulted in the ploughing of wet peat hags and areas with semi-permanent surface water. Apart from providing habitat diversity they are silviculturally difficult sites. Scots pine has been planted on this very wet site.

CHAPTER 10

THE MANAGEMENT OF SEMI-NATURAL HARDWOOD WOODLANDS

10.1 Introduction

Of the 15 sample NNRs four - Craigellachie, Morrone Birkwoods, Mound Alderwoods and Rassal Ashwoods - were designated as NNRs solely because of their important hardwood woodlands and a fifth - Inverpolly - at least in part because of its hardwood woodlands. Except for Mound Alderwoods NNR, which is not further discussed, each of the woodlands shows obvious signs of contraction and/or opening up. With the cessation of heather burning (H. Blakenay, pers. comm.) Craigellachie is unique in having simultaneously extended its woodland range upwards into old heather moorland.

Because the woodlands are so important in the reserve ecosystems it was considered essential to establish the direction and rate of change in the woodlands and if a deterioration was evident to examine how the NCC has reacted. Aerial photographic interpretation was clearly the only practicable way to measure such changes. Within the constraint of suitable photographic surveys at least part of the time span over which change was measured coincided as nearly as possible with the period under NCC administration (Table 10.1).

It is clearly impossible to reverse the deterioration of an over-mature canopy but it is frequently possible to provide conditions under which regeneration and rehabilitation can occur. Browsing animals - sheep and deer - are primarily responsible for the failure of hardwood

Reserve	Year declared as NNR	Photo surveys used	Nominal scale
Morrone Birkwoods	1972	1955; F21 58 RAF 1773; 0132-0134	1: 9000
		1964; V:58 RAF 6500; 0071-0072	1:12000
		1975; K17 AK Univ. Cambridge; 184-188	1: 9000
Inverpolly	1961	1960; OS/60/20V; 066-078, 135-136	1:26000
		1975; RC 8 AZ; 172-174, 178-180	1:26000
		1980; OS 2653-80099; 027-028	1:26000
		-80100; 066-067	1:26000
Rassal Ashwoods	1956	1948 CPE/SCOT/UK/192; 1225-1226	1:15000
		1959 OS/59/121V; 054-055	1:26000
		1980 V HYDRA RN; 062-063	1:11000

Table 10.1 Aerial photographic surveys used to measure changes in hardwood woodlands in Morrone Birkwoods, Inverpolly and Rassal Ashwoods NNRs.

regeneration (where it is present) to develop and in some cases the NCC has used deer and sheep-proof exclosures to encourage regeneration. Thus, where relevant the role of exclosures is discussed along with changes in the parent canopy. As described in Section 2 a regeneration survey of part of Morrone Birkwoods NNR was undertaken in order to define the pattern of birch regeneration and to clarify the options for rehabilitating the woodland.

Finally, hardwood woodlands are a feature of NNRs in Scotland, occurring in 21 of 56 reserves and extending to 2000 ha. Whilst the results of the following analyses cannot be extended to these other woodlands, a number of them are managed under similar conditions.

10.2 General Methods

All photo surveys falling within a few years either side of the year of declaration of Morrone Birkwoods, Rassal Ashwoods, Inverpolly and Craigellachie NNRs were assessed for their suitability to provide the state-at-declaration baseline. The main technical requirements

were for vertical or near vertical stereoscopic cover of the woodlands at a scale of 1:10000 to 1:30000, taken when the trees were in full leaf. The one essential was for a suitable post-1975 survey to provide the 'present day' baseline. Only for Craigellachie NNR were these requirements not met and this reserve was excluded from the study. Analyses of woodland on Morrone Birkwoods, Inverpolly and Rassal Ashwoods NNRs were carried out on the photo surveys shown in Table 10.1. For Morrone Birkwoods and Rassal Ashwoods NNRs photo surveys pre-dating declaration were studied to confirm trends and to provide additional data.

Except for Section 2 the general methodology was as follows:-

a) All detailed work on stereo pairs was undertaken on a Bausch and Lomb SIS-95 stereo interpretation system with zoom facility independently adjustable for each eye-piece.

b) To establish woodland boundaries the outline of the woodlands was accurately outlined in ink on the earliest photo survey and then precisely transferred to photos in subsequent surveys mostly using the Bausch and Lomb SIS-95. Where woodland boundaries had clearly changed the modified boundaries were inked onto the relevant photos.

c) Because of overlapping and shading it was not possible to distinguish individual tree crowns even on the larger scale photos. Hence, tree cover frequency, being the coincidence of dots on a dot grid with tree canopy in areas drawn as woodland was used in place of actual counts of tree density. Tree cover is the conversion of tree cover frequency to an area basis, and percent change in tree cover (P) was calculated as follows:

$$P = \left(\frac{A_0 - A_1}{A_0} \right) 100$$

where A_0 = extent of tree cover in original measurement, and

A_1 = extent of tree cover in later measurement.

d) For the 1:9000 scale photographs for Morrone Birkwoods a 25 dots/cm² grid was used to measure tree cover frequency. For all other areas, and scales, a 100 dots/cm² grid was used.

e) The results for Inverpolly are not comparable with the other two areas because at the 1:26000 scale individual dots on the grid covered an area of about 35m² and because of the effects of slope and shadow a gap had to be at least of this size before it could be consistently recognised. At larger scales the dots could be regarded as infinitely small points.

f) For Morrone Birkwoods and Rassal Ashwoods NNRs a Carl Zeiss Aero Sketchmaster was used to transfer woodland outlines onto a 1:1000 topographical map, and areas then measured from the map. This eliminates error due to tip and tilt but is time-consuming and was not considered to be useful for the many small woodlands on Inverpolly NNR.

g) In calculating areas from aerial photographs patches of woodland were individually scaled. In hilly topography substantial differences in scale existed between runs and even across the face of a single photo.

h) Before any comparisons were made cover frequency values were reduced to a common scale based on the proportionate difference in total frequency of dots for individual areas in the photo surveys being compared.

i) The rate of change in the amount of tree cover is measured according to the discounting formula in Duerr (1960) where

$$A_0 = \frac{A_n}{(1+r)^n} \qquad \text{and} \qquad r = \sqrt[n]{\frac{A_n}{A_0}} - 1$$

A_0 = area of tree cover measured on original photo survey,

A_n = area of tree cover measured on subsequent photo survey,

r = rate of change in percent per annum,

n = number of years between the two photo surveys.

j) In the following text 'woodland' refers to areas in which the predominant vegetation is trees. These areas, as they apply to the reserves under study, are mapped in Figs 10.1 to 10.7 inclusive. 'Tree cover' refers to the area within a woodland that is actually covered by tree canopy. A 'stand' is a small patch of woodland.

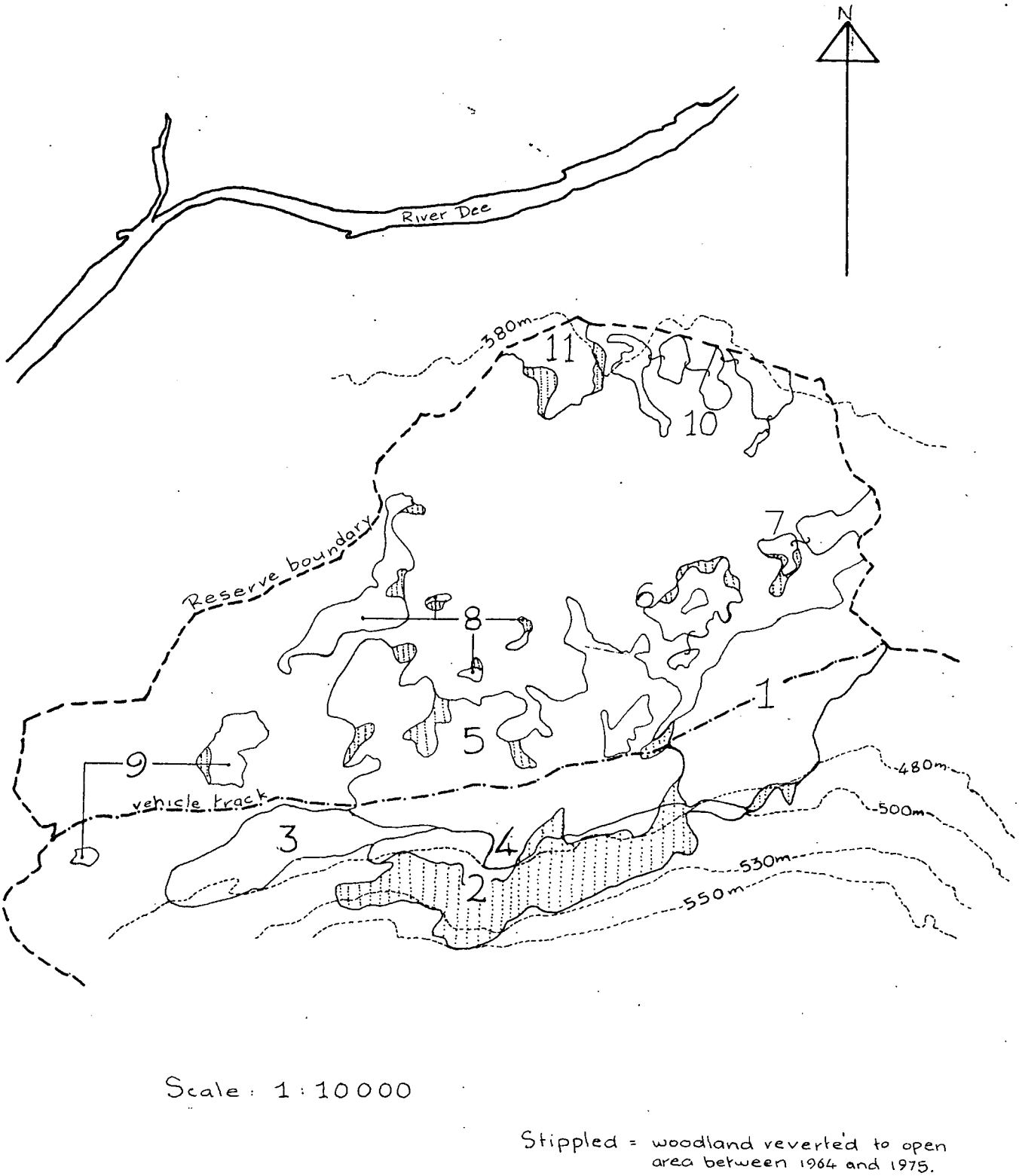
SECTION 1 - MORRONE BIRKWOODS WOODLANDS

Although Morrone Birkwoods did not become a NNR until 1972, 1955 was chosen as a convenient 'base' year and is close to the time when the area was first recommended to the then Scottish Committee of the Nature Conservancy as an NNR in 1960 (Marran and Batty, 1980).

Three photo surveys were used. A pilot study comparing the three zones showing the greatest changes over the 1955 to 1975 period showed that no consistently measurable changes in woodland area or tree cover frequency had occurred between the 1955 and 1964 photo surveys. Because the 1955 photos were of superior quality and at a more convenient scale all measurements were made on them. In calculating time-dependent changes it has been accepted that the woodland was substantially the same in 1955 and 1964 and 1964 has been used as the 'base' year for such calculations. The original woodland is therefore referred to as the 1955/64 woodland.

10.3 Woodland Zoning

Some 33.2 ha of woodland (as at 1975) was stratified into 11 zones (Fig. 10.1) to aid in measurement and interpretation of change. (The total area of land below the 530 m contour line in Fig. 10.1 is 126 ha.) The primary division was into a large central woodland (subsequently zones 1 to 5) and into outliers of woodland (subsequently zones 6 to 11). Within the main block a dense homogeneous zone 1 in the east and an open zone 3 in the west were recognised. The high altitude zone 2, beginning just below the 480 m contour line, was split off along a conspicuous break in slope. The remaining main block woodland was split into a relatively stable zone 4 above the track and a lower zone 5 with a long irregular margin. Of the outliers,



Scale: 1:10000

Stippled = woodland reverted to open area between 1964 and 1975.

Fig. 10.1 Woodland zones within Morrone Birkwoods NNR in 1975 showing changes in woodland boundaries between 1964 and 1975. Woodland zones numbered according to text. Important contour lines are shown.

zone 11 was split off from zone 10 because it underwent comparatively drastic modification in the 1955/64 to 1975 period.

10.4 Changes in Tree Cover and Area of Woodland

In the 11-year period between 1964 and 1975 there were significant changes in tree cover (Table 10.2) and area (Table 10.3, Fig. 10.1). All zones show a decrease in the amount of tree cover with the greatest absolute change occurring in the three originally most dense stands (zones 1, 7,11). (See also Plate 10.1.) Least change has occurred in zone 3 with its relatively large-crowned windfirm trees, and in zone 10. Mean tree cover has decreased from 43.2% in 1955/64 to 33.2% in 1975.

Zone	Tree cover 1955/64 %	Tree cover 1975 %	Absolute reduction %	Reduction in tree cover of residual woodland between 1955/64 and 1975 %
1	54.2	34.8	19.4	35.3
2	37.4	30.3	7.1	33.9
3	19.1	17.4	1.7	9.4
4	40.7	32.3	8.4	21.3
5	43.0	35.8	7.2	19.8
6	41.0	34.8	6.2	16.9
7	62.1	45.8	16.3	31.3
8	40.3	30.9	9.4	24.8
9	46.4	30.8	15.6	33.3
10	53.1	48.1	5.0	11.2
11	56.8	31.6	25.2	45.6
Means	43.2	33.2	10.0	26.3

Table 10.2 Changes in tree cover in areas mapped as woodland in Morrone Birkwoods NNR between 1955/64 and 1975.

Percentage reduction in tree cover (P) $= \left(\frac{A_0 - A_1}{A_0} \right) 100.$

A_0 = tree cover for zone X in 1955/64,
A_1 = tree cover for zone X in 1975.

A more useful measure of deterioration is the percentage

reduction in tree cover, over the 1955/64 - 1975 period, for the residual woodland (col. 5, Table 10.2). Thus, in zone 11 the amount of tree cover in 1975 was 45.6% less than it was in 1955/64. In addition, the actual woodland area decreased by 19.1% (Table 10.3). Zones 1, 2, 7 and 9 have suffered about a one third loss in tree cover over the same period, whilst the two main block zones 4 and 5 lost about one fifth of their tree cover. All show a decrement in area. There is no significant difference between the average loss of tree cover in the main block (zones 1 to 5) at 26.4% and the outlying patches (zones 6 to 11) at 25.9%. The overall loss was 26.3%.

Zone	Area 1955/64 ha	Area 1975 ha	Decrease in area %
1	7.80	7.70	1.2
2	7.04	1.24	82.4
3	3.20	3.20	0
4	5.12	4.84	5.5
5	8.92	8.20	8.1
6	1.36	1.12	17.6
7	1.16	1.05	9.7
8	1.92	1.80	6.1
9	0.96	0.89	7.1
10	1.92	1.92	0
11	1.68	1.36	19.1

Table 10.3 Changes in the areas mapped as woodland in Morrone Birkwoods NNR between 1955/64 and 1975. Areas calculated after transferring woodland outlines from 1:9000 aerial photographs to 1:10000 map using Carl Zeiss Aero Sketchmaster.

The most outstanding change in area has been the virtual disappearance of woodland in zone 2 (from 7.04 ha to 1.24 ha - Table 10.3). (See also Plate 10.2.) Two of the outlying woodlands - zones 6 and 11 - have decreased in area by 17.6% and 19.1% respectively. Inexplicably, zone 10 remained stable. So also did zone 3 but the remaining zones contracted by 1.2% (zone 1) to 9.7% (zone 7). The

average contraction of main woodlands (zones 1 to 5) was 21.5% reducing to 4.4% if zone 2 is excluded. These equate to losses of 6.9 ha and 1.1 ha of woodland respectively. The outlying woodlands (zones 6 to 11) averaged a 9.6% (0.86 ha) contraction in area, mostly along the woodland margins (Fig. 10.1). The overall contraction in woodland was 18.9% (7.8 ha) reducing to 5.8% (2.0 ha) if zone 2 is excluded.

10.5 Priority of Zones for Protection

Despite plentiful seedling regeneration (see Section 2) the currently deteriorating woodland canopy is not being replaced by ingrowth because development of the seedlings is prevented by red deer browsing. Enclosure permits the development of existing seedlings (10.9.1; Plate 10.3) and there is a clear case for enclosure to prevent the demise of existing wooded areas and to permit recolonisation of old woodland sites. There are practical (and perhaps ecological) objections to total enclosure of all potential woodland sites and it is therefore opportune to examine how the exclosures which are built might be most profitably distributed.

If we accept that (a) larger areas are in general terms biologically more valuable than smaller areas of similar type and that (b) those zones which have deteriorated most are more urgently in need of rehabilitation than those which have proven more stable, then it is possible to derive a ranking, based on these considerations, which indicates the zones most urgently in need of enclosure. Three factors are derived:

a) size factor: the area of each zone is expressed in relation to the area of the largest zone (zone 5)

$$\text{size factor} = \frac{\text{area of zone X}}{\text{area of zone 5}}$$

The deterioration of zones is indicated by the contraction in area and by the change in tree cover in the period 1955/64 to 1975. Thus

b) $$\text{area contraction factor} = \frac{\text{area of zone X in 1955/64}}{\text{area of zone X in 1975}}$$

c) $$\text{tree cover factor} = \frac{\text{tree cover zone X in 1955/64}}{\text{tree cover zone X in 1975}}$$

Zone	Ranking 1	Ranking 2	Ranking 3	Ranking 4
1	3	4	6	6
2	1	1	1	1
3	10	10	11	11
4	5	7	8	7
5	4	3	6	9
6	7	6	4	5
7	6	5	3	3
8	9	8	8	8
9	8	8	5	4
10	11	10	10	10
11	2	2	2	2

Table 10.4 Ranking of woodland zones 1 to 11 in Morrone Birkwoods NNR for priority for enclosure. Rank 1 indicates highest priority for enclosure. For the derivation of ranking refer to section 10.5 in text.

These data are ranked in four ways (Table 10.4) with rank 1 in each case equating to the greatest need for enclosure. In Ranking 1 (col.2) the sum of the three factors for each zone is ranked. In Ranking 2 (col.3) the individual factors for each zone were ranked and the ranks for each zone totalled and ranked (after Maxwell, 1961). In Rankings 3 and 4 (cols 4 and 5, respectively) the above strategies were repeated for the two deterioration factors only.

There is incontrovertible evidence that zones 2 and 11 are most urgently in need of enclosure and that zones 3 and 10 are of the lowest priority. For these four zones the rankings for priority are consistent whether or not size is regarded as a legitimate criterion.

If sustaining large areas is more important than small areas then zones 1 and 5 are also of high priority for protection (cols. 2 and 3). If size is of no significance then zones 6 and 7 assume a higher priority (cols. 4 and 5).

Zone	Rate of change in tree cover	Tree cover of zone (ha)			Number of years from 1975 until nominated proportion of tree cover disappears		
	% per annum	1975	1997	2022	25%	50%	75%
1	-5.04	2.68	0.86	0.24	6	13	26
2	-13.90	0.38	0.04	0.01	2	5	9
3	-0.90	0.56	0.46	0.36	31	75	153
4	-2.57	1.56	0.88	0.46	11	26	53
5	-2.64	2.94	1.63	0.84	11	26	52
6	-3.12	0.39	0.19	0.09	9	22	44
7	-3.91	0.48	0.20	0.07	7	17	34
8	-3.03	0.56	0.28	0.13	9	22	44
9	-3.96	0.27	0.11	0.04	7	17	34
10	-1.07	0.92	0.73	0.56	26	63	129
11	-9.58	0.43	0.05	0.01	3	7	14
TOTAL		11.17	5.43	2.81			

Table 10.5 Predicted changes in the area of tree cover in Morrone Birkwoods NNR. All values derived from calculated rate of change (see 10.2 i)).

Notes: 1. 1997 is the year in which the current NRA expires.
2. 2022 is the year in which the new NRA will expire if it is renewed for the standard 25-year term from 1997.
3. Areas in cols. 3, 4,5 are areas of actual tree cover within the woodland zones, not the area of the zones themselves.

10.6 Predicted Changes in Morrone Birkwoods

Table 10.5 shows the predicted pattern of change in the woodland zones if the rates of change in tree cover in the 1955/64 to 1975 period continue and there are no changes in land use patterns or woodland management. By the end of the current NRA the woodland cover in zones 2 and 11 will be about one ninth of the 1975 cover. Overall, tree cover would be 48.6% of its 1975 level and by 2022 only 25.2%

of the 1975 tree cover will remain. In nine of the 11 zones 25% of the tree cover will have disappeared by 1986 and all except zones 3 and 10 will have lost 75% of the 1975 tree cover by 2010. Note, however, that although based on historically recent patterns of change the results indicate trends in the broadest sense only. Changes in land use practices and woodland management will affect the trends and already substantial divergence from the predicted pattern will occur locally with the enclosure of 23 ha of woodland and open area in the 1978-80 period. Furthermore, the predicted persistence of tree cover in zones 3 and 10 implies a lifespan for trees of over 150 years which is in excess of the normal lifespan for birch in the Highlands (Kinnaird, 1968; J. Kinnaird, pers. comm.) and these results clearly underestimate the average rate of decline (but see also comments on the decline of birch woodlands in 10.15).

10.7 Existing Exclosures

Zone	Area in 1955/64 (ha)	Area of zone enclosed (ha)	Exclosure number	Year erected
2	7.04	0.39	3	1980
11	1.68	0		
5	8.92	3.01	2,4	1978,80
1	7.80	4.20	2,3,3	1978,78,80
7	1.16	0		
6	1.36	0.35	2	1978
9	0.96	0		
4	5.12	0.39	3	1980
8	1.92	0.10	4	1980
10	1.92	1.92	1	1978,80
3	3.20	0		

Table 10.6 Enclosure of woodland zones 1 to 11 in Morrone Birkwoods NNR. Zones are arranged in decreasing order of priority for enclosure from cols. 2 and 3, Table 10.4. In row 4 part of zone 1 was enclosed in 1978 by exclosure 3, which was added to in 1980.

The overlay to Fig. 10.1 shows the existing exclosures in relation to the 11 woodland zones. Table 10.6 shows the area of zones 1 to 11 actually enclosed. In total 23.0 ha of land is enclosed including 10.36 ha of woodland and 12.64 ha of open area. Exclosure 1 (5.67 ha) includes the whole of zone 10 which is consistently of low priority for enclosure whilst the adjacent very high priority zone 11 is entirely unprotected. Exclosure 2 (3.16 ha) includes small parts of zones 1, 5 and 6 with intervening open ground. Exclosure 4 (3.97 ha) includes a substantial segment (2.30 ha) of zone 5. Exclosure 3 includes half of the zone 1 woodland (3.88 ha), very small parts of zones 2 and 4 and a substantial area (5.00 ah) of open ground running up to 530 m altitude. Plate 10.3 shows a portion of this exclosure responding freely to the cessation of browsing. Prior to enclosure the only regeneration of birch and rowan more than a few centimetres tall was within the protection of juniper bushes (Plate 10.4).

SECTION 2 - MORRONE BIRKWOODS SEEDLING SURVEY

A survey of tree seedlings, concentrating on zone 2, was carried out in June 1980 to provide data relating to the possible results of enclosure and to characterise regeneration in the area.

10.8 Method

Five parallel lines spaced 60 m apart were run on a compass bearing upslope from the track (Fig. 10.1 overlay) to sample about 60% of the unenclosed parts of zones 2 and 4. Some 251, 2m² circular plots were located at randomly chosen intervals of 3, 5 or 7 m along these lines giving a sampling intensity of 0.67%.

Seedlings of tree species present in each plot were recorded by species and height. In this context 'seedling' refers to all regeneration and differs from the terminology of Kinnaird (1974) and Miles and Kinnaird (1979a, 1979b) where 'seedlings' are first-year plants only. No first-year plants were identified: by sampling in early June most of the previous year's seedlings will have died (Kinnaird (1974) reports 96 to 99% mortality during the first year) and the bulk of the current year's seedlings would still be germinating (Miles and Kinnaird, 1979a).

Five ground-cover types were recognised: heather (*Calluna vulgaris*), grass (mainly *Agrostis- Festuca- Potentilla*-type), juniper (*Juniperus communis* ssp. *communis*), cowberry (*Vaccinium vitis ideae*) and flush (mainly Carices and *Luzula* spp.) and each plot assigned to the predominant cover type. Ground cover height was measured.

The distance from the centre of each plot to the edge of the

canopy of the nearest tree was measured. This measure was used to calculate a tree density index: this being the sum of these individual distances divided by the relevant number of plots. It indicates the relative density of tree canopy.

The sample area lent itself to division into three altitudinal belts (Table 10.7) of about equal width and with boundaries roughly parallel to the track.

Belt 1. Lowermost birch (Betula pubescens ssp. odorata)/juniper/grass community with a tree density index of 2.40 m. Juniper (47.9%) and grass (30.2%) are the most frequent ground-cover types.

Belt 2. Central birch/grass community more open than belt 1 with a tree density index of 3.36 m. Grass provides 82.6% of the ground cover.

Belt 3. Upper birch/heather/grass community, very open with a tree density index of 9.51 m. Heather (43.4%) and grass (42.1%) provide most of the ground cover.

Additional areas were sampled as follows:

a) 50 x 1 m^2 plots were located as above along 250 m of lines in the 1.5 ha of heather included in the original exclosure of the east end of exclosure 3 (Fig. 10.1 overlay).

b) 50 x 2 m^2 plots were similarly located above the old timberline along 50 m extensions to the five main survey lines.

c) 100 x 2 m^2 plots were located as above along 500 m of lines in the recently enclosed portion of zone 1 (part exclosure 3 - see Fig. 10.1 overlay).

10.9 Results

10.9.1 Heather Area, East End of Exclosure 3 (Fig. 10.1 overlay)

Mean seedling density was 2.14 ± 0.47 seedlings/m^2 with birch providing

94.4% of the total. About one third of the area of 1.5 ha, in the north-east extremity, averaged 5.56 ± 0.57 seedlings/m² (Plate 10.3). Heather (92.0%) and grass (8.0%) make up the ground cover. After two complete growing seasons the heather was 18.9 ± 0.8 cm tall and the mean height of seedlings 16.0 ± 0.6 cm. However, 41.0% of seedlings were taller than their surrounding cover and few seedlings were being suppressed.

10.9.2 Regeneration Above Old Timberline (550 m altitude)

Seedlings were located only in the heather and cowberry cover types which made up 54.0% and 8.0% of ground cover respectively. Some 18.5% and 25.0% respectively, of such plots contained tree seedlings. Mean seedling density was 0.06 ± 0.02 seedlings/m² with twice as many rowan as birch.

10.9.3 Density of Seedlings in Zones 1 and 2

The mean density of birch (0.37 seedlings/m²) and birch plus rowan (0.48 seedlings/m²) in zone 2 (belts 2 and 3 in Table 10.7) is significantly greater ($P<0.05$) than in the recently enclosed portion of zone 1 with 0.09[1] and 0.20[2] seedlings/m² of birch and birch plus rowan respectively. The tree density index for zone 1 at 1.50 m is significantly less ($P<0.001$) than for belts 2 (3.36 m)[3] and 3 (9.84 m)[4] which together make up zone 2. The seedlings are not clumped in light wells and hence those in zone 1 are more heavily shaded than in zone 2. The former are therefore less likely to develop (cf. Kinnaird, 1974).

10.9.4 Density and Distribution of Seedlings in Zones 2 and 4

Table 10.7 summarises the abundance and distribution data for seedlings in this part of the survey area. Overall seedling density was 0.37 ± 0.04 seedlings/m² with 82.0% birch and 18.0% rowan. Excepting Dinnet Moor, this density is low compared with Kinnaird's (1974) results

1 $t = 2.231$ d.f. = 299
2 $t = 2.022$ d.f. = 299
3 $t = 3.847$ d.f. = 134
4 $t = 4.414$ d.f. = 115

Belt	Cover type	Density of seedlings per m² of cover type		% of cover type in belt	Density of seedlings per m² of belt		
		Birch	Rowan		Birch	Rowan	Total
1	Heather	0.22		16.7	0.12		0.12
	Grass	0.07	0.02	30.2	0.02		0.02
	Juniper	0.13	0.01	47.9	0.06		0.06
	Cowberry	0.20		5.2	0.01	trace	0.01
	Flush					trace	
Sub total		0.21±0.05	0.01±0.01		0.21±0.05 (2137)	0.01±0.01 (104)	0.22±0.05 (2241)
2	Heather	0.72	0.22	10.5	0.07	0.02	0.10
	Grass	0.25	0.04	82.6	0.21	0.03	0.24
	Juniper		0.15	2.2	0	trace	trace
	Cowberry	0.88		4.7	0.04		0.04
	Flush						
Sub total		0.32±0.06	0.06±0.03		0.32±0.06 (3263)	0.06±0.03 (582)	0.38±0.07 (3845)
3	Heather	0.65	0.25	43.4	0.28	0.11	0.39
	Grass	0.28	0.07	42.1	0.12	0.03	0.15
	Juniper						
	Cowberry	0.17	0.25	8.7	0.01	0.02	0.03
	Flush			5.8			
Sub total		0.41±0.11	0.16±0.05		0.41±0.11 (4125)	0.16±0.05 (1593)	0.57±0.11 (5718)
Zone 2 (belts 2 and 3)					0.37±0.09 (3742)	0.11 ± 0.04 (1054)	0.48 ± 0.09 (4796)
GRAND TOTAL					0.31±0.04 (3088)	0.07±0.02 (677)	0.37±0.04 (3765)

Table 10.7 Morrone Birkwoods NNR. Seedling densities by belt and cover type for zones 2 and 4. Values in brackets are equivalent densities in seedlings per hectare.

from selected 500 m² sites at Inverpolly NNR (2.5 ± 1.3 saplings/m²), Glen Feshie (2.5 ± 1.0 saplings/m²) and Dinnet Moor (0.3 ± 0.01 saplings/m²). However, with 31.1% of plots stocked there are sufficient seedlings to provide a well-stocked stand should browsing cease. Mean seedling density increases evenly from 0.22 ± 0.05/m² in belt 1 to 0.57 ± 0.11/m² in belt 3. These differences are related in part to the distribution and frequency of the major cover types and some features are discussed below.

10.9.4.1 Effects of cover type. In each belt heather patches are consistently well stocked with 0.72 to 0.94 seedlings/m² (Table 10.7). However, in belts 1 and 2 heather provides only 16.7% and 10.5% of ground cover respectively, and the effect on stocking rate per unit area of belt is smaller than in belt 3 where heather provides 43.4% of ground cover and 68.4% of total seedlings.

Grass provides 30.2%, 82.6% and 42.1% of ground cover in belts 1, 2 and 3 respectively. The average stocking rate of tree seedlings in this cover type is significantly lower ($P<0.01$) in belt 1 at 0.09 seedlings/m² than in belts 2[1] and 3[2] (0.29 and 0.35 seedlings/m²). This contributes in a major way to the low overall stocking rate in belt 1.

In belt 1 juniper provides 47.9% of ground cover. It is sparsely stocked (0.14 seedlings/m²) and therefore nurse to only 30.2% of tree seedlings in belt 1. In contrast heather (16.7% of ground cover) is nurse to 53.9% of total seedlings.

Cowberry and flush cover types do not exceed 8.7% of ground cover in any belt. However, the second highest average stocking rate for cover types in any belt occurs in cowberry in belt 2 (0.88 seedlings/m²) and is still high at 0.42 seedlings/m² in belt 3.

Rowan seedlings are rare in all cover types in belt 1 and in

1 $t = 2.864$ d.f. = 98
2 $t = 2.977$ d.f. = 54

belts 2 and 3 birch seedlings outnumber rowan by 5.6 and 2.6 times respectively. Heather (belts 2 and 3) and cowberry (belt 3) with 0.22 to 0.25 rowan/m² are the favoured cover types.

10.9.4.2 Grass and juniper as habitats for tree seedlings. As above the grass cover type in belt 1 supports a lower density of tree seedlings than in belts 2 and 3. Grass plots in belt 1 are on average significantly ($P<0.01$) closer at 1.48 m to the tree canopy than in belts 2[1] and 3[2] (3.11 m and 6.93 m respectively) and grass plots stocked with tree seedlings are on average significantly more distant from the tree canopy than unstocked plots in belts 1 and 2 (Table 10.8). (No such effects are demonstrated for belt 3, but the latter is so open anyway that shading effects must be very local). On average, the grass cover type in belt 1 is also significantly ($P<0.05$) taller at 11.0 cm than in belts 2[3] and 3[4] (8.7 and 8.6 cm respectively) and widespread poaching, which can provide microsites suitable for the establishment of seedlings in otherwise unattractive habitats (Miles and Kinnaird, 1979a, 1979b), is more characteristic of belts 2 and 3 than of belt 1. These features in combination may explain the comparatively low stocking of tree seedlings in the grass cover type in belt 1.

Belt	Mean distance to tree canopy (m) stocked plots	unstocked plots	t	Probability	d.f.
1	4.33	1.28	2.288	P<0.05	27
2	4.50	2.71	2.272	P<0.05	69
3	6.00	8.07	1.091	NS	25

Table 10.8 Grass cover type, Morrone Birkwoods NNR. Comparison of mean distances from plot centre to tree canopy for 2 m² plots with and without tree seedlings in zones 2 and 4.

1 $t = 2.849$ d.f. = 98 3 $t = 2.444$ d.f. = 98

2 $t = 3.373$ d.f. = 54 4 $t = 2.362$ d.f. = 54

Although the protective functions of juniper for some herbaceous species are emphasised in the relevant literature (Huntley and Birks, 1979; Marran and Batty, 1980) it is a comparatively poor nurse for tree seedlings with only 0.14 and 0.15 seedlings/m^2 of cover type in belts 1 and 2 respectively (Table 10.7). However, seedlings establishing amongst juniper are on average significantly ($P<0.01$) taller at 10.4 cm than those in grass, heather and cowberry cover types (6.3, 6.7 and 7.3 cm respectively)[1] implying some protection from browsing (Plate 10.4). Nonetheless, the mean height of tree seedlings at 10.4 cm is substantially less than the mean height of the juniper bushes within which they are growing (69.2 cm).

10.10 Discussion, Sections 1 and 2

Substantial changes have occurred in the woodlands of the Morrone Birkwoods NNR between 1955/64 and 1975 with an overall reduction in tree cover frequency of 26.3% and a contraction in area of 18.9% (equivalent to 7.8 ha). Change was greatest in zones 2, 11, 5 and 1 but tree cover in all 11 zones was reduced. Photo surveys from 1955 and 1964 show that no measurable changes occurred in this period. Undoubtedly minor attrition occurred but this wastage was accelerated from 1966 as the result of an epidemic of defoliating Geometrid larvae (Marran and Batty, 1980). In 1978 two 'average' trees were shown to be 115 and 148 years old respectively (ibid.) and even in 1966 the birchwoods would have been old by Highland birchwood standards (J. Kinnaird, 1968, and pers. comm.). Further, in 1977 Dent (in Marran and Batty, 1980) estimated that 50% of the birch was moribund and many trees host to bracket fungi. Clearly the woods were in a state of decline and the epidemic merely the catalyst for the great changes measured in this study.

1 $F = 7.979$ d.f. = 3,183

In the absence of excessive browsing the opening up of a birchwood permits a new woodland ecosystem to develop. Whilst it has been shown that birch and rowan will establish under a thinning birchwood canopy e.g. Emberlin and Baillie, 1980; Kinnaird, 1974 (see also Plate 10.7), where a wider variety of seed was available as in the past birch probably also acted as precursor to other hardwoods and to Scots pine (Miles and Kinnaird, 1979a). However, although seedlings were present in the Morrone woods heavy browsing by red deer was preventing the development of this regeneration (Plates 10.3, 10.4) and with the parent canopy collapsing without replacement the unique woodland ecosystem was disappearing. By 1986 some 25% of the already depleted 1975 canopy would have disappeared with no replacement, and by the year 2022 only 25% of the 1975 canopy would have remained.

Although negotiations to enclose areas within deer-proof fences to permit regeneration to develop had been going on since declaration of Morrone as a NRA NNR in 1972 (E. Mathew, pers. comm.), it was not until 1978 that the first 7.05 ha were enclosed. By 1980, 10.36 ha of actual woodland had been enclosed. This represents 31.1% of the 1975 area of woodland. The NCC has also followed a policy of enclosing old woodland sites. The 12.64 ha of such sites enclosed means that 18.3% of the potentially forestable area of 126 ha below the 530 m contour is enclosed in a judicious mix of open and wooded sites. The total, however, falls far short of what might be regarded as an adequate and representative woodland ecosystem. If, for example, diversity of birdlife is considered important, Moore and Hooper (1975) recommend a minimum of 100 ha of woodland.

Comprehensive ranking procedures based on area, decrement in area and rate of loss of tree cover frequency have shows that two zones - 2 and 11 - were invariably of highest priority for enclosure.

Zones 3 and 10 were of lowest priority. Existing exclosures include the whole of zone 10 and a miscellany of other zones in which zones 2 and 11 are barely represented. With respect to the existing woodland there has been a tendency to include the most stable (though still deteriorating) woodland at the expense of the most vulnerable.

The most serious omission is undoubtedly that of zone 2. One of the main features of the Morrone woods was the sequence of woodland from 380 to 550 m altitude. The virtual disappearance of woodland from zone 2 (reduced from 7.04 ha to 1.24 ha) has effectively reduced the altitude range by 60 m to 490 m maximum (and also makes up three quarters of the total loss in woodland area). The loss is not adequately compensated for by the extension of part of exclosure 3 to 530 m altitude.

The collapse of woodland in zone 2 coupled with persistent and heavy browsing has resulted in dense sedge and grass communities forming much of the ground cover (from 30.2% to 82.6% in different belts). Although generally unsuitable for seedling establishment (Kinnaird, 1974; Miles and Kinnaird, 1979a) heavy poaching by red deer throughout the zone has produced sufficient disturbed sites for birch and rowan seedlings to establish (cf. Miles and Kinnaird, 1979a, 1979b). With additional seedlings established in the few precarious areas of heather and cowberry, enclosure now would permit natural regeneration of the site to woodland by rowan and birch seedlings which exist at a density of $0.48/m^2$. Commenting on the loss of a woodland ecosystem in Inverpolly NNR, Emberlin and Baillie (1980) note that "It will be difficult to reverse this process if species impoverishment were allowed to progress to the exclusion of most broadleaved herbs." This has, in fact, happened in zone 2. Furthermore, the reversal problem is exacerbated because part of the zone is close to the altitudinal

limit for the tree species and continuing decay and attrition below zone 2 is gradually removing the closest seed trees.

The crags at and to the west of zone 2 "... provide habitats for several species that are very rare or absent in other parts of Morrone" (Huntley and Birks, 1979). They list 11 vascular species in addition to "... a multitude of saxicolous lichens ...". Continuing loss of woodland must affect the microclimate of the crag system and subsequent changes in the flora, including the loss of species, is possible. Species intolerant of browsing such as Festuca altissima, Filipendula ulmaria, Geranium sylvaticum, Mercurialis perennis, Potentilla crantzii, and Rubus saxatilis, "... all of which invariably grow within the protection of large juniper bushes ..." (ibid.) and the rare Linnaea borealis which is also "... especially associated with juniper scrub below the crags ..." (Marran and Batty, 1980) may be at risk if changes in the woodland are such that the form and density of juniper is modified by increased trampling and/or browsing as more animals are displaced from the shelter of the contracting woodland in and about zone 2.

In 1980, 15.95 ha of exclosures were built, largely in low priority zones and including 8.42 ha of exclosure 3 in zone 1 adjacent to zone 2. Whilst wholly commendable in itself it would seem that enclosure of zone 2 and the crag system to the west was of demonstrably higher priority than the extension of exclosure 3 in zone 1. Apart from the newly enclosed part of zone 1 being comparatively stable, zone 2 is currently in a better state for regeneration. The latter has a significantly higher density of tree seedlings than zone 1 which have also established under less shaded conditions. They are therefore more likely to develop quickly following the cessation of browsing.

It is suggested, therefore, that the enclosure of zone 2 including the crag system to the west be treated as urgent and of the highest priority. In adjacent Coire nam Muic birch woodland extends to about 575 m altitude. Pears (1967, 1968) concluded that the natural timberline in the Cairngorms probably lies between 610 and 640 m altitude (the latter being scrubland in sheltered places) with a tendency towards the former. In Morrone itself tree seedlings at a density of 0.06/m² were found in a belt extending 50 m above the old timberline at 550 m altitude and occasional seedlings were located above 600 m altitude. Obviously, there are sufficient seedlings above 550 m to permit the development of at least an open scrubland and below 550 m (0.48 seedlings/m² in zone 2) to establish a woodland. In view of these observations it is suggested that the upper boundary should lie along the 620 m contour (or higher) to establish the timberline level under the prevailing climatic conditions and ultimately to demonstrate the characteristics of a natural timberline.

Finally, there is the question of whether a piecemeal approach to enclosure can do justice to the reserve and make the best use of the money available to the NCC. In addition to zone 2, zone 11 is urgently in need of full protection, and all other areas within the reserve will soon require enclosure if preservation of the existing woodland and its associated ecosystem is paramount. Depending on the line taken the whole 126 ha below the 530 m contour could be enclosed by about 5 km of fencing. To date 3.99 km of fencing encloses just 23.0 ha and another 7 ha enclosure will take the total to 5 km. The owner of the land has his own legitimate interests to protect (the woodlands provide shelter and food for the red deer which in turn provide an income for the estate) and is reluctant to alienate the whole woodland and associated open areas. It must therefore be asked

whether compulsory purchase of this small area of 126 ha could be justified in order to preserve the woodland in its entirety and ultimately to reduce the NCC's inputs. A single fence of 5 km length will free all areas from browsing by red deer and such grazing as might be required to maintain flush and other communities could be carried out by sheep confined within a portable electric fence.

In zones 2 and 4 heather was consistently well stocked with tree seedlings (0.72 to 0.94 seedlings/m^2 of heather). The amount of heather varied from 16.7% to 10.5% in belts 1 and 2 respectively to 43.4% in belt 3 and this, coupled with the variation in stocking rate and the distribution of the grass cover type, largely determined the overall stocking rate of 0.37 seedlings/m^2. Whilst not approaching the mean stocking rate of the short heather in the north-east corner of exclosure 3 (2.14 seedlings/m^2) or the comparable mean values reported by Kinnaird (1974) for small selected sites at Inverpolly NNR and Glen Feshie (2.5 seedlings/m^2) there are certainly sufficient seedlings to regenerate the woodland lost between 1964 and 1975.

Cowberry, comprising less than 7% of the overall ground cover, provided good microsites for seedlings in belts 2 and 3 (0.88 and 0.42 seedlings/m^2 respectively) with most seedlings nestled against the irregular margins of the cowberry patches. Juniper was abundant only in belt 1 where it provided almost half the ground cover, but overall was sparsely stocked with 0.14 seedlings/m^2.

Only birch and rowan occurred on the plots although infrequent bird-cherry and juniper seedlings were seen. Relative to birch, rowan occurred with increasing frequency with increasing altitude. Thus in belt 1 rowan was virtually absent whilst in belt 3 it made up over a quarter of all seedlings. Above the old timberline rowan was twice as common as birch. Overall, birch was more than 4 times as common

in belts 1 to 3 (at 0.31 seedlings/m^2) than rowan (at 0.07 seedlings/m^2).

The grass cover type in belt 1, with 0.09 seedlings/m^2, supported less than one third the number of seedlings in belts 2 and 3. Grass plots in belt 1 were closer to tree canopy than in belts 2 and 3 (hence more heavily shaded) and the grass was taller and more effective in competing with seedlings for light. Although tracked in a similar way to belts 2 and 3, belt 1 appeared to be less extensively poached than the former. It is the presence of small bared patches, often initiated by trampling, that makes some otherwise unattractive sites (including grass) locally suitable for establishment of tree seedlings (Kinnaird, 1974; Miles and Kinnaird, 1979a, 1979b). These factors in combination probably account for the differential in stocking rate of the grass cover type between belt 1 and belts 2 and 3.

Juniper bushes are clearly of significance in preventing several vascular species intolerant of browsing from local extinction (Huntley and Birks, 1979; Marran and Batty, 1980). However, juniper is a comparatively poor habitat for tree seedlings. It is probable that the massive build up of feather mosses including Hylocomium splendens and Pleurozium schreberi, which characterises the bases of old juniper bushes at Morrone, is too deep for germinating seedlings to establish in and emerge from (Miles and Kinnaird, 1979a). Desiccation, even during short dry spells, is likely to cause much mortality and in this context Kinnaird (1974) noted that moss carpets supported high seedling densities "... wherever flushing occurred ...". Although seedlings that do establish in juniper are on average taller than other seedlings they rarely approached the height of the nurse bushes and substantial selective browsing of tree seedlings obviously occurs. Nonetheless, they are well suited to exploit any cessation of browsing by virtue of their size and well-developed root system.

SECTION 3 - INVERPOLLY NNR WOODLANDS

The baseline photo survey for the Inverpolly woodlands flown in 1960 coincides almost exactly with the year of declaration as a NNR in 1961. Thus all measured changes have occurred during NCC stewardship although the conditions for many of the changes developed prior to NCC's involvement.

At least one woodland from each of the 3 sections has been surveyed. They include Loch Veyatie and most of Loch an Doire Dhuibh woodlands (Drumrunie), Loch Doire na h-Airbhe and Stac Pollaidh woodlands (Polly) and Rhegreanoch woodlands (Eisg brachaidh). Their location is shown in Fig. 10.2. Photo cover dating from 1980 was available for the Drumrunie section but for Polly and Eisg brachaidh the most recent cover dated from 1975. Both these photo surveys were used (Table 10.1).

The indifferent quality of some photographs and the small scale (1:26000) made precise measurement of small changes uncertain and to this extent the measurements are an estimate of the real changes. As in 10.2 new openings in the canopy less than about 35 m^2 could not always be located at this small scale and the measurement of changes in the canopy is therefore conservative. For the same reasons no attempt was made to re-draw the woodland boundaries as at 1975 or 1980. Measurement of change is based entirely on observed changes in tree cover frequency.

10.11 Changes in Tree Cover

The Rhegreanoch woodlands (Fig. 10.3) include the only unenclosed stands in which there has been an increase in tree cover. The maximum

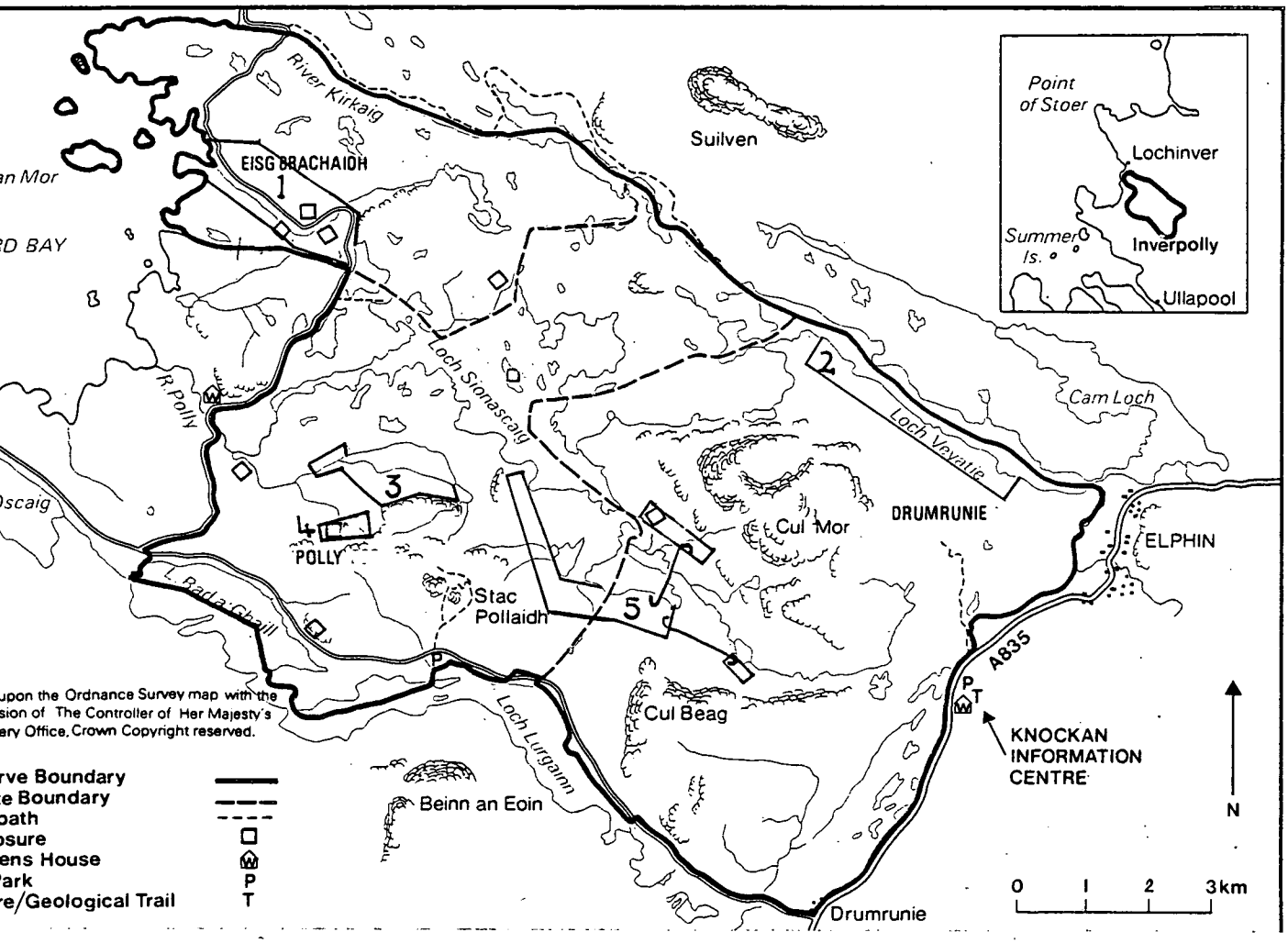


Fig. 10.2 Woodlands surveyed in Inverpolly NNR. 1 - Rhegreanoch. 2 - Loch Veyatie. 3 - Loch Doire na h-Airbhe. 4 - Stac Pollaidh. 5 - Loch an Doire Dhuibh.

increase was in stand R6 (+14.30%) with a mean increase for the whole woodland (14 stands) of 3.29% in the period 1960 to 1975. There were no measurable changes in woodland boundaries but rather increases in cover within the 1960 boundaries. The total area drawn as woodland in 1960 (Fig. 10.3) was 54.87 ha.

In the Loch Veyatie woodlands (Fig. 10.4) only the small stand V5 maintained its condition between 1960 and 1980. Tree cover in the other seven stands decreased by 5.6% (V2) to 31.0% (V4, Plate 10.5) and in the major area of woodland (V7) by 22.9%. Deterioration was more severe towards the western end of the latter stand. The overall decrease in tree cover over the 20 year period was 17.8%, equivalent to the loss of 5.28 ha of closed canopy woodland. The total area drawn as woodland in 1960 was 37.63 ha.

Devastating decreases in tree cover have occurred in the small residual woodlands about Loch Doire na h-Airbhe (Fig. 10.5) on Polly Estate. Decreases in tree cover in individual stands range from 29.3% (A4) to 66.7% (A1, Plate 10.6) between 1960 and 1975. The mean loss in tree cover was 42.8% which is equivalent to the loss of 8.06 ha of closed canopy woodland out of a 1960 total of 18.83 ha of tree cover. The area drawn as woodland in 1960 was 23.00 ha.

Tree cover in the small Stac Pollaidh woodlands extending to 11.99 ha in 1960 (Fig. 10.5) decreased by 15.5% in 15 years. The tiny outlier (S2) now consists of a few bent, wind-torn trees.

The small stands D10 and D12 about Loch an Doire Dhuibh (Fig. 10.6) have lost 44.4% and 30.6% of their tree cover respectively, between 1960 and 1980. The two major woodlands, D5 and D13 have lost 14.9% and 9.7%, of their cover respectively. The average loss in tree cover has been 14.3% in the 1960 woodland area of 36.51 ha.

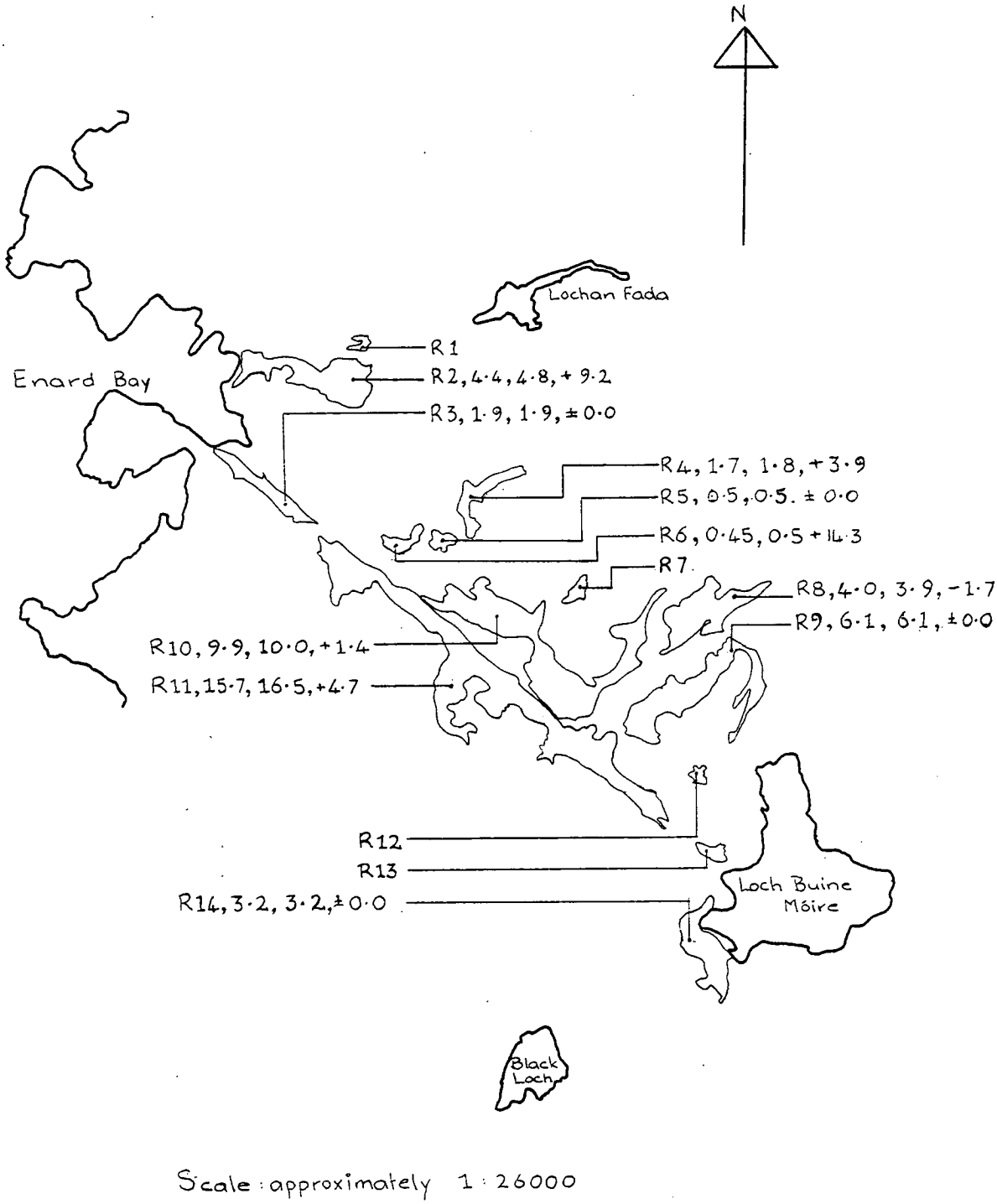
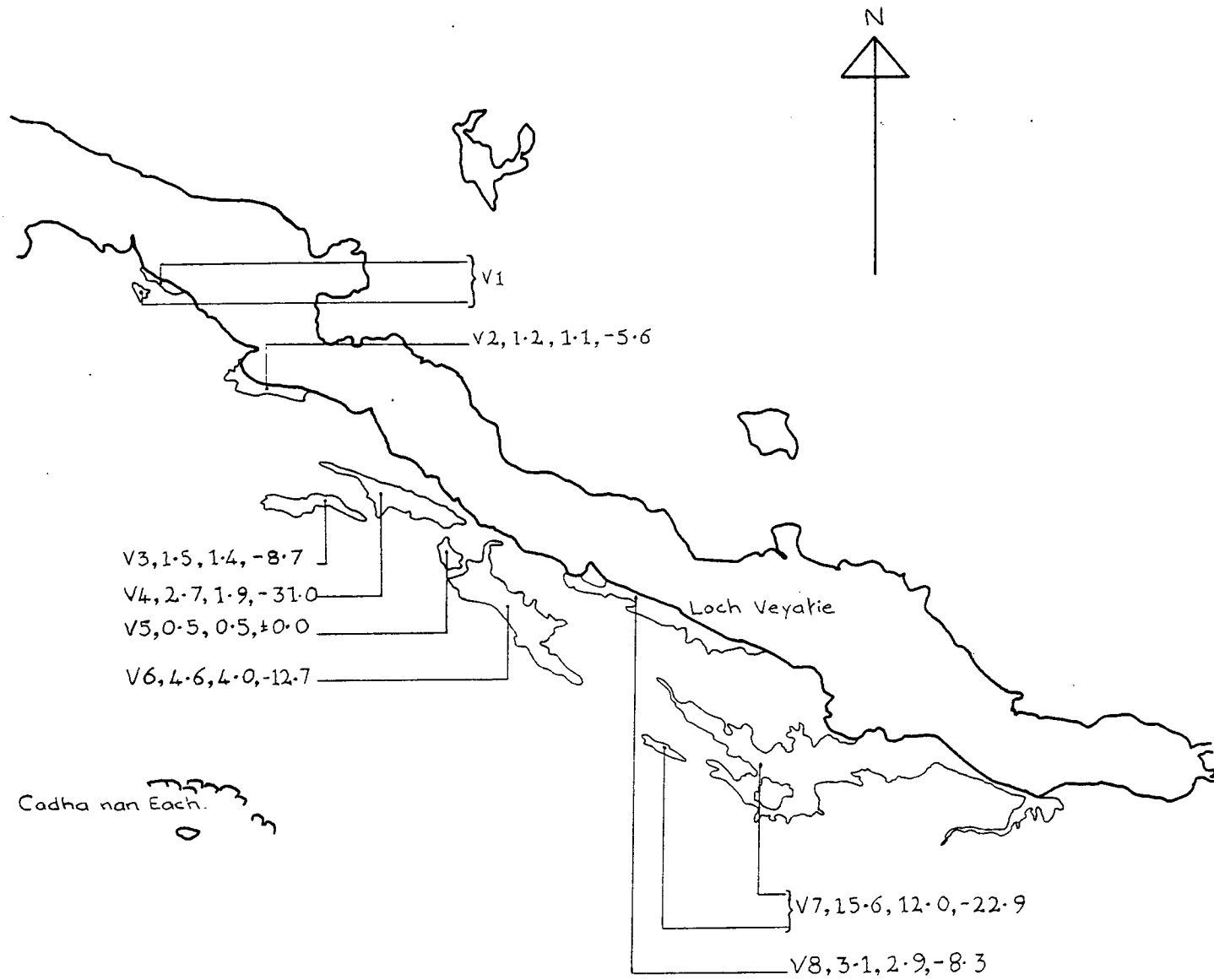


Fig. 10.3 The Rhegreanoch woodlands (R1 to R13) in Inverpolly NNR with boundaries as at 1960. Notation is stand number, tree cover (ha) in 1960, tree cover (ha) in 1975, percent change relative to 1960 area. All values rounded. Separate values are not shown for wooded areas less than 0.5 ha in area in 1960. No corrections have been made for photographic distortion.



Scale: approximately 1:25500

Fig. 10.4 The Loch Veyatie woodlands (V1 to V8) in Inverpolly NNR with boundaries as at 1960. Notation and specifications as for Fig. 10.3 except that second measurements of tree cover are at 1980, not 1975.

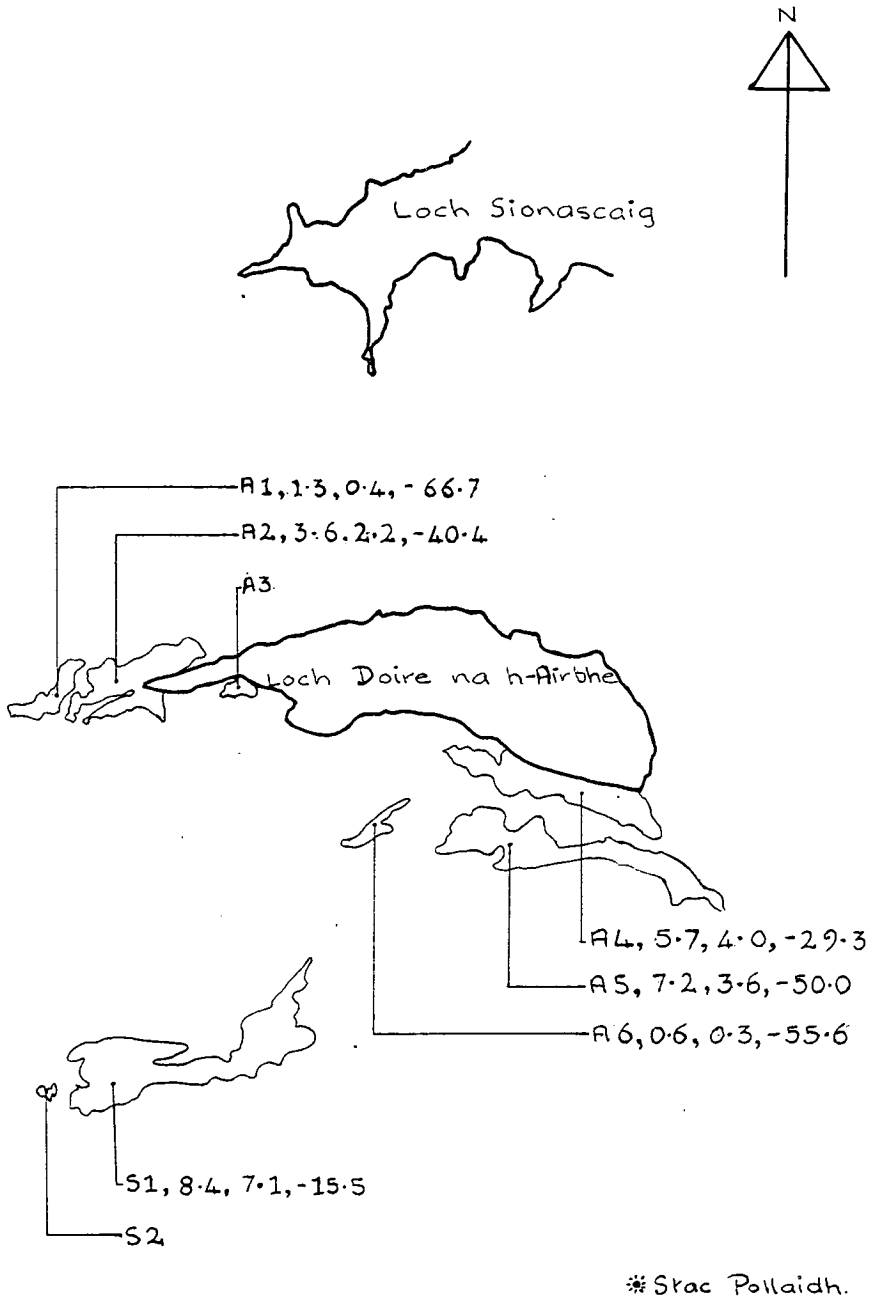


Fig. 10.5 The Loch Doire na h-Airbhe (A1 to A6) and Stac Pollaidh (S1, S2) woodlands in Inverpolly NNR with boundaries as at 1960. Notation and specifications as for Fig. 10.3

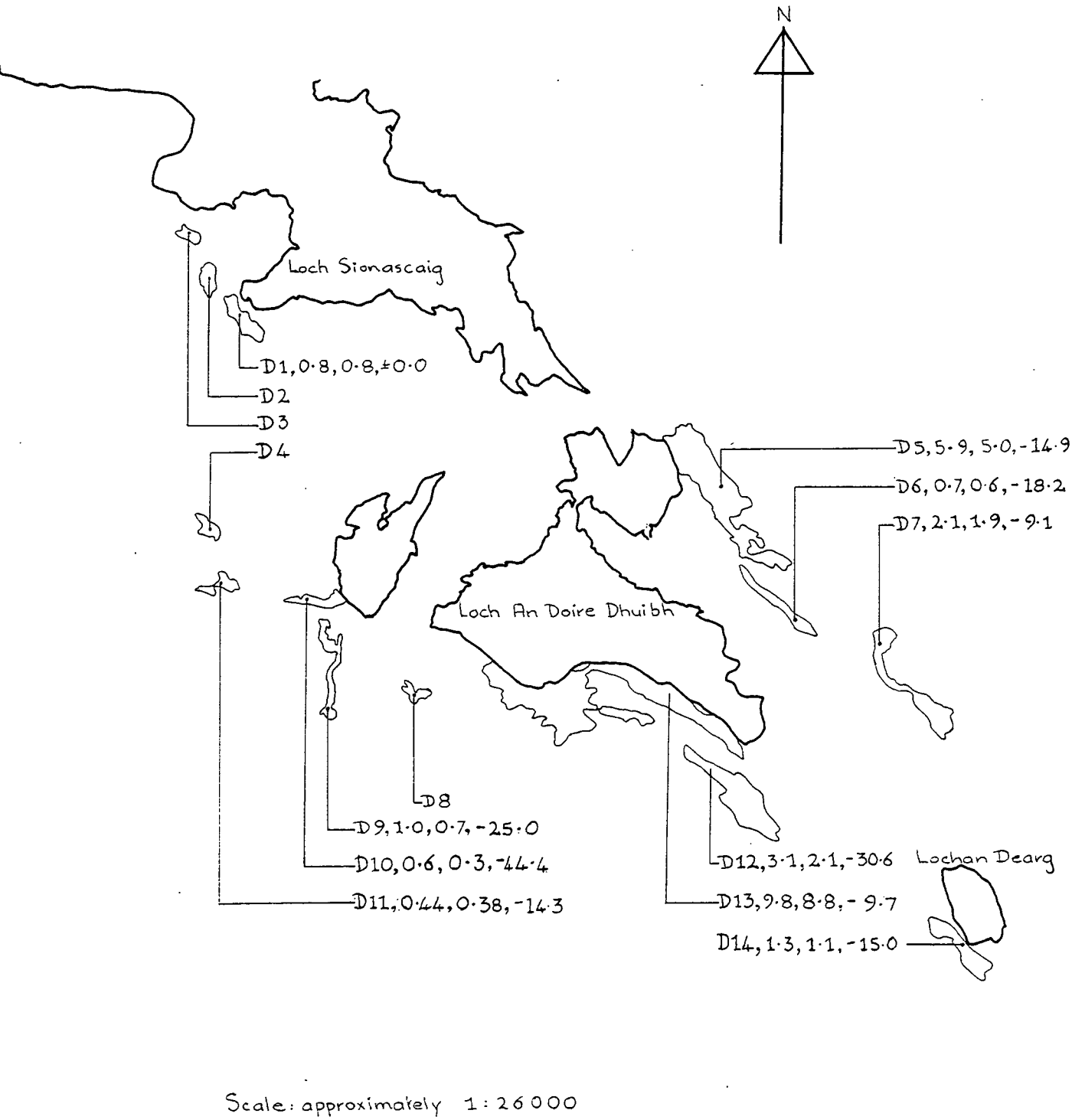


Fig. 10.6 The Loch an Doire Dhuibh woodlands (D1 to D14) in Inverpolly NNR with boundaries as at 1960. Notation and specifications as for Fig. 10.3 except that second measurements of tree cover are at 1980, not 1975.

10.12 Predicted Changes in Inverpolly Woodlands

In Table 10.9 possible future patterns of change in the five Inverpolly woodlands are shown. The predicted values are based on the average performance of each woodland over the past 15 (or 20) years. Values are derived on the basis that there are no changes in land use or woodland management.

To relate the changes to future management of the reserve values are presented for 1986 when the current NRAs for Inverpolly NNR expire, and for 2011 in which year the renewed NRAs will expire if they are renewed in 1986 for 25 years. Even at the most conservative rate (using the average rate for the whole woodland) Loch Doire na h-Airbhe woodlands would lose some 75% of their already diminished 1980 canopy within 37 years and only 2.82 ha of a 1980 total of 8.94 ha of tree cover would remain by 2011. If other stands (and other woodlands) declined at the rate of stand A1 they would lose 25%, 50% and 75% of their tree cover in 6, 15 and 30 years respectively, from 1980. Average and maximum rates of change were similar for Loch an Doire Dhuibh and Loch Veyatie woodlands implying the loss of 50% of existing tree cover within 38 years and 75% within 76 years. The measured change in the Stac Pollaidh woodland was less than for the other woodlands but 50% of tree cover is predicted to disappear within 54 years. However, in the longer term at least these estimates are clearly conservative as they approach, and sometimes exceed, the life span of birch in the Highlands and some increases over historical rates of change may be expected (see 10.16). A small increase in tree cover is predicted for the Rhegreanoch woodlands and by 2011 it may have increased from 51.25 ha in 1980 to 54.79 ha, possibly more.

Woodland	Rate of change in tree cover frequency (percent per annum) Average rate for whole woodland	Rate for fastest changing stand in each woodland	Rate for stand A1 Loch Doire na h-Airbhe	Area of tree cover (ha) 1975	1980	1986	2011	Number of years from 1980 until nominated proportion of tree cover disappears 25%	50%	75%
Loch Doire an h-Airbhe	-3.66			10.77	8.94	7.15	2.82	8	19	37
		-4.52	-4.52		8.55	6.48	2.04	6	15	30
Loch an Doire Dhuibh	-0.77				24.50	23.39	19.28	37	88	176
		-1.81				21.95	13.91	16	38	76
			-4.52			18.57	5.85	6	15	30
Stac Pollaidh	-1.27			7.06	6.63	6.14	4.46	22	54	108
		-1.27			6.63	6.14	4.46	22	54	108
			-4.52		5.61	4.25	1.34	6	15	30
Loch Veyatie	-0.98				24.35	22.95	17.95	30	70	140
		-1.83				21.79	13.72	16	38	76
			-4.52			18.45	5.81	6	15	30
Rhegreanoch	+0.22			50.70	51.25	51.92	54.79			
		+0.59			52.21	54.09	62.67			

Table 10.9 Predicted changes in the area of tree cover for five Inverpolly woodlands.

Notes: 1. For Loch Doire na h-Airbhe, Stac Pollaidh, Rhegreanoch woodlands there was no 1980 photo cover. The 1980 values are derived from the 1975 measurements at the nominated rate of change.
2. 1986 is the year in which the current NRAs expire.
3. 2011 is the year in which the new NRAs will expire if renewed for a 25-year term.

10.13 Existing Exclosures

By 1981, 9 exclosures had been completed on Inverpolly NNR (Fig. 10.2; Table 10.10). Five lie within the woodlands studied and are numbered 1A, 1B, 1C, 4, 5 to correspond with the relevant woodlands in Fig. 10.2. The total area enclosed was 33.5 ha of which about 19.6 ha is wooded. Of the 164 ha of woodland surveyed 15.0 ha (9.2%) is enclosed, of which at least 4.9 ha is adjacent open moorland. No part of Loch Doire na h-Airbhe or Loch Veyatie woodlands has been enclosed although some of the most rapidly deteriorating individual stands (A1, A2, A5, A6, V4) occur in these woodlands. The former also shows by far the greatest average decline in tree cover. That area of Loch an Doire Dhuibh woodland that has been enclosed (part D5) is no less stable than areas left unprotected.

Spectacular responses to enclosure have been obtained in parts of the Rhegreanoch and Millwood exclosures. In the Millwood exclosure (Plate 10.7) two transects two metres wide and totalling 175 m in length with contiguous 1 m x 2 m plots (a 1.75% sample of the exclosure) gave a stocking rate on 2 m^2 plots of 35.4%. Rowan was present on 27.4% of plots, birch on 10.3% and *Salix* sp. on 4.6%. Equivalent densities were 2943, 686 and 229 s p ha respectively for saplings over 30 cm tall (many were over 5 m tall and 12 cm diameter). A portion of each transect passed through gaps which were made in 1964 by slightly enlarging natural gaps (J. Kinnaird, pers. comm.). Prior to enclosure the ground was shorn of all vegetation more than a few centimetres tall (cf. Plate 10.8) by the grazing of sheep, cattle and red deer.

Exclosure	1A	1B	1C	2	3	4	5	6	7
Site	Rhegreanoch	Rhegreanoch	Rhegreanoch	Millwood	Oakwood	Stac Pollaidh	Doire Dhuibh	Eilean Mor	Cean o'Bheigh
Erected	1964	1964	1964	1964	1971	1978	1975	1973	1978
Treatment	Burning Draining Fertilising Planting: Birch Willow	Burning Draining Fertilising Planting: Birch Willow		Tree-felling Planting: Oak	Planting: Scots pine (300)	Planting: Scots pine Rowan	Planting: Scots pine (400) Hazel (100)		Planting: Scots pine (1000) Oak (6) Hazel (150)
Area (ha)	3.74	1.18	3.15	1.97	4.72	1.0	5.90	5.90	5.90

Table 10.10 Deer-proof exclosures on Inverpolly NNR. Modified, after Collier, R.V., 1979 (unpubl.). Exclosures 1A, 1B, 1C, 4 and 5 are located within woodlands 1, 4 and 5 respectively (Fig. 10.2) which are included in the photo interpretation exercise.

SECTION 4 - RASSAL ASHWOODS WOODLAND

Three photo surveys - 1948, 1959, 1980 (Table 10.1) - were analysed for changes to the woodland. The 1980 photo cover was of inferior quality and provided only about 75% stereo cover. The 1959 survey equates closely with declaration of the area as a NNR in 1956. In the interpretation scattered trees were ignored and two stands - west and east (Fig. 10.7) - were studied (of 1.47 ha and 14.12 ha respectively). The estimated total wooded area of the reserve, including the gorge parallel to the south-east boundary which was excluded from the interpretation for technical reasons, was 20.20 ha.

There was no change in the outline of the stands over the period studied although there were changes in tree cover. The only possible question was whether, in 1980, the west block could still be called 'woodland'.

10.14 Changes in Tree Cover

Woodland zone	Percent tree cover frequency in years			Corresponding percent reduction in tree cover frequency for period:		
	1948	1959	1980	1948-59	1960-80	1948-80
West	36.99	33.35	23.81	11.11	29.17	37.04
East	51.36	48.00	40.92	6.39	14.84	20.28
TOTAL	50.00	46.87	39.22	6.72	15.79	21.45

Table 10.11 Changes in woodlands in Rassal Ashwoods NNR between 1948 and 1980.

Table 10.11 demonstrates a continuing decline in tree cover frequency between 1948 and 1980. Notable is the comparatively large reduction in tree cover frequency (from 33.35% to 23.81%) in the small west

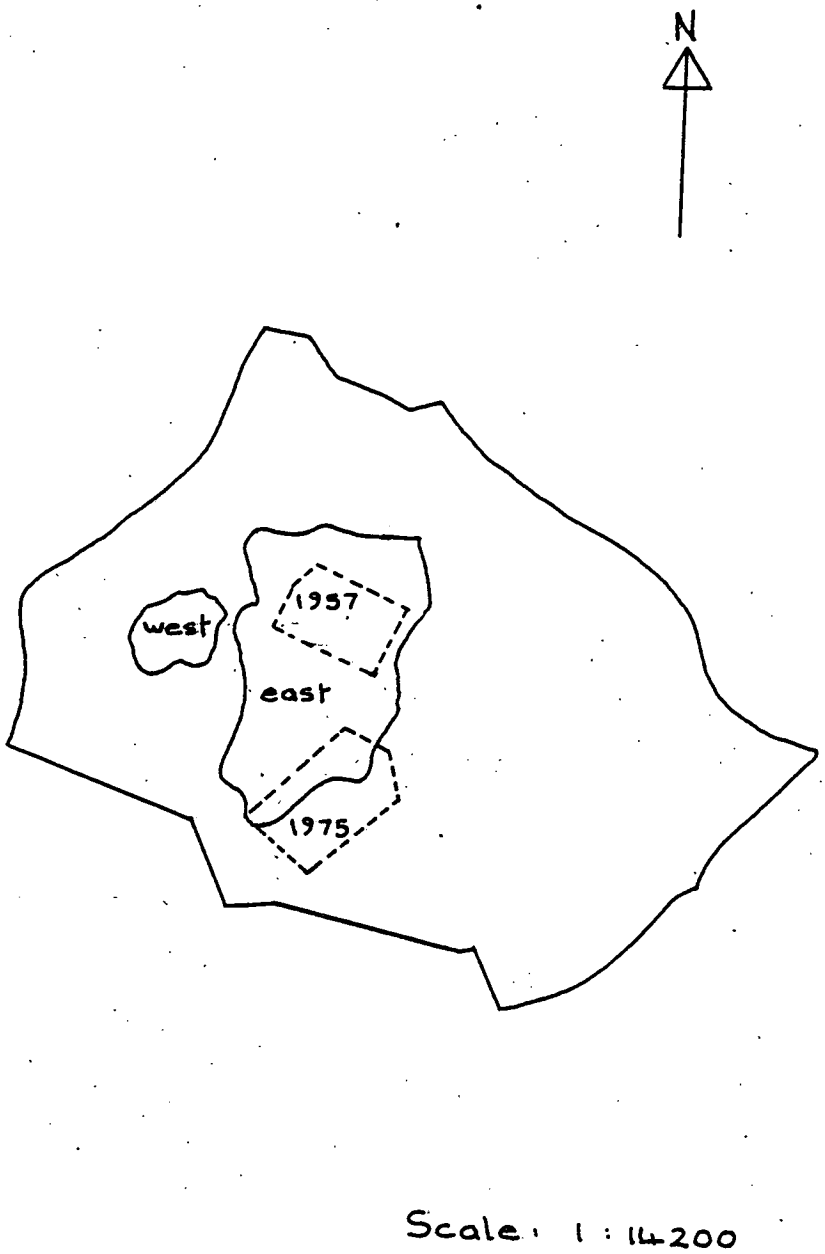


Fig. 10.7 Rassal Ashwoods NNR showing west (1.47 ha) and east (14.12 ha) stands of woodland. The approximate position and size of the two exclosures, built in 1957 and 1980, are shown.

stand between 1959 and 1980. This equates to a 29.17% reduction in tree cover for the period. Overall, the west stand has opened up to a greater extent than the east stand with a 37.04% compared to 20.28% decrease in tree cover frequency over 32 years.

The percent annual losses relative to tree cover for the stands at the beginning of each period are shown in Table 10.12. In each period the annual rate of loss of tree cover in the west stand was almost twice that in the large east stand. Thus, for the 1948-59 period the percent annual losses for west and east stands were 1.00% and 0.58% per annum respectively, for the 1960-80 period 1.38% and 0.71%,and for the 1948-80 period 1.15% and 0.63% per annum respectively.

Woodland zone	Percent per annum loss in tree cover for period: 1948-59	1960-80	1948-80
West	1.00	1.38	1.15
East	0.58	0.71	0.63
TOTAL	0.61	0.75	0.67

Table 10.12 Rate of change (% per annum) in tree cover in west and east stands, Rassal Ashwoods NNR.

10.15 Existing Exclosures

Two exclosures have been built in Rassal Ashwoods NNR (Fig. 10.7). The first, in 1957, encloses 2.8 ha and the second, in 1980, some 3.7 ha. There has been a spectacular response within the 1957 exclosure (Plate 10.8). Contiguous 1 m x 2 m plots along 182 m of transects (a 1.32% sample of the exclosure) showed 32.4% of the 2 m^2 plots to be stocked with saplings over 30 cm tall. Hazel (1154 s p ha), rowan (714 s p ha) and ash (440 s p ha) occurred most frequently. Hazel, rowan and ash occurred on 17.6%, 12.1% and 6.6% of plots respectively.

Individual saplings were up to 6 m tall and 12 cm diameter.

The second exclosure is part open grassland (where some ash seedlings have been planted) and part woodland.

10.16 Discussion, Sections 3 and 4

Of the five woodlands investigated in Inverpolly NNR only one - Rhegreanoch - showed an increase in tree cover frequency since 1960. The increase was 3.3%. The four others showed substantial decreases in tree cover frequency between 1960 and 1975 (or 1980 for two woodlands on Drumrunie section). The woodlands studied cover the range of tenures and land uses on Inverpolly NNR and additional field inspections indicate that the results are representative of the reserve.

Only in the Loch Doire na h-Airbhe woodland was there a substantial contraction in the woodland boundaries e.g. Plate 10.6. In other areas it was mostly a case of general attrition continuing the process of thinning out that began long before the NCC had any influence over the management of the area. For the Stac Pollaidh, Loch Veyatie and Loch an Doire Dhuibh woodlands the deterioration has been similar with a range of 14.3% to 17.8% decrease in tree cover but for individual stands within the woodlands the changes have been more variable. Decreases range from zero to 31.0% in Loch Veyatie stands and from zero to 44.4% in Loch an Doire Dhuibh stands (all between 1960 and 1980). In the Loch Doire na h-Airbhe woodland the deterioration has been more sudden and drastic. Between 1960 and 1975 individual stands have lost between 29.3% and 66.7% of their tree cover, and the average loss was 42.8%. Emberlin and Baillie (1980) classed over half the Stac Pollaidh woodland as "discontinuous moribund Betula species" which "... appear to be in a state of

transition to a moorland community ..." and an increase in the rate of deterioration is possible. This is in line with Kinnaird's (1968) statement that birchwoods terminate "... in a decline that is commonly rapid due to fungal decay". Kinnaird (1968) and Miles (1981) have both remarked on the even-agedness of most stands of birch and logically the rate of decline in a mature even-aged stand must increase as the stand begins to open up. Local death and windfall exposes previously sheltered trees to the effects of wind and storm, falling trees snap branches off neighbouring trees to provide entry points for pathogens and the fallen trees themselves provide breeding grounds for pathogens. For these reasons it may be that, depending on the position in the cycle of decay, the predicted rates of loss based on historical precedents could under-estimate some future rates of loss. Furthermore, it is not possible to account for catastrophic loss, as might occur in mature stands as the result of exceptional snowfall, or from epidemics of pathogens, e.g. the epidemic of Geometrid larvae in birchwoods on Morrone Birkwoods NNR in 1966 or the epidemic of pine beauty moth (Panolis flammea) on lodgepole pine in Sutherland in 1978 and 1979 (Forestry Commission, 1980). If the rate of loss of tree cover of the worst affected stand in the whole survey (stand A1, annual rate of loss of tree cover 4.52%) became general woodlands would lose 25%, 50% and 75% of their tree cover within 6, 15 and 30 years respectively. Although some stands may approach this rate it is more likely overall losses will continue at around 2% per annum indicating a 25% decrease in tree cover frequency within 15 years and 50% loss within 35 years.

As for Morrone Birkwoods, this opening up is to be expected in an essentially seral species but what is again disturbing is the virtually complete lack of replacement. Graphic evidence of the

resilience of at least some of these woodlands is provided by the Rhegreanoch and the Millwood exclosures (Plate 10.7). In the latter after 16 years of protection from browsing, regeneration, principally of rowan, is fully established at 3858 s p ha. In their study of regeneration in Stac Pollaidh and the south-east end of the Loch Veyatie woodlands, Emberlin and Baillie (1980) found that "... tree seedlings are frequent at both sites ..." and in Stac Pollaidh 25% of 1 m² quadrats were stocked with birch and 50% with rowan seedlings. However, almost all seedlings were less than five centimetres tall although canopy conditions were not limiting for growth to the sapling stage. The lack of effective regeneration was, in the authors' opinion, due mainly to fire (outside the woodland) and grazing. Moribund trees were recorded as widespread with the inevitable result that "... the remaining woods will contract, the canopies will become patchy". As this study shows, the process is well in train.

Of the total of 164 ha of woodland actually surveyed only 10.1 ha (plus 4.9 ha of adjacent moorland) have been enclosed. In the whole of the reserve with 354 ha of woodland (from survey data supplemented by data from current Ordnance Survey maps) only 19.6 ha of woodland (5.5%) is enclosed (plus 13.9 ha of adjacent moorland). Because all the woodlands (except Rhegreanoch where three of the nine existing exclosures are sited) are visibly deteriorating there is little point in attempting to define priority areas. All are in need of protection from deer browsing and/or sheep grazing if woodlands are to remain a significant element in the Inverpolly ecosystem. This was foreseen in 1961 when the woodland management plans in the AMPs for Eisg brachaidh and Polly Estates list as one of three primary requirements "The limitation of grazing pressure on the woodland areas ...". Management "... should aim ... at ... ensuring a steady supply of

young trees ..." and this was to be achieved by a system of permanent and rotational enclosure. Owners were thus informed of the NCC's intentions and although the areas envisaged even at that time were small (not to exceed 32 ha at any one time on each section) they have not even yet been reached.

There is at present a plan to establish a 200 ha exclosure in the south-east corner of Drumrunie section to be jointly financed by the NCC and the Estate (Collier, 1979). Progress has been slow and troubled and by mid-1982 only about a third of the 6000 m of fencing required had been erected. With the Estate's interest in the exclosure it is to be opened up to very large numbers of red deer once adjudged 'regenerated' (A. Scott, pers. comm.). This is an ambitious and worthy project but there would seem to be some scientific and economic arguments for siting such an exclosure elsewhere. Thus, although there is locally abundant seedling regeneration of birch currently being held in check by red deer, almost all the woodland proper has disappeared and with it the associated fauna and flora (particularly epiphytic mosses, lichens and liverworts which depend on the humid conditions provided by a closed woodland canopy). It may prove more difficult to win back the latter than the woodland itself (cf. Emberlin and Baillie, 1980). Further, a much larger area - up to 400 ha - could be enclosed with the same length of fence if the Loch Veyatie woodlands and adjacent moorlands up to 320 m altitude were to be enclosed (using the loch as one of the long sides). Miles (1981) establishes that moorlands such as these are 'degraded' and 'biologically impoverished' and in a large moorland (but potentially mixed habitat) reserve such as Inverpolly NNR there are arguments for attempting at least minimal extension of some of the existing residual and declining patches of woodland. Woodlands and moorland adjacent to

Loch an Doire Dhuibh and, to a lesser extent, Loch an h-Airbhe lend themselves to large scale and comparatively economical enclosure. Unfortunately, the possibility of fencing off and thereby isolating, at comparatively small cost, the Eisg brachaidh peninsula from sheep and deer has been lost with the private construction, in 1981, of a deer fence parallel to the Kirkaig road. By excluding deer it is intended to intensify sheep grazing on the peninsula and to use at least part of the area as a lambing park (A. Scott, pers. comm.). Although the NCC will fence off the existing woodland within the area with a sheep fence this intensification of stock management must be regarded as a retrograde step for the reserve ecosystem as a whole.

The three Inverpolly NRAs are due to be re-negotiated in 1986. If this area is to continue to function in the role for which it was originally selected, i.e. as a mixed habitat north-west Highlands ecosystem (Campbell, 1967; NRAs/AMPs) then substantial changes in the management of the birchwoods are essential. With major changes in the stocking rates of sheep and deer unlikely, extensive enclosure of the threatened woodlands is necessary to preserve the scientific, wildlife and amenity values of the reserve.

The changes in the woodlands of Rassal Ashwoods NNR parallel the changes at Inverpolly with a 20.3% decrease in tree cover in one stand and a 37.0% decrease in the other. However, the 1957 exclosure in Rassal Ashwoods demonstrates in the same spectacular way as the oldest Morrone Birkwoods and Inverpolly NNR exclosures, the regenerative capacity of the woodland when protected from browsing and grazing. The overall stocking rate in the 2.8 ha exclosure is 2363 s p ha of which 79.1% is hazel and rowan. A similar response may be expected in the wooded part of the second exclosure of 3.7 ha

erected in 1980.

In a useful NRA/AMP the NCC in effect negotiated the right to regenerate the whole of the west and east stands by 1980. Thus, up to 4 ha were to be enclosed in 1956 followed by another 4 ha when the former had "proven its worth" (by about 1960). The remaining area of woodland was to be fenced when the second area was regenerated and opened up to stock (sheep). After 20 years the second exclosure would no doubt have been sufficiently regenerated to open it up to sheep although naturally it would have been a pity to do so. Nevertheless there was the opportunity to have enclosed the whole woodland by 1980, with the first and last areas being still enclosed (11 ha in total) and 4 ha regenerated and opened up. In addition up to 4 ha of open grassland was permitted to be enclosed at any time. The total area enclosed by 1980 - some 6.5 ha - does not bear comparison with what was possible under the agreement. For an area in which the first objective of management is "To perpetuate and if possible extend the existing ashwood and its characteristic ground flora ..." (McVean et al., 1959) and one which responds so well to enclosure it has been a disappointing performance. In absolute terms the tiny over-grazed ash remnant, subject to continuing windthrow and general attrition, is more at risk than Scots pine woodland in nearby Beinn Eighe NNR where 366 ha of mainly moorland have been enclosed by the NCC for regeneration to Scots pine since 1951. Rassal Ashwoods deserves more attention than it has thus far been accorded.

In a broader sense, enclosure of a small relict woodland like Rassal Ashwoods is merely an expedient way of preventing its demise. Re-establishment of the woodland on a more secure basis is biologically desirable and as the whole reserve is only 85 ha in extent, and the vegetation outside the woodland and gorge "... is of little interest

in its present state ..." (McVean et al., 1959; Brown and Cross, 1980) it would not seem unreasonable to press for enclosure of the whole reserve. With the retiral of the incumbent tenant in 1980 and the re-letting of the grazing lease (D. MacClennan, pers. comm.) the NCC would seem to have missed an opportunity to purchase the relevant grazing rights.

In conclusion, the management of these hardwood woodlands in Morrone Birkwoods, Inverpolly and Rassal Ashwoods NNRs leaves no room for complacency. It would appear that no single factor is responsible for the continuing decline of the woodlands although the fact that they are privately owned and, over part of Inverpolly NNR and in Morrone Birkwoods NNR, revenue producing in that they provide shelter and browse for large numbers of red deer, obviously biases the owners' attitude to their total protection. But financial stringencies within the NCC (which means that cash for costly deer fences must be sparingly allocated), lack of clear long-term plans for the management and regeneration of the woodlands in these NNRs exacerbated by the lack of prescriptive management plans have all played their part. Few would disagree with Kerr (1981) who, when commenting on the NCC's responsibility for the conservation of woodlands, noted that "... it must be clear to all that they are failing to cope with the protection of even the main nationally important sites."

Plate 10.1 Deteriorating birch woodland in lower part of zone 1, Morrone Birkwoods NNR. Note thin crowns of residual trees, frequent large canopy gaps and open juniper understorey with current years growth often browned off. Percent tree cover in 1955/64 was 54.2%; in 1975, 34.8%. There is a total absence of birch or rowan saplings in the replacement tiers. Many other un-enclosed areas of Morrone Birkwoods have a similar appearance.

Plate 10.2 Part of zone 2, Morrone Birkwoods NNR, 60 m below the timberline as at 1980. Up until 1964, at least, this area was fully wooded with a tree cover frequency of 37.4%. Without enclosure rehabilitation of this area is impossible under current conditions of management. Sufficient seedlings are present to re-afforest the area if deer are excluded from the site.

Plate 10.3 Area enclosed in 1978 in north-east corner of exclosure 3, Morrone Birkwoods NNR. This photo, taken in July 1980, shows seedlings (often >10/m²) emergent over the heather matrix and up to 33 cm tall. Mean seedling density over the 1.5 ha area is 2.14 seedlings/m². Mean top height of heather is 18.9 cm and of seedlings 16.0 cm, but 41.0% of seedlings overtop the heather.

Plate 10.4 Under a heavy browsing regime the tallest seedlings develop under the tallest cover and juniper bushes, although not particularly good microsites, do provide protection for seedlings developing within their cover. This rowan seedling, well established but repeatedly browsed back to 25 cm in height was enclosed in 1978 and grew 45 cm, to 70 cm in height, in two growing seasons.

Plate 10.5 Stand V4, Loch Veyatie woodland, Inverpolly NNR. Tree cover in this stand has declined by 31.0% between 1960 and 1980. Grazing by sheep ceased in 1972 but browsing by deer still prevents the development of regeneration. Photo shows part of a previously wooded gap (30 m x 20 m) with attrition continuing about the wooded margins.

Plate 10.6 Stand A1, Loch Doire na h-Airbhe woodland, Inverpolly NNR. This stand collapsed between 1960 and 1975 and browsing by red deer has prevented any replacement. If enclosed in the 1960s it would now resemble woodland in the nearby Millwood exclosure (Plate 10.7). Tree cover in this stand has declined by 66.7% and by 42.8% in the woodland as a whole.

Plate 10.7 Millwood exclosure, Inverpolly NNR (adjacent to River Polly below Loch Doire na h-Airbhe woodland, Fig. 10.2). Enclosed in 1964, with three small natural gaps artificially enlarged, the whole of this woodland is now regenerated. The main species are rowan, birch and Salix sp. at 2943, 686 and 229 s p ha (over 30 cm tall), respectively. Prior to enclosure the ground flora was grazed down to a few centimetres in height (J. Kinnaird, pers. comm.).

Plate 10.8 North-east corner of 1957 exclosure, Rassal Ashwoods NNR. Inside the deer-proof fence rowan, ash, hazel and birch saplings over 30 cm tall are found at densities of 714, 440, 1154 and 55 s p ha, respectively. Outside the fence there is no developing regeneration. Further, the over-mature ash outside the exclosure are being increasingly isolated as windfall occurs (left middle distance) and the woodland habitat is disappearing.

CHAPTER 11

THE REGULATION OF PEST AND GAME SPECIES ON NNRs

SECTION 1 - PEST CONTROL

The destruction of, or right to destroy, those animals and birds variously referred to as pests, vermin and predators (hereafter "pests") occurring on NNRs is the subject of this section. The NCC obviously discourages the killing of some predators (especially the illegal killing of birds of prey which still continues, e.g. Cramp, 1977; Prestt, 1977; Nelson, 1980; RSPB, 1982) but as Table 11.2 shows many other predatory species may be destroyed, with the NCC's acquiescence, on NNRs. Conclusions about the NCC's attitudes to pest control are drawn from an examination of NRAs and from the NCC's performance in the management of NNRs.

11.1 Method

Information on pest species lists and on requirements for pest control within NNRs has been drawn from management plans and from the NRA/AMP covering each reserve/section. Data relating to pest destruction and to presence or absence of species on each habitat-section were obtained from structured interviews (as per Appendix 3A) with reserve wardens and from agricultural tenants, sporting tenants, gamekeepers, factors and owners. Presence/absence data was supplemented by reference to reserve species lists and general literature. The relevant tables in this chapter have been constructed from these data.

Respondents familiar with the field situation were asked to estimate the abundance of each pest species according to the criteria in Table 11.1. These criteria are necessarily broad but worked exceptionally well in the field.

Abundance rating	Specification
Rare	Hardly ever seen on Reserve.
Occasional	Individuals or small groups observed on odd occasions.
Common	Individuals or small groups seen on most days in field.
Very common	Many individuals or large flocks or groups seen each day in the field.

If an animal is seasonal in occurrence, answer with respect to "in season" period.

Table 11.1 Abundance ratings and specifications for populations of pest and game species on NNRs.

For the conspicuous animals including fox (Vulpes vulpes), carrion crow (Corvus corone corone), hooded crow (C. corone cornix), jackdaw (C. monedula), greater black-backed gull (Larus marinus), jay (Garrulus glandarius), grey squirrel (Sciurus carolinensis), red squirrel (S. vulgaris), brown hare (Lepis europaeus), blue hare (L. timidus) and rabbit (Oryctolagus cuniculus) there is no reason to doubt the accuracy of the abundance ratings. However, for secretive species including the brown rat (Rattus norvegicus), mink (Lutreola lutreola vison), stoat (Mustela erminea) and weasel (M. nivalis) it is more difficult to obtain a true picture of their abundance and wardens were sometimes less certain as to whether these species were destroyed by keepers, tenants and owners. Data for such species should be accepted with caution.

Respondents were also asked whether any species not on the pest list was taken but were generally reluctant to divulge potentially

inflammatory information. However, golden eagles (Aquila chrysaetos) have apparently been taken on one reserve recently, buzzards (Buteo buteo) on another and wildcats (Felis sylvestris grampia) - not on the pest list in this case - on a third. Pearl mussels (Margaritifera margaritifera) were destroyed on another reserve in 1980.

11.2 Extent of Pest Control in Sample NNRs

Table 11.2 lists the species nominated as pests in the various reserves and indicates the extent of pest control operations. All sample NRA reserves have a pest species list and two of the owned reserves have current lists. There are no specific controls over the numbers that may be killed or the methods by which the animals may be destroyed. Except that annual kill returns are requested of sporting lessees by the owners of some reserves, no monitoring is specified. Where conditions are imposed they generally establish the right of signatories to supplement the control rate.

Some 26 vertebrate species are nominated as pests on the various NNRs. Inverpolly (17 species), Inchnadamph and Cairngorms (14 species) and Kirkconnell Flow NNRs (13 species) have the largest number of species nominated as pests although control operations on the Speyside sections of Cairngorms NNR are at a low level (Lord Dulverton; J. Grant, pers. comm.).

In the 12 NRA reserves brown rats, carrion and hooded crows, foxes, rabbits, grey squirrels and stoats are nominated as pest species on at least 9 reserves. Both species of crow, and foxes, are widespread and almost universally persecuted. Only on Caerlaverock, Craigellachie and St Cyrus NNRs are foxes and crows believed to be not destroyed although on Craigellachie NNR these species have been destroyed in "recent years" (H. Blakenay, pers. comm.). On the other hand, brown

	NRA NNRs													Owned NNRs			
	Caenlochan	Caerlaverock	Cairngorms	Craigellachie	Inchnadamph	Invernaver	Inverpolly	Kirkconnell Flow	Morrone Birkwoods	Mound Alderwoods	Rassal Ashwoods	St Cyrus	TOTAL for NRA NNRs	Beinn Eighe	Cairngorms (pt)	Rannoch Moor	Tentsmuir Point
Adder			1				xt						1				
Brown rat	x	x	x	x	x	x	x	x	x	x	x		11			x	
Capercailzie									x				1				
Cat - wild	t				x[2]		x[3]						2				
Cormorant							x						1				
Crow																	
- carrion	xt	x	xt	x[4]	xt		xt	xt	xt	xt	xa		10			xt	
- hooded	xt		xt	x[4]	xt	xt	xt		xt	xt	xt		9			xt	
Deer - roe									x				1				x[4]
Fox	xt	x	xt	x	xt	xt	xt	xt	xt	xt	xt		11			xt	x[4]
Gull																	
- greater b.b.*	xt				xt	xt	xt	x		t			5				
- herring								x					1				
- lesser b.b.					x		x						2				
Hare																	
- blue			x	x		x					x		4				
- brown		x							xt				2				x[4]
Jackdaw			x		xa		x	x					4				
Jay		x	xa	xa	xa		xa	xt			xa		7				
Magpie		xa	xa	xa	xa		xa	xt			xa		7				
Merganser							x						1				
Mink													0			x	
Pigeon - wood		x	x	x	x	x	x	xt		t	xt		8			x	
Rabbit	x	x	xt	x	xt	xt	x	xt	xt	x	xt	xt	12			x	x[4]
Seal												xt	1				
Squirrel																	
- grey	xa	xa	xa	xa	xa		xa	xa	xa		xa		9				
- red	xa		x										2				
Stoat	x	x	x	x	x	x	x	x		t	xt		9				
Weasel			x					x		t			2				
TOTAL	10	10	14	11	14	8	17	13	9	4	11	2		0	0	7	4

Table 11.2 Species takeable as pests or vermin in sample NNRs.
x = nominated as pest and present on reserve;
xa = nominated as pest and absent from reserve;
xt = nominated as pest and known to be taken on reserve.
* b.b = black-backed.

Notes: 1. Watson (1977) reports adders killed on Cairngorms NNR.
2. No wildcats taken on Inchnadamph 1977-80 although 10 years ago they were taken as frequently as foxes (P. MacGregor, pers. comm.).
3. Wildcats may be taken on Drumrunie section if they damage shooting interests.
4. Under terms of acquisition from Forestry Commission must be taken if they become 'over-abundant'.

rats, stoats, blue hares and woodpigeon (Columba palumbus) are often included on pest species lists, occur widely but are rarely, if ever, destroyed.

Species not actually present on reserves are sometimes nominated as pests, e.g. grey squirrel, magpie and jay on 9, 6 and 5 reserves, respectively. Carrion crow, jackdaw and red squirrel are also in this category.

There is an unusual inconsistency in the attitude to stoats and weasels. They have similar predatory habits and utilise much the same range of prey species, yet stoats which occur on all 12 reserves appear on 9 pest lists, whilst weasels, present on 11 reserves, appear on 2 pest lists.

Pest control on owned reserves is inconsistent with seven species takeable under the NCC's sporting lease on Rannoch Moor NNR, four species takeable by the Forestry Commission on Tentsmuir Point NNR and no recognised 'pest' species on Beinn Eighe NNR and part Cairngorms NNR.

11.3 The NCC's Attitude to Pest Control on NNRs

11.3.1 Pest Control on NRA NNRs

In general the NCC has permitted a positive, even doctrinaire, attitude to pest control on NRA NNRs. In the sample NNRs the "Conservancy" or "their agents" are, along with owners, tenants and lessees, variously entitled to destroy by "... shooting or any other means ..." animals nominated as pests. In the Craigellachie NNR management plan (NC , 1962) "... any necessary control of pests ..." is part of the primary objective whilst aggressive conditions relate to pest control by sporting tenants under sporting leases which may be negotiated over Glen Feshie and Rothiemurchus sections of Cairngorms NNR and Caenlochan, Inchnadamph and Inverpolly NNRs. Here tenants are exhorted to "... take

all reasonable measures to kill and trap vermin ..." whilst the owner or his agents reserve the right to destroy "... foxes, hoodie crows, squirrels and rabbits ... by shooting or any other method ..." irrespective of tenancy. The owner himself shall "... use his best endeavours to control pests." In these large and important reserves the NCC has acceded to an active pest control programme including the potentially unrestrained destruction of the 20 species nominated as pests.

11.3.2 Pest Control on Owned NNRs

In general the NCC's preferred attitude can be inferred from their management of owned reserves. Thus on Tentsmuir Point NNR no pest control operations are currently undertaken by the NCC though under the terms of acquisition the Forestry Commission occasionally takes foxes and rabbits (P. Kinnear, pers. comm.). However, in the early 1970s an exploding rabbit population was threatening important communities and rare plant species (Gordon, 1963) and in 1973 the reserve objectives were modified to include a capacity for directed artificial control of the rabbit population (Smith, 1973). In the same way other pest species are to be "... controlled as necessary ...". (ibid.). Directed and scientifically justifiable pest control programmes are also carried out on Isle of May and Loch Leven NNRs, neither of which is owned. On Isle of May NNR a substantial and well-documented annual cull of breeding gulls is undertaken to preserve the vegetation (and hence the soil) both of which would disappear if the gulls were permitted to breed unrestrainedly (E. Idle, pers. comm.). On Loch Leven a number of predators, including foxes, rats, mink and jackdaws, are destroyed to prevent predation of eggs and nestlings of waterfowl on St Serfs Island (NCC, 1974a). The island provides a breeding ground for an extraordinarily dense colony of breeding birds the protection

of which is a primary object of reserve management.

There are no current pest species lists, nor are pest control operations carried out, on the owned section of Cairngorms NNR or on Beinn Eighe NNR (D. Gowans, D. Holland, H. Brown, pers. comm.). This was not always so for Beinn Eighe, as in 1953 it is recorded that "Action has been taken to control the fox population" (Nature Conservancy, 1953) and in 1965 "Hooded crows ... not abundant, even so an attempt is made to destroy any nest on Conservancy property" (Boyd and Campbell, 1965). In contradistinction, a recent sporting lease has been negotiated by the NCC for Rannoch Moor NNR in which the Council permits foxes, rabbits, brown rats, mink, woodpigeon and crows to be killed as pests. No constraints are specified except that under an "... obligation to neighbours ..." the NCC should ensure that control is sufficient to protect "... neighbours' interests ..." (NCC, 1979c). Similarly, on the 182 ha portion of Glen Tanar NNR purchased by the NCC in 1979 for £116,000, the previous owner (and those deriving from her) has been granted the long-term right to destroy, again without adequate constraints, any or all of the 16 species listed as pests, and four species - roe deer, capercailzie, blackgame and grouse - listed as game (Glen Tanar NRA/AMP). On Glasdrum and Cairnsmore of Fleet NNRs sporting and pest control rights were held by third parties at the time of acquisition but on other reserves owned by the NCC (including Taynish, Claish Moss, part Loch Sunart, Morton Lochs and Rhum NNRs) no generalised pest control is currently permitted although control operations may be directed against a particular species to further the objects of management. However, in the past hooded crows and large numbers of brown rats have been destroyed on Rhum NNR (L. Johnston, pers. comm.).

11.3.3 Some International Obligations

Two of the sample reserves - Beinn Eighe and Caerlaverock NNRs - are Biosphere Reserves (IUCN, 1980). Biosphere reserves are required to have a core zone "Managed for minimum human interference ... (and) ... to serve as a baseline for the biological region ..." (IUCN, 1979). With no pest control on Beinn Eighe NNR and a substantial sanctuary area (= core zone) on Caerlaverock NNR, where no shooting is permitted, these reserves fulfill the requirement with respect to pest control.

Seven of the 15 sample reserves including Beinn Eighe, Caerlaverock, Caenlochan, Cairngorms, Inchnadamph, Inverpolly and Rannoch Moor NNRs are listed as nature reserves in the 1980 United Nations list of National Parks and equivalent reserves (IUCN, 1980). They fall into Category IV - Nature conservation reserves/managed nature reserves/wildlife sanctuaries - in which "... each would have as its primary purpose the protection of nature" (ibid.). Predator control is permissable but only if justifiable in a conservation sense, e.g. "... an endangered animal may need protection against predators" (ibid.). Comprehensive lists of pest species with blanket rights for owners and agents (and others) to trap, shoot and poison without scientific controls or clearly stated conservation objectives, as in the case of parts of all the above NNRs except Beinn Eighe, would seem to fall substantially short of IUCN requirements.

11.4 Changes in Intensity of Pest Control in NNRs

Table 11.3 shows the changes in intensity of pest control that have occurred since the reserves were declared. Information for the table was supplied by past and present gamekeepers and wardens and by tenants, factors and owners. Action may differ between sections of a reserve and where this is known to be so scores for separate sections are shown.

Reserve/ Section	Species of pest: Crows and foxes — Control pressure (- = +)			Species of pest: Other pest species — Control pressure (- = +)			Notes
NRA RESERVES							
Caenlochan							No raptors now taken, and no blue hares since 1974. Largest tally of foxes -76- in 1978.
Invercauld		x			x		
Tulchan		x		x			
Caerlaverock	x			x			
Cairngorms							Very few foxes taken on Glen Feshie. Crows are main target.
Glen Feshie	x	x		x			
Rothiemurchus		x		x			
Craigellachie	x			x			Crows last persecuted 1977.
Inchnadamph		x		x			
Invernaver		?		?			'Low key' control by warden but current role of crofters not known.
Inverpolly							
Drumrunie		x		x			Polly/Eisg brachaidh have long been un-keepered but crofters kill foxes, crows, adders
Eisg brachaidh		x			x		
Polly		x			x		
Kirkconnell Flow		x			x		
Morrone Birkwoods		x		x			Blue hares, mustelids taken outside reserve.
Mound Alderwoods		x			x		
Rassal Ashwoods		x			x		
St Cyrus		nil		?			Rabbits taken, but infrequently.
OWNED RESERVES							
Beinn Eighe	x			x			No pest control by NCC.
Cairngorms (pt)	x			x			No pest control by NCC.
Rannoch Moor	x			x			Only foxes and crows taken.
Tentsmuir Point	x			x			Sporadic persecution of foxes and rabbits by Forestry Commission.

Table 11.3 Current control pressure in sample reserves relative to control pressure in the past. Changes may have occurred at declaration or, more commonly, gradually throughout the period the site has been a NNR. (- = + less, same, more)

Only on three of the 16 NRA reserves/sections has there been a clearly identifiable decrease in the intensity with which crows and/or foxes are persecuted whilst on each of the four owned reserves/sections there has been a decrease. However, control pressure on 'other' pest species has decreased on at least eight, possibly 10, reserves/sections and again on all owned areas. On Rannoch Moor NNR in particular, control of pests was extremely intensive during the 1950s when relatively enormous numbers of grouse were taken (M. Pearson, pers. comm.). Apart from Caerlaverock and Craigellachie NNRs, where control continues on the rest of the estates, it is not always clear whether changes in control pressure on the NRA NNRs result from declaration of the area as a NNR or from changes in estate policy. Lord Dulverton (pers. comm.) indicates that the latter is the case for fox control on Glen Feshie Estate and other similar changes on other reserves may reflect the current trend away from intensive keepering of Highland estates.

On at least part of five (out of six) NRA reserves with full-time wardens, decreases in control intensity occurred for 'other' species. On the six casually wardened NRA reserves only part of Caenlochan NNR shows the same response.

11.5 Current Pest Control Operations in NNRs

11.5.1 Pest Control by Habitat-Sections

Table 11.4 details pest control operations throughout the range of habitat-sections on NRA and owned sample reserves. On NRA reserves foxes occur in all 26 habitat-sections, may be killed on 92% of them and actually are taken in 85% of these areas. Carrion and hooded crows are similarly widely distributed (they occur on 25 and 22 habitat-sections respectively) and are heavily persecuted (on 76% and 95%

Species	Total NRA habitat-sections in which species is:						Total owned habitat-sections in which species is:					
	Present	Takeable		Taken			Present	Takeable		Taken		
Fox	26	24	(92)	22	(85)		6	2	(33)	2	(33)	
Stoat	26	20	(77)	3	(12)		6	0		0		
Weasel	25	3	(12)	2	(8)		6	0		0		
Carrion crow	25	21	(84)	19	(76)		4	1	(25)	1	(25)	
Brown rat	24	22	(92)	2	(8)		5	1	(20)	0		
Hooded crow	22	22	(100)	21	(95)		6	1	(17)	1	(17)	
Wood pigeon	19	12	(63)	3	(16)		5	1	(20)	0		
Rabbit	19	19	(100)	10	(53)		5	1	(20)	0		
Greater b.b.* gull	18	9	(50)	11	(61)		4	0		0		
Herring gull	16	1	(6)	0			4	0		0		
Jackdaw	15	4	(27)	0			3	0		0		
Blue hare	14	3	(21)	2	(14)		3	0		0		
Merganser	11	2	(18)	0			2	0		0		
Brown hare	8	3	(38)	0			1	1	(100)	0		
Cormorant	8	4	(50)	0			0	0				
Adder	8	2	(25)	2	(25)		1	0		0		
Lesser b.b. gull	7	4	(57)	3	(43)		0					
Red squirrel	5	1	(20)	0			3	0		0		
Jay	2	2	(100)	1	(50)		1	0		0		
Mink	2	1	(50)	0			0	0				
Magpie	1	1	(100)	1	(100)		0	0				
Grey squirrel	0	8		0			0	0				
Wildcat	?	3		2			4	0	(0)	0	(0)	

Table 11.4 Summary of pest control operations in sample NNRs. Percentages in relation to number of habitat-sections in which species is present are in brackets. There is a total of 26 habitat-sections held under NRAs, and six more are owned by the NCC. To be 'takeable' a species must be nominated as a pest in the relevant NRA/AMP, or the acquisition agreement, lease or management plan. In addition roe deer are classed as pests on Tentsmuir Point and roe deer and capercailzie on Morrone Birkwoods NNRs, but are not taken. (*b.b. = black-backed)

of the areas on which they occur respectively). Rabbits and greater black-backed gulls are widely distributed and are taken on over half the habitat-sections on which they occur. Young (1971) records that control pressure on these gulls on Kirkconnell Flow NNR was such that a formerly breeding population was "shot out". Stoats, brown rats and woodpigeon are widely distributed, usually classed as pests (on 77%, 92%, 63% of the habitat-sections on which they occur respectively) but are hardly ever killed. Conversely, magpies (Pica pica) and jays occur on only one and two habitat-sections respectively, are classed as pests in each case, and are often killed. Herring gulls (Larus argentatus), jackdaws, merganser (Mergus serrator), brown hares, cormorants (Phalacrocorax carbo), red squirrels and mink each appear on up to four pest lists but are not known to be killed on any sample NNR.

Wildcats (Felis sylvestris grampia) were not included in the questionnaire because of the difficulty in consistently distinguishing them from feral cats (F. catus) but cats are taken as they appear on Inchnadamph NNR and probably on the Invercauld section of Caenlochan NNR (D. Petrie, pers. comm.) although they are not included on the pest list for the latter area.

As above, on owned NNRs pest control operations are relatively minor but in the only sample habitat in which they occur (in Tentsmuir Point NNR) brown hares may be destroyed as pests.

11.5.2 Abundance Ratings of Some Pests and Their Control

Table 11.5 shows that on NRA reserves pest species are destroyed without regard to their abundance. For example, carrion crows which are 'rare' in nine of the 25 habitat-sections on which they occur are persecuted without restraint on seven of these sites. They are never 'very common' and are destroyed on 12 of the 16 sites on which they are 'occasional' or 'common' in abundance. Hooded crows are destroyed on 21 of the 22

Species	Abundance ratings 1	2	3	4	Habitat-sections in which species is takeable as a pest	Habitat-sections in which species is taken as a pest
Fox	3				2	0
		21			20	20
			2		2	2
				0	0	0
Carrion crow	9				7	7
		6			4	4
			10		10	8
				0	0	0
Hooded crow	0				0	0
		4			4	3
			18		18	18
				0	0	0
Greater black-backed gull	2				0	0
		5			3	3
			11		8	8
				0	0	0
Wood pigeon	1				1	0
		12			7	1
			4		4	2
				2	2	0
Rabbit	1				1	0
		6			6	4
			7		7	2
				5	5	4
Magpie	1				1	1

Table 11.5 Abundance ratings and pest control operations in NRA reserves for species killed in more than 50% of the habitat-sections in which they occur.
Abundance ratings: 1 = rare; 2 = occasional; 3 = common; 4 = very common (see Table 11.1)

sites on which they occur (invariably occasional or common in abundance). Greater black-backed gulls are taken where they are occasional or common as are rabbits and, to a lesser extent, woodpigeon. Coincidentally, foxes are not taken in the three habitat-sections in which they are rare (in St Cyrus and Caerlaverock NNRs) but they are only 'occasional' on 91% of other sites on which they are present and where they are almost invariably persecuted. Magpies are 'rare' on Kirkconnell Flow NNR but are destroyed as pests. Brown rats, stoats, weasels and jays are takeable as pests on 10, 7, 3 and 1 habitat-sections respectively where they are classed as 'rare', but with the exception of stoats on Rassal Ashwoods NNR, are not known to be killed.

11.5.3 Pest Control by Area of Habitat Type

Table 11.6 shows the area, by habitat type, over which the four most extensively taken pest species occur in the sample NNRs, and the area over which they are destroyed. Foxes are destroyed in all habitats but most extensively in uplands and peatlands. Scots pine woodland and upland habitats on Beinn Eighe and part Cairngorms NNRs provide a small sanctuary for this species (and for carrion and hooded crows). Foxes also occur (but rarely) on Caerlaverock and St Cyrus NNRs but are not destroyed in these coastal habitats. Nevertheless, they are destroyed on 81% of the total habitat over which they range. The control of carrion and hooded crows follows a similar pattern; they being killed over 79% and 82% of their range respectively. Greater black-backed gulls are not destroyed on NCC-owned reserves and less extensively (on 55% of the NRA range) than the other three main pest species. Overall they are persecuted on one fifth of the area over which they occur.

Species	Habitat Type	Area of habitat on which species occurs (ha)		Percentage of area over which species killed as pest		
		NRA	Owned	NRA	Owned	Combined
Fox	Upland	28272	5953	99	0	82
	Woodland	1332	433	90	0	68
	Peatland	161	1423	100	100	100
	Coastal	832	122	24	100	34
T o t a l / M e a n		30597	7931	97	20	81
Carrion crow	Upland	28218	5953	98	0	81
	Woodland	1316	433	90	0	68
	Peatland	161	1423	100	100	100
	Coastal	832	122	0	0	0
T o t a l / M e a n		30527	7931	95	18	79
Hooded crow	Upland	28272	5953	99	0	82
	Woodland	1322	433	90	0	68
	Peatland	6	1423	100	100	100
	Coastal	200	122	100	0	62
T o t a l / M e a n		29800	7931	99	18	82
Greater black-backed gull	Upland	27704	5953	42	0	35
	Woodland	0	0	-	-	-
	Peatland	161	1423	100	0	10
	Coastal	832	122	24	0	21
T o t a l / M e a n		28697	7498	55	0	22

Table 11.6 Area of occurrence, by habitat types, and extent of pest control operations for the four species most extensively destroyed as pests in the sample NNRs (areas drawn from Appendix 1A).

11.6 Effect of Control Operations on Crows, Foxes and Wildcats

11.6.1 Carrion and Hooded Crows

Both species of crow are destroyed because they predate the eggs and nestlings of desirable species (mainly grouse in the Highlands) and because they are reputed to kill lambs and cast ewes. The comprehensive studies of Jenkins et al. (1963, 1964) demonstrated two features of particular relevance to this study. Firstly, although predators (including foxes and crows) in Glen Esk were "... destroyed at every opportunity ..." overall predator abundance was not controlled by keepering. Control operations could locally depress early summer populations pending immigration of surplus animals from other areas and similarly Chesness et al. (1968), in their comprehensive study of the reproductive success of pheasants (Phasianus colchicus) in Minnesota, found that there were no carry-over effects of predator control one year after predator removal despite an increasing intensity of control over three years. On the other hand Nethersole-Thompson and Watson (1981) state that "... on some estates persecution is so severe that crows are scarce ..." whilst the intensive keepering possible in lowland areas may prevent colonisation of suitable habitat by buzzards and other avian predators (e.g. Moore, 1957; Tubbs, 1974). According to Weir (1978) the widespread use of modern poisons for pest control began in 1969 and he documents the spectacular decline of the raven (Corvus corax) population in Speyside, largely by poisoning, in the 1968 to 1977 period.

Secondly, Jenkins et al. (1963, 1964) demonstrated that in Glen Esk predators did not limit grouse (Lagopus lagopus scoticus) breeding populations. They mainly predated the intrinsically more vulnerable non-territory-holding ("surplus") birds forced into marginal habitats as the result of intra-specific competition for territories. Again,

Chesness et al. (1968) found that although nesting success of pheasants increased on an area with intensive pest control, nest predation (by crows, foxes and other species) was only one factor affecting reproductive success and that the combination of other factors was of greater significance in the population dynamics. Jenkins et al. (1964) further concluded that in a season that would normally produce a surplus of birds even the combination of predation and shooting at then current intensities, would still result in a surplus of birds at the end of the shooting season.

In a study of predation of lambs by hooded crows on hill farms in Argyll, Houston (1977) showed that of 297 lamb carcases examined, 48% had been molested by crows. However, 92% were attacked only after they had died from other causes and of the 24 that were attacked before death in only two cases (1.4% of the sample) could their death be positively attributed to crows. He concluded that of 1700 lambs born in the area only two extra lambs would have survived had there been no crow attacks. Similarly, Burgess (1963) studied predation of lambs by carrion crows in north England and concluded that half the lambs attacked were weakly and that overall about one in 2000 healthy lambs was attacked.

With respect to the blinding of cast ewes (a not uncommon occurrence) Houston (1977) argues that the blinding contributes to the unpleasantness of the ewe's death but that in the majority of cases the rapid build up of gases in the ewe's stomach leads to death by suffocation anyway.

11.6.2 Foxes

As above, Jenkins et al. (1964) concluded that foxes had little or no overall effect on grouse populations in Glen Esk, and that keepering had little effect on fox populations. In a situation that might bear

comparison with foxes in the Highlands, Evans and Pearson (1980) examined the effects of the Federal-State predator control programme on coyote (Canis latrans) populations in open rangeland in the western United States between 1971 and 1977. The harvest had little or no effect on the coyote populations, loss rates of domestic livestock were unchanged and a major post-1974 increase in control intensity was not reflected in the residual populations. Connolly and Longhurst's (1975) computer simulation of a coyote population indicated that only at the highest intensity of control could the population not maintain itself. Wagner (1975) concluded with respect to coyote populations that generalised control merely established a baseline population about which natural fluctuations occurred. Hence, D. Grant (pers. comm.) comments that for decades, and with more or less constant effort, between 40 and 76 foxes have been destroyed on Tulchan Estate (part Caenlochan NNR) each spring and that the greatest number - 76 - were killed in 1978 after decades of persecution. On Inchnadamph NNR an average of 28 adult and 15 juvenile foxes are killed each year (P. MacGregor, pers. comm.) despite which "there is a definite increase in the number of foxes in the area." Over a period of more than 40 years Mr A. MacClennan (pers. comm.) has destroyed "many hundreds of foxes" in the grazings that surround Rassal Ashwoods NNR but "stock losses are just as high as ever". Stephen (1979) comments that despite persistent and widespread snaring, trapping, poisoning, gassing, shooting and dogging there is "... no noticeable effect on the population of foxes" whilst in Glen Esk Jenkins et al. (1964) concluded that the fox population was unlikely to increase greatly if their persecution was relaxed. However, Nethersole-Thompson and Watson (1981) record that fox populations on the Cairngorm massif increased during the second World War when keepering was relaxed and they also suggest

that the invasion of some lowlands in the Grampian region by foxes since the mid-1950s may be related to less intensive keepering.

11.6.3 Wildcats

This section is included only to document the possible recent decline of wildcats in and about Inchnadamph NNR. Eggeling (1958) states that "... no fewer than 50 wildcats (including feral cats) were killed in 1955 and 62 in 1956 on the Assynt shootings". Twelve and 11 were taken from the beat of which the reserve comprises about one third and "... it is certain that most ... were true wildcats" (ibid.). Until 10 years ago wildcats were killed more frequently in snares and gin-traps than were foxes (P. MacGregor, pers. comm.) but their numbers have decreased and none were taken between 1977 and 1980. Locally they may be close to extinction, possibly due to persistent persecution, and it may be that foxes have taken over the niches that wildcats once occupied. The phenomenon is not necessarily a general one for both Nethersole-Thompson and Watson (1981) and Jenkins (1962) document the post-1940s' spread of wildcats in parts of the Grampian region.

11.7 Pest Species Lists in Recent NRAs

That there has been little general change in landowners' or NCC's attitude to pest species is reflected in the NRAs negotiated in the last 10 years (Table 11.7). In fact the mean number of species takeable under the terms of the agreements has increased from 10.3 to 11.3 species per reserve for the pre- and post-1972 NRAs respectively. With nominated pest and game species taken together Muir of Dinnet, Strathfarrar and Glen Tanar NNRs have 27, 26 and 26 legitimate quarry species respectively. The NCC's positive attitude to pest control is exemplified in the Loch a' Mhuilinn NRA/AMP (1980) where despite the NCC's "... exclusive right of shooting and sporting over the land ..."

Post-1972 NRA Reserves	No. species in pest list	Sample reserves (pre-1972)	No. species in pest list
Ben Lawers	11	Caenlochan	10
Gualin	5	Caerlaverock	10
Glen Nant	12	Cairngorms	14
Glen Tanar	16	Craigellachie	11
Loch a'Mhuilinn	14	Inchnadamph	14
Loch Lomond	12	Invernaver	8
Loch Maree	3	Inverpolly	17
Loch Sunart	15	Kirkconnell Flow	13
Milton Woods	12	Morrone Birkwoods	9
Muir of Dinnet	17	Mound Alderwoods	4
Nigg and Udale Bays	9	Rassal Ashwoods	11
Strathfarrar	10	St Cyrus	2
Mean number of species per reserve	11.3		10.3

Table 11.7 Number of species takeable as pests under the terms of the NRAs for post-1972 NRA (or part NRA) mainland reserves and sample NRA reserves (pre-1972). Whitlaw Moss NNR (1974) has no pest species list but shooting rights remain with the owner. Presumably all legal species are takeable.

a comprehensive pest species list of 14 species has been drawn up.

However, there are a few recent departures from past conditions of pest control as they relate to NRA reserves. For example, the owners of Muir of Dinnet NNR (with an alarming 17 species on the pest list) have agreed to consult with the NCC at least annually on the destruction of pest species and in some NRA reserves, e.g. Muir of Dinnet and Glen Tanar NNRs the NCC is to have first option to purchase long-term sporting rights (presumably including the right of pest control) as current leases expire.

SECTION 2 - GAME SHOOTING

Although game shooting (particularly of grouse and red deer) is the raison d'être for many Highland estates in their current form (and including Caenlochan, Cairngorms, Inchnadamph and Morrone Birkwoods NNRs) there would seem to be opportunities to rationalise some aspects of game shooting on most of the sample NNRs. Thus in this section the pattern of game shooting on the NNRs is examined.

Data collection was as for section 1 but using the proforma shown in Appendix 3B.

11.8 Extent of Game Shooting in NNRs

Seven of the 12 sample NRA reserves have game lists specifying up to 14 species which may be shot as game. The five other reserves - Craigellachie, Invernaver, Morrone Birkwoods, Mound Alderwoods and St Cyrus have no game lists but shooting rights remain with the owners and it is assumed that all game present on these reserves is legitimate quarry. On one owned NNR - Rannoch Moor - the NCC has leased the sporting rights.

Table 11.8 lists the species nominated as game and indicates the extent of game shooting. There are no specific controls over the numbers of animals that may be killed - except that sporting tenants are usually required to leave "... a good and sufficient breeding stock of game ..." at the termination of their leases - and no monitoring except of numbers of red deer by the NCC and the Red Deer Commission on some reserves and by the NCC for waterfowl, geese and waders on Caerlaverock NNR.

Some 19 species are nominated as game on the various NNRs. Hares, rabbits and woodpigeons are routinely nominated as both game and pests

Game species	NRA NNRs: Caenlochan	Caerlaverock	Cairngorms	Craigellachie	Inchnadamph	Invernaver	Inverpolly	Kirkconnell Flow	Morrone Birkwoods	Mound Alderwoods	Rassal Ashwoods	St Cyrus	TOTAL for NRA NNRs	Owned NNRs: Beinn Eighe	Cairngorms (pt)	Rannoch Moor	Tentsmuir Point
Black game			xt	x					xt	x	xa		5				
Capercailzie			xt	x							xa		3				
Deer - red	xt		xt		xt		xt		xt	xt	xt		7			xt	
- roe	x		xt				x	xt	x				5			x	
Geese - greylag		xt				x				x			3				
Grouse - red	xt		xt	x	xt	x	xt	xa	xt	x	x		10			xt	
Mallard	x	xt	x	x	x	x	xt	x	x	xt	xa		11			x	
Partridge	xa		xa		xa		xa	xt	x		xa	x	8			xa	
Pheasant			x	x			xa	xt	x	xt	xa	x	8			xa	
Plover - golden	x	xt				x	x		x	x			6				
Ptarmigan	xt		xt				x				xa		4				
Snipe	xt	xt	x	x	x	x	x	x	x	x	xt	x	12			x	
Stockdove			xa		xa		xa	xt			xa	x	6				
Teal	x	xt	x	x	x	x	xt	x		xt	xa		10			x	
Wigeon		xt	x	x	x	x	xt	xa		xt	xa		9				
Woodcock	x		xt	x	x	x	xt	x	x	x	xt	x	11			xa	
TOTAL	10	6	14	9	9	8	13	10	10	11	13	5					

Table 11.8 Species takeable as game in sample NNRs.
x = nominated as game species and present on reserve;
xa = nominated as game but absent from reserve;
xt = nominated as game and known to be taken.

Notes: 1. Craigellachie, Invernaver, Morrone Birkwoods, Mound Alderwoods and St Cyrus NNRs have no game lists. All game species present on the reserves are assumed to be legitimate quarry.
2. Curlew, pinkfoot geese, pintail and redshank are also shot as game on Caerlaverock NNR.
3. With the NCC's written consent, blackgame may be shot on Rannoch Moor NNR.
4. Hares, rabbits and wood pigeon are usually classed as both pests and game. To avoid confusion they have been included only as pests.

and having been considered in section 1 are not further referred to in this section. The Cairngorms (14 species) and Inverpolly and Rassal Ashwoods NNRs (13 species) have the greatest number of nominated game species (excluding hares, rabbits and woodpigeons).

In the 12 NRA reserves grouse, mallard (Anas platyrhynchos), snipe (Gallinago gallinago), teal (Anas crecca), wigeon (A. penelope) and woodcock (Scolopax rusticola) are included as game on at least nine reserves. Of these only grouse are known to be regularly shot on more than 3 reserves, although snipe and woodcock are probably shot casually on some other reserves.

Game lists have been compiled in the same casual way as the pest lists. On Rassal Ashwoods NNR only four of the 13 game species have ever been seen on the reserve and only three - red deer, snipe and woodcock - have been taken, and then infrequently. Partridge (Perdix perdix) are not found on five of the eight reserves where they are classed as game and stockdoves (Columba oenas) are not present on four of six reserves. Snipe are game on all 12 reserves but are shot regularly on only two and woodcock are taken regularly on only three of 11 reserves on which they are game.

On Rannoch Moor NNR three of the nine game species are not found on the reserve and only two of the remaining six are shot.

11.9 Game Shooting by Habitat-Sections

On NRA reserves woodcock are the most widespread game species occurring on each of the 26 habitat-sections (Table 11.9). Red deer are found on 22, grouse on 16 and roe deer, mallard and golden plover (Pluvialis apricaria) on 15. Red deer are shot on 17 (77%) of the habitat-sections on which they occur, ptarmigan (Lagopus mutus) on 3 (43%) and roe deer on 6 (40%). Woodcock are regularly taken on only 7 habitat-sections (27% of the sites on which they occur), snipe on 3 (15%) and golden

Species	Total NRA habitat-sections in which species is:			Total owned habitat-sections in which species is:		
	Present	Takeable	Taken	Present	Takeable	Taken
Woodcock	26	25 (96)	7 (27)			
Deer - red	22	22 (100)	17 (77)			
Snipe	20	20 (100)	3 (15)	3	1 (33)	0
Grouse - red	16	16 (100)	6 (38)	3	1 (33)	1 (33)
Deer - roe	15	14 (93)	6 (40)	3	1 (33)	1 (33)
Mallard	15	14 (93)	4 (27)	4	1 (25)	0
Plover - golden	15	10 (67)	1 (7)	4	0	0
Teal	14	13 (93)	4 (29)	3	1 (33)	0
Wigeon	12	12 (100)	4 (33)	2	0	0
Blackgame	10	7 (70)	2 (20)	4	1 (25)	0
Pheasant	10	9 (90)	3 (30)	3	0	0
Geese - greylag	8	5 (63)	1 (13)	1	0	0
Ptarmigan	7	6 (86)	3 (43)	2	0	0
Partridge	5	4 (80)	0	1	0	0
Stockdove	4	3 (75)	1 (25)	1	0	0
Capercailzie	3	2 (67)	1 (33)	1	0	0

Table 11.9 Summary of game shooting operations in sample NNRs. Hares, rabbits and woodpigeon not included as per Table 11.8. Percentages in relation to number of habitat-sections in which species is present are in brackets. There is a total of 26 habitat-sections held under NRAs, and six are owned by the NCC. To be 'takeable' a species must be nominated as game in the relevant NRA/AMP, or the acquisition agreement, lease or management plan.

plover on 1 (7%). Mallard, teal, wigeon, pheasant, stockdove and capercailzie (Tetrao urogallus) are all taken on around 30% of the habitat-sections on which they occur whilst grouse, present on 16 habitat-sections, are taken on 6 (38%) of these sites.

All game species, except red deer, are takeable on at least two, and most are present on at least three, times as many habitat-sections on which they are actually known to be regularly taken.

11.10 Abundance Ratings and Gamebird Shooting

Table 11.10 shows the abundance ratings of six of the most frequently taken gamebirds (grouse, wigeon, ptarmigan, capercailzie, teal, woodcock) and the corresponding areas on which they are shot as game. (Deer are dealt with in Chapter 12.) Coincidentally (for game need not be abundant on NNRs before it may be shot) none of these species are known to be taken on habitat-sections on which they have been classed as 'rare'. However, with the single exception of ptarmigan on Inchnadamph NNR, each species is nominated as game on the total of 12 habitat-sections in which they are 'rare'. All species together are shot on 10 (24%) of the 42 habitat-sections on which they are 'occasional' in abundance, and on 12 (57%) of the 21 habitat-sections on which they are 'common'.

11.11 The Importance of Game Shooting to NRA NNRs

Table 11.11 indicates the importance of the various species as game to the economy of the estates concerned in managing these areas as NNRs. Red deer are of great importance to the economy of Caenlochan, Cairngorms, Inchnadamph, Morrone Birkwoods NNRs and the Drumrunie section of Inverpolly NNR. No other game species approaches red deer in value. Grouse shooting is of significance on Invercauld section of Caenlochan NNR, on Inchnadamph NNR and, to a lesser extent, on Morrone Birkwoods

Species	Abundance ratings 1	2	3	4	Habitat-sections in which species is takeable as game	Habitat-sections in which species is taken as game
Grouse - red	1				1	0
		8			8	1
			6		6	3
				1	1	1
Wigeon	2				2	0
		7			7	1
			2		2	2
				1	1	1
Ptarmigan	1				0	0
		4			4	3
			2		2	0
				0	0	0
Capercailzie	1				1	0
		2			1	1
			0		0	0
				0	0	0
Teal	4				4	0
		7			6	1
			3		3	3
				0	0	0
Woodcock	4				4	0
		14			13	3
			8		8	4
				0	0	0

Table 11.10 Abundance ratings and game-bird shooting in NRA reserves for species killed in 33% or more of the habitat-sections in which they are present, plus woodcock (27%) and teal (29%).
Abundance ratings: 1 = rare; 2 = occasional; 3 = common; 4 = very common (see Table 11.1)

Game species	NRA reserves/sections														
	Tulchan	Invercauld	Rothiemurchus	Glen Feshie	Craigellachie	Inchnadamph	Invernaver	Drumrunie	Eisg brachaidh	Polly	Kirkconnell Flow	Morrone Birkwoods	Mound Alderwoods	Rassal Ashwoods	St Cyrus
Blackgame			1	1	1							2	1	0	
Capercailzie			1	1										0	
Deer - red	3	3	3	3		3		3	1	2		3	2	1	
- roe	1	0	1	1				1	1	1	1	1			
Geese - greylag							1						1		
Grouse - red	1	2	1	1	1	2	1	1	1	1	0	2	1	1	
Mallard	1	0	1	1	1	1	1	1	1	1	1	1	2	0	
Partridge	0	0	0	0	0	0		0	0	0	1	1		0	
Pheasant			0	0	1	1		0	0	0	2	1	1	0	1
Plover - golden	1	1					1	1	1	1		1	1		
Ptarmigan	1	1	1	1		1		1	1	1				0	
Snipe	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Stockdove			0	0		0		0	0	0	1			0	1
Teal	1	0	1	1		1	1	1	1	1	1		2	0	
Wigeon			1	1	1	1	1	1	1	1	0		2	0	
Woodcock	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 11.11 Importance ratings for game species in sample NRA NNRs. Scored for all species nominated as game in NRAs/AMPs or for game present in NRA reserves with no game list (see Table 11.8).
Ratings are: 0 - species not on reserve.
1 - species not shot, or if shot only on a casual basis.
2 - significant numbers shot and/or makes a contribution to estate finances.
3 - species provides a major source of income for estate.
Tulchan and Invercauld sections of Caenlochan NNR, Rothiemurchus and Glen Feshie sections of Cairngorms NNR and Drumrunie, Eisg brachaidh and Polly sections of Inverpolly are scored separately.

NNR, and waterfowl shooting on Mound Alderwoods NNR. Except perhaps blackgame on Morrone Birkwoods NNR, other species are shot on a casual basis with small financial advantage to the owners.

11.12 Discussion

Comprehensive pest species lists are the norm for sample NRA reserves and for other post-1972 mainland NRA reserves. Permissible methods of killing and the number of animals (or the proportion of the population) that may be taken are never specified, nor is there any creditable monitoring of the effects of control operations. Pest lists usually include all species that could, even remotely, affect any potential operation or facility. Minimum reference is made to the field situation and only 14 of 26 pest species are ever known to be taken on NNRs. Other species, widespread on NRA NNRs (including merganser, weasel and herring gull) appear on just one or two pest lists and are not known to be taken on these reserves. Carrion crows, jays, magpies, jackdaws and red squirrels are nominated as pests on reserves on which they do not occur, thus forestalling the colonisation of nature reserves by native species. Species often classed as 'rare' in abundance, e.g. stoats, weasels and jays, appear on pest species lists and species of restricted distribution on NNRs (including jays and magpies) are routinely killed on the sites on which they do occur.

Ratcliffe (1971) is representative of a wide body of scientific opinion when he comments that diversity is perhaps the most important single criterion in the selection of nature reserves and that "... variety in numbers of both communities and species ..." (Ratcliffe, 1977) is of great import. Naturalness (Peterken, 1977; Ratcliffe, 1971, 1977) and, where relevant, its management corollary of non-intervention (Duffey, 1970; Peterken, 1977) are important on sites where naturalness exists and naturalness, especially of predator

populations, is a feature that characterises Highland ecosystems (Lance, 1978). A policy that affirms as pests a list of arbitrarily chosen predators and permits the potentially unrestrained destruction of them is subverting these basic principles of nature conservation.

With the sanction of the NCC, sporting tenants on Glen Feshie and Rothiemurchus sections of Cairngorms NNR and on Caenlochan, Inchnadamph and Inverpolly NNRs are enjoined to "... take all reasonable measures to kill and trap vermin ..." and owners, too, are to use their best endeavours to control pests (relevant NRAs/AMPs). Whilst no restraint need encumber an owner or his agents in exercising their legal rights to shoot, trap, gas, poison or dog any of the 20 species that appear on the pest lists of these reserves a certain cynicism is inevitable when, again on each of these reserves, the NCC is obliged to "... use its best endeavours to prevent persons from killing, injuring, damaging or taking the plant or animal life within the Reserve." On Inverpolly NNR "No (other) person shall take, molest or wilfully disturb, injure or kill any living creature in the Reserve ..." (third draft of bye-laws for Inverpolly NNR, October 1979). There would appear to be further conflicts of interest on Inverpolly NNR (with 17 pest and 13 game species) where the primary object of management is "... the conservation of a rich and varied sample of the North-West Highland mountain country" (relevant NRAs/AMPs) and on Inchnadamph NNR (with 14 pest and 9 game species) which is to be managed for "... maintaining a varied and numerous population of fauna and flora ..." (Inchnadamph NRA/AMP).

Although distaste has been expressed for generalised pest control (Boyd, 1967; NCC, 1981c) the NCC's policy to date has been less certain and the model NRA published by Feist (1978) includes a standard clause under which 'pests' may be destroyed by the owner and NCC staff. Even on owned NNRs the NCC's actions have been ambiguous with sporting

rights (including pest control) offered over Rannoch Moor and part Glen Tanar NNRs but with no generalised control operations currently promoted over other reserves. For Rannoch Moor NNR the reason given for pest control is an "... obligation to neighbours ..." (NCC, 1979c). This same responsibility or the need to be a good neighbour, is recognised as an important issue on other occasions (McCarthy, 1980a; NC 1958; NCC 1974, 1977). Although such an attitude is generally commendable its relevance must be questioned if it extends to compromising reserve values and conservation principles and leads to mimicking undesirable aspects of land management occurring outside NNRs.

On all owned NNRs there has been a decrease in the intensity of control of all 'pest' species since declaration of the sites as NNRs, but the situation on NRA NNRs, especially for foxes and crows, has been less satisfactory. Destruction of foxes and carrion and hooded crows on NRA reserves continues on 85%, 75% and 95% respectively of the habitat-sections on which they occur, and over 81%, 79% and 82% respectively of the total area of habitat over which they range. None of these three species are ever classed as 'very common' on the sites on which they occur and are destroyed, and frequently they are 'occasional' or, for carrion crows, 'rare'. Despite this almost universal persecution the efficacy of control (in terms of increased yields from 'desirable' species) has not been clearly demonstrated. There is evidence that intensive control pressure can reduce populations of avian predators (including corvids) and prevent the colonisation of potentially suitable sites. Similarly, intensive control of mammalian predators over limited areas (as for foxes, mink and rats on Loch Leven NNR and possibly mink on Gladhouse Reservoir LNR - E. Idle pers. comm.) can clearly enhance the survival prospects of

the potential prey species. However, studies in Scotland and in the western United States suggest that generalised control, i.e. routine control over large areas of fox and coyote populations may have little long-term effect on the populations and act only to establish a base-line level about which natural fluctuations in numbers occur. Anecdotal evidence from three NNRs supports this interpretation. Further, it appears that predators (including foxes and crows) may not always have the deleterious effect on grouse breeding populations that they are often assumed to have and there is some evidence to suggest that the effect that crows have on early lamb mortality is small. Foxes do take lambs and fawns but the relative susceptibility of weakened (and hence mortality-prone) individuals has not been determined. Lockie (1973) suggests that if fox control is essential that it be confined to the spring period during which cubs are being reared.

The control of particular species may be justifiable and where the need is demonstrable it is within the management objectives for most reserves. The control of rabbits on Tentsmuir Point NNR, foxes on Sands of Forvie NNR (Patterson, 1977), foxes, mink, rats and jackdaws on Loch Leven NNR and gulls on Isle of May NNR, and the destruction of deer on parts of Cairngorms, Beinn Eighe and Loch Sunart NNRs are recent examples of this approach. Virtually all informed scientific opinion endorses the argument for pest control on the basis of clearly defined need even outside reserves, e.g. Berryman, 1972; Hornocker, 1972; Leopold, 1964; McCabe, 1972; Watson, 1977. Within reserves the case for pest control on the basis of demonstrated need is irrefutable and should be pursued with greater vigour than in the past. It is encouraging that, for the first time in a Scottish NNR, the Cairngorms Policy Guidelines (NCC, 1981c) propose that pest control be carried out only when a case for it is "clearly established" and that

"... compensation for proven loss should be explored". Unfortunately, baselines relating to changes in predator numbers or to changes in livestock losses due to predation where there has been no control have not been established by the NCC on any reserve. The cost of compensation for proven loss is therefore an unknown quantity but there is some evidence to suggest that increased losses of game and domestic livestock may not be excessive.

In view of the above it is suggested that:

i) The standard clause permitting generalised control over a list of arbitrarily chosen pest species in current NRAs be re-negotiated to

a) prohibit pest control unless it is demonstrably necessary to meet reserve objectives for the conservation of fauna and flora;

b) expressly proscribe the generalised control of foxes and carrion and hooded crows on reserves. However, permit springtime control of foxes (with annual reports to be made to the NCC) on reserves where sheep rearing is important until further research demonstrates the efficacy or otherwise of such control programmes;

c) offer compensation at market rates for proven additional losses (using five- or 10-year averages for lambing percentages and grouse tallies);

d) promote improvements in sheep husbandry including the use of 'sheep parks' or lambing areas, with supplementary feeding, to combat lamb losses to foxes.

ii) Instigate a comprehensive study to evaluate what effect generalised control of foxes and crows has on their population structure within reserves and to determine what effects, if any, such control programmes have on the prey populations of lambs and fawns.

iii) As a second-rate alternative, if proposals such as these are not acceptable to individual owners of NRA reserves then at least delete from pest species lists all locally rare species, species at the limits of their range, species not currently destroyed and species not already present on the reserve.

iv) Justify the pest control option over Rannoch Moor NNR in scientific terms and, if necessary, re-negotiate the lease.

As for pests, comprehensive game lists are the norm for sample NRA reserves and where game species are not nominated the owners have retained the sporting rights, presumably with no limitation on the species that may be taken. Again there are no satisfactory controls, in conservation terms, over the number of animals that can be shot.

Lists of game species have been prepared in a cavalier fashion, and sometimes bear little relation to the species actually present on the reserve, e.g. Rassal Ashwoods NNR. They frequently include species that are rarely, if ever, shot on the reserve e.g. snipe, golden plover and woodcock. Partridge and stockdoves are hardly ever found on the sample NNRs yet are often nominated as game. If game lists are to continue to be a feature of NNRs then a great deal more research and restraint must be exercised in their compilation. Only species that are clearly intended to be shot, and that have been shot regularly in the past, should be included. Species not present on the reserve in abundance or at the limits of their distribution should never appear on a game list.

With species other than red deer and grouse on these (mainly) Highland reserves the effects of traditional shooting methods on the animal populations are likely to be minimal, mostly extending to a few shots at temporary colonists as the occasion permits. Only with resident species such as snipe, blackcock and capercailzie could the

colonisation of sites be prevented and none of these species are taken when 'rare'. Jenkins et al. (1963) have demonstrated that traditional shooting methods are unlikely to have a long-term effect on grouse populations and monitoring of waterfowl, wader and geese populations on Caerlaverock NNR since 1957 has shown no decline in the populations that can be attributed to the fairly intensive but restrained shooting permitted by the NCC on this site (Harrison, 1974).

Despite the apparently limited effects on the reserve ecosystem, the potential for random, uncontrolled shooting of a wide range of game species without reference to the stated conservation objectives of the NNR cannot be regarded as legitimate within NNRs where the over-riding objective is usually to protect the indigenous fauna and flora. Furthermore, for those NNRs recognised as nature reserves by the IUCN (Inverpolly,Cairngorms, Caenlochan, Caerlaverock, Beinn Eighe, Rannoch Moor and Inchnadamph NNRs in the sample, and which would include other sample NNRs but for the size limitation of a minimum of 1000 ha) the primary purpose of management is "... the protection of nature, and not the production of harvestable, renewable resources ..." (IUCN, 1980). Hence, in terms of widely accepted international standards for this type of nature reserve (and in general conservation terms) the harvesting of game species without sequential benefit to other specified biota of the ecosystem is undesirable. However, one must recognise the essential role that game harvesting plays in the economy and the maintenance of some Highland estates (see, for example, Dulverton, 1971, 1980). Thus, deer management and stalking on Cairngorms, Caenlochan, Inchnadamph and Drumrunie section of Inverpolly NNRs must, for the present, be accepted by conservationists as an essential, legitimate, but largely competing land use, and similarly

for grouse shooting on Invercauld section of Caenlochan NNR and Inchnadamph NNR, and waterfowl and red deer shooting on Mound Alderwoods NNR. Red deer and grouse are important on Morrone Birkwoods NNR but as the reserve forms only a very small proportion of their range under common ownership the same argument may not apply.

Apart from these species on these reserves/sections there is little apparent financial reward to owners in their exploitation of shooting rights. Amenity benefits to owners, guests and sporting tenants outweigh financial considerations and it should not be beyond the NCC's ingenuity and resources to purchase the sporting rights over all minor game animals in all other sections and reserves. Sporting rights would need to be split, usually into "grouse plus red deer", and "all other species", with the former remaining with the owners where they are essential to the well-being of the estate and the latter passing to the NCC.

As with pest control on Rannoch Moor NNR, game shooting seems anachronistic and unjustifiable in conservation terms. The sporting lease should be re-appraised (see Chapter 12 for comment on deer management).

In summary, most reserve owners have not been required to make any significant concessions in pest control or game shooting over land that has been declared a NNR. With few exceptions, there has been no particular recognition of the unique nature conservation role that these few chosen sites must play. However, if as suggested, pest control on all NNRs is reduced to a "demonstrated need" basis (with possibly some specific exceptions for fox control during lambing in April) and game shooting confined mainly to grouse and red deer on specified reserves, the overall management of the vertebrate biota will more closely resemble that envisaged by international conservation

organisations and most conservationists. The additional financial commitment required of the NCC is likely to be small.

CHAPTER 12

THE MANAGEMENT OF RED DEER ON NNRs IN SCOTLAND

SECTION 1 - RED DEER IN NNRs IN SCOTLAND

12.1 Red Deer and Other Herbivores in NNRs.

In reviewing the distribution of red deer on reserves and SSSI in Scotland, Campbell (1975) wrote "...of the 27 reserves and SSSI (A's) totalling 170,306 acres which hold red deer...26 were established for wholly or partly botanical reasons." Although exclosures are used to protect parts of some botanically important areas "On 17 (sites) no attempt is made by the NCC to influence deer control mainly because of the ownership situation" (ibid.). The latter refers to reserves being held under NRAs.

In the intervening seven years the situation has not changed. Of 42 mainland terrestrial NNRs red deer occur regularly on 26 of which only six - Beinn Eighe, Cairnsmore of Fleet, Claish Moss, Glasdrum, Rannoch Moor and Taynish NNRs - are more than 50% owned by the NCC. Roe deer are found on seven further reserves on which red deer are absent (or rare) and domestic stock on 3 reserves on which all deer are absent or rare. This leaves only five small reserves (including Corrieshalloch and Allt nan Carnan gorges, Whitlaw and Blawhorn mosses and Tynron Junipers) on which large herbivores do not exert a significant (usually overwhelming) effect on ecosystem dynamics over the bulk of the reserve. Of the 36 NNRs with herbivores only

on Glen Roy NNR were botanical values not of primary importance in the selection of the site as a NNR. On 17 of the 26 NNRs where red deer occur regularly browse sensitive woodlands and/or scrublands were a primary reason for the selection of the site and tall-herb and montane-herb communities are important on several additional reserves including Ben Lawers, Ben Lui, Invernaver and Rannoch Moor NNRs.

Whilst domestic stock are important on 14 mainland NNRs, and like red deer may have adverse effects on the flora, they are responsible in several areas for at least part of the conservation interest. On St. Cyrus NNR (locally preventing development of coarse grasses and spread of gorse), Caerlaverock and part Taynish NNRs (maintaining goose pasture), Craigellachie, Glasdrum and part Loch Sunart NNRs (maintaining glades for lepidopteran fauna) domestic stock are, or have recently been, of importance. Their role is not further discussed.

Red deer are present in sufficient numbers to exert a significant restraining influence on the development of important floras on many of the 26 reserves on which they occur. Aspects of their management, with particular reference to woodland and sample NNRs, are discussed.

12.2 Effects of Red Deer on Upland and Forest Ecosystems.

There is a voluminous literature relating to the effects of red deer on forest, scrubland and upland ecosystems and some of the pertinent British and European literature is summarised by Mitchell *et al.*,(1977).

The general conclusions are that red deer (and other herbivores) have a restraining influence on the development of floras and if present in sufficient numbers can cause some species and communities to become extinguished. On the acidic uplands characteristic of many Highland NNRs heavy grazing, often exacerbated by fire causes "Not only common ericoids

such as heather (to) disappear but (also) rarer species such as bearberry, crowberry, cowberry, dwarf juniper and along with them other organisms which depend on these dwarf shrubs for food and shelter" (Ratcliffe, 1965; c.f. also Duffey, 1974; Welch, 1974). On base rich uplands calcicolous dwarf shrubs, small willows and *Dryas octopetala* may disappear or exist only as grazed down remnants (Ratcliffe, 1965). On Rassal Ashwoods NNR grazing has apparently resulted in the demise of *Dryas octopetala* and *Salix myrsinites* (McVean, *et al.*, 1959) and on Caenlochan NNR dwarf willow and tall herb communities exist only as remnants mostly in inaccessible places (Huntley, 1976).

The maintenance of traditional grazing pressures on established floras does not usually threaten the *status quo* (Welch, 1974) and because refuges often exist does not necessarily decrease the total flora (*ibid.*). However, the development of dwarf shrub, shrub and tree species is frequently prevented (Chapters 9, 10 and above).

In Table 12.1 data on red deer densities on sample NNRs is presented. Because of sometimes enormous seasonal variations in deer numbers and the differing responses of plant species to browsing such data are merely indicative of browsing pressure on the reserves. Mound Alderwoods and Craigellachie NNRs have the lowest red deer populations relative to the area of woodland (17 and 24 deer/100 ha respectively) but the effects are supplemented by grazing of domestic stock. On Morrone Birkwoods NNR and Glen Feshie section populations can reach 1809 and 1140 deer/100 ha of woodland respectively (184.9 and 18.5 deer/100 ha of total reserve area respectively). Despite having the lowest overall population of red deer at 3.5/100 ha regeneration of tree species on Beinn Eighe NNR is widely prevented by browsing. It supports the equivalent of 127 deer/100 ha of woodland. With its more amenable climatic and soil conditions Rothiemurchus section with 39 deer/100 ha of woodland and 5.6 deer/ha overall is renowned for its natural Scots pine regeneration (Plate 9.5).

Reserve/Section	Unfenced woodland (ha)	Deer population	Unfenced woodland: deer/100 ha	Whole reserve: deer/100 ha
Beinn Eighe	130	165	127	3.5
Caenlochan		1500/2000		41.2-55.0
Cairngorms				
Rothiemurchus	842	332	39	5.6
Glen Feshie	126	1436	1140	18.5
Invereshie	544	204	38	6.6
Craigellachie	133	32	24	12.3
Inchnadamph		377		29.1
Inverpolly				
Eisg brachaidh / Polly	229	219	96	3.7
Drumrunie	116	332	286	6.8
Mound Alderwoods	179	30	17	11.2
Morrone Birkwoods	23	416	1809	184.9
Rannoch Moor		167		11.1

Table 12.1 Deer populations and density relative to area of unenclosed woodland and total reserve area in sample NNRs with significant red deer populations.

Notes:
1. Beinn Eighe : mean of 21 counts between 1954 and 1981.
2. Caenlochan : winter population is often zero : summer population 1500 to 2000 + animals. (RDC counts 1966, 75, 79; L. Stewart, pers. comm.)
3. Cairngorms : mean of RDC counts in 1967 and 1980, NCC counts in 1974, 76, 78, 79.
4. Craigellachie : highest population recorded in intensive survey Dec/Jan 1980/81 (B. Lightfoot, pers. comm.) About 100 ewes plus lambs on reserve.
5. Inchnadamph : RDC count, Feb/Mar 1976.
6. Inverpolly : mean of 14 counts between 1963 and 1981. 1200 ewes (and 840 lambs May to September) on Eisg brachaidh and Polly sections.
7. Mound Alderwoods : D. Duncan, guesstimate. 65 cows plus followers on reserve May to October.
8. Morrone Birkwoods : RDC count Feb/Mar 1967.
9. Rannoch Moor : mean of 24 counts between 1959 and 1982.
10. RDC counts (all in Feb/Mar) include animals adjacent to reserve boundaries and which regularly cross the boundaries into the reserve.

Caenlochan NNR has about 50 deer/100 ha of reserve and ranks with Morrone Birkwoods NNR as the most heavily populated area.

That damage to regenerating woodlands and shrublands occurs at the densities is predictable. Holloway (1967) found that at a winter density of 25 deer/100 ha few seedlings of birch, larch or Scots pine survived and only at 1.7 deer/100 ha was development little impaired. Noting that the situations are not strictly comparable Phillips and Mutch (1974) record that foresters on the continent permit only 2 or 3 deer/100 ha of woodland (which results in acceptable levels of damage) whilst Mitchell et al., (1977) report a range of 0.8 to 2.7 deer/100 ha of woodland. Periodically, stocking rates in woodland on NNRs are from about 10 to 600 times the average rates on the continent and even by Scottish standards (which reach 15 deer/100 ha overall only in heavily stocked areas - Mitchell et al.,(1977)) tend to be high.

The actual grazing pressure required to bring about changes in dwarf shrub heaths and other upland communities do not appear to have been quantified. The only upland exclosures (on Beinn Eighe and Inchnadamph NNRs) show spectacular responses to the cessation of browsing and grazing (Plate 9.2; Ratcliffe, 1977; personal observation) at densities of 3.5 deer/100 ha for Beinn Eighe and 29.1 deer plus 31.3 ewes/100 ha for Inchnadamph.

12.3 The NCC's Management Policy for Red Deer.

A clear statement of intent is contained in the Report to the Director (Scotland) of the Red Deer Working Group (1975) chaired by Mr. N. Campbell. In it the Working Group said of red deer that "Their status on reserves is that of a native herbivore and they must be controlled... to the extent that the aims of reserve management are not adversely affected." The recent Cairngorms Policy Guidelines (NCC, 1981c)

confirm this philosophy.

Because it has frequently been demonstrated that current browsing levels are inimical to the botanical values of many important plant species and communities, but not yet demonstrated that current browsing levels are necessary for the maintenance of features for which the sample reserves were chosen, a general decrease in red deer (and sometimes other herbivore) populations is desirable. The two methods of reducing browsing pressure - by enclosure and by an overall reduction in deer numbers - are discussed.

12.3.1 Exclosures in Mainland NNRs with Woodlands.

Table 12.2 shows that of the 23 mainland terrestrial NNRs in Scotland with woodlands with conservation values only three - Allt nan Carnan, Corrieshalloch and Tynron Junipers NNRs - are essentially free of red and roe deer. In general the NCC has reacted to the adverse effects of deer browsing by enclosing parts of the woodlands (or potentially regenerable or afforestable areas) within deer-proof exclosures.

Excluding Glen Tanar NNR (as per Table 12.2) the total area enclosed - 765 ha - is equivalent to 15.1% of the extant area of woodlands within these 23 reserves. Beinn Eighe and Cairngorms NNRs (366 ha and 155 ha enclosed respectively) make up 68.1% of the total area enclosed: in other reserves only 244 ha (7.9%) of a total wooded area of 3098 ha is protected. Despite these measures more than 2200 ha of woodland is known to be not effectively regenerating on favourable sites because of browsing, and on large upland reserves such as Beinn Eighe, Cairngorms, Inverpolly and Strathfarrar the area of potentially forestable land is, in the absence of herbivores, limited mainly by time and by altitude limits.

The Ariundle part (70 ha) of Loch Sunart NNR and Loch a' Mhuilinn

Reserve	Red deer	Roe deer	Woodland (ha)	Area Enclosed (ha)	% of Woodland Enclosed
With Woodland					
Alt nan Carnan			7	0	0
Beinn Eighe	x	x	184	366	199.0
Cairngorms	x	x	1769	155	8.3
Corrieshalloch			5	0	5
Craigellachie	x	x	135	2	1.5
Dinnet Oakwood		x	13	0	0
Glasdrum	x	x	102	6	5.9
Glen Nant	x	x	59	0	0
Glen Tanar	x	x	see Note 2		
Inverpolly	x	x	354	33	9.3
Kirkconnell Flow		x	126	0	0
Loch a'Mhuilinn	(x)	x	20	67	335.0
Loch Lomond		x	128	0	0
Loch Maree	x	x	200	0	0
Loch Sunart	x	x	120	70	58.3
Milton Woods		x	24	0	0
Morrone Birkwoods	x	x	33	23	69.7
Mound Alderwoods	x	x	179	0	0
Muir of Dinnet	x	x	475	0	0
Rassal Ashwoods	x		16	7	43.8
Strathfarrar	x	x	881	36	4.1
Taynish	x	x	216	0	0
Tynron Junipers			5	0	0
Total Owned Reserves			1294	538	41.6
Total NRA Reserves			3757	227	6.0
Grand Total			5051	765	15.1
Moorland					
Caenlochan	x	x	4	0	
Inchnadamph	x			8.8	
Invernaver	x		5	0.01	
Rannoch Moor	x	x	4	4.0	

Table 12.2 Deer distribution, woodland area and exclosures in mainland NNRs with important woodlands. Sample 'moorland' NNRs also shown.

Notes:
1. Area enclosed excludes woodlands or afforested areas enclosed primarily for production purposes (as on Beinn Eighe and Cairngorms NNRs)
2. Glen Tanar includes a 182 ha "Red deer free zone" and a 1253 ha "fenced forest zone", from which attempts are made to exclude deer, in a total of 1916 ha of Scots pine woodland. All fences were built before declaration of Glen Tanar as a NNR.
3. On Loch a' Mhuilinn NNR red deer (and sika deer) were present until recently fenced out.
4. On Rannoch Moor NNR the 4 ha exclosure has been planted up with tree species.
5. On Caenlochan and Invernaver NNRs no part of the woodland has been enclosed and only insignificant areas of the woodlands on Beinn Eighe, Cairngorms and Strathfarrar NNRs.
6. Only on Inchnadamph NNR (8.8 ha) and Beinn Eighe NNR (0.6 ha) have moorlands been enclosed for reasons other than afforestation.

NNR have been completely enclosed to permit their woodland ecosystems to regenerate and develop. Other reserves including Glen Nant, Dinnet Oakwood, Milton Wood and Taynish, with comparable woodland values and lacking in regeneration are completely unprotected.

With 41.6% of woodland (or equivalent areas) enclosed on owned NNRs and only 6.0% on NRA reserves the NCC has clearly biased its efforts towards owned reserves (Table 12.2).

12.3.2 Overall Reduction in Deer Numbers within Mainland NNRs.

On mainland NNRs regular counts of red deer over a long period are available only for Inverpolly, Beinn Eighe, Rannoch Moor and, to a lesser extent, Cairngorms NNRs (Table 12.3). In Cairngorms NNR a very

Reserve/Section	Period					
	1953-57	1958-62	1963-67	1968-72	1973-77	1978-82
Beinn Eighe	4/154	5/134	4/176	4/203	2/167	2/169
Cairngorms			1/2010		1/1734	2/1552
Inverpolly						
Drumrunie			5/262	5/264	2/423	2/515
Eisg brachaidh plus Polly			5/261	5/223	2/129	2/195
Overall			5/523	5/487	2/552	2/710
Rannoch Moor		4/159	4/204	4/221	1/205	3/125

Table 12.3 Summary of red deer counts on four NNRs for which long-term data is available. The first figure refers to the number of counts, the second to the mean of the counts. Data from counts in Feb./Mar./April period except for Beinn Eighe NNR where up until 1967 counts were made in summer or autumn.

low NCC count in 1978 was not confirmed by the 1980 RDC count and the implied decrease in the last period is misleading whilst the single

count in 1967 is insufficient to establish the early population level. Certainly Dulverton (1980 and pers. comm.) maintains that deer populations on Glen Feshie have been stable since 1967, and Rothiemurchus counts have always been around 330 animals. Similarly the low average for the 1978-82 period for Rannoch Moor NNR is due in part to a very low count in 1982 and RDC counts for the region including Rannoch Moor NNR show a regular increase from 6309 to 7832 between 1967 and 1982.

In 1972 some 500 ewes were removed from the Drumrunie section of Inverpolly NNR and recent counts indicate that red deer numbers are building up to replace the sheep stock. There is little evidence to suggest that Eisg brachaidh and Polly deer have drifted permanently onto Drumrunie although a decrease in the mean for the 1973-77 period coincides with the removal of the sheep stock from Drumrunie.

Deer numbers on Beinn Eighe NNR have remained stable for 30 years or more and there is no evidence that deer stocks on the two owned reserves - Beinn Eighe and Rannoch Moor - have been treated differently to those on the two reserves held under NRAs.

Apart from Loch Sunart and Loch a' Mhuilinn NNRs it is not thought that significant decreases in red deer populations have occurred on any of the reserves in Table 12.3. However, increases in the numbers of red and sika (Sika nippon) deer are reported for Taynish NNR following the removal of domestic stock in 1977 (R. Bridson, pers. comm.) and D. Grant (pers. comm.) maintains that there has been a one third increase in the numbers of summering deer on Caenlochan NNR. Numbers of wintering red deer have probably increased in Morrone Birkwoods NNR following the enclosure and planting-up of large areas of adjacent lowland and deer numbers in Glen Nant have also probably increased for the same reason.

12.4 Summary.

In the preceding sections it has been argued that large numbers of red deer are generally damaging to the upland and woodland communities for which most NNRs have been established; that sample NNRs, at least, have abnormally high seasonal concentrations of red deer in relation to conservation values and that the NCC has a policy of controlling deer numbers if reserve objectives are threatened. The only method used to reduce browsing pressure has been by excluding deer from selected areas of woodland or from areas to be regenerated or planted to woodland.

Proportionately greater areas of woodland have been enclosed on owned as compared with NRA reserves although insignificant areas of upland communities have been released from browsing pressure. There is clearly more freedom to act on owned NNRs (c f. also Campbell, 1975; NCC, 1981c) and the management of red deer on the three owned sample NNRs with red deer populations is examined with reference to reserve objectives.

SECTION 2 - MANAGEMENT OF RED DEER ON OWNED SAMPLE NNRs

12.5 Red Deer Management on Beinn Eighe NNR.

The main management objective of Beinn Eighe NNR is "...to maintain, improve and diversify the area...for the continuous ecological study of its forest, moorland and montane habitats, and the animal communities which these support." (Boyd and Campbell, 1965). The objective will be promoted by 1) the re-creation of natural type forest and 2) the preservation of the montane communities (ibid.).(See 9.2.2.1 for a brief description of the montane shrub heaths). These proposals recognise that the main values of Beinn Eighe as a NNR lie in the preservation and development of its flora (c f. also NCC, 1975) and the commitment with which the NCC has pursued the restoration of woodland (Chapter 9) verifies this. However, the practicalities of achieving the third stated proposal, that of "...the maintenance by scientific management of the Red Deer herd" has proven to be largely incompatible with the botanical interest and wider conservation values of the reserve.

On no occasion has it been demonstrated (nor is it likely to be) that large numbers of red deer are necessary for the maintenance of conservation values within the reserve. They do have an amenity value, but under the terms of the 1949 Act the NCC is not obliged to accommodate recreational and amenity values at the expense of scientific and ecological values, and in any case amenity values are well met on the adjacent National Trust for Scotland's Torridon property and on innumerable other reserve areas throughout Scotland.

It is the intention in this section to demonstrate that the objective of maintaining a herd of red deer on Beinn Eighe is unnecessary and not in the best conservation interests of the reserve.

12.5.1 The Need for a Research Herd of Red Deer.

The NCC is required to provide, on its NNR series, "...special opportunities for the study of, and research into, matters relating to the fauna and flora of Britain..." (HMSO, 1949). The original justification for maintaining large numbers of red deer on Beinn Eighe NNR was for research purposes (Boyd and Campbell, 1965). For various reasons the deer herd on the reserve has not been exploited for serious research purposes: almost all research on red deer on NNRs in Scotland is carried out on Rhum NNR where "...as almost nowhere else in Scotland, Red Deer can be studied in a contained environment, unaffected by outside interests..." (NC , 1970). In comparison, Beinn Eighe provides an inferior experimental situation and there is no reason for unnecessarily duplicating research opportunities on the small range of owned NNRs particularly when red deer are damaging to other reserve interests. Rhum NNR does not provide conditions for studying deer behaviour in a woodland environment but Beinn Eighe has been used for this purpose only in a minimal way e.g. Mitchell et al., 1982; Herbert, 1982 and such research should logically be centred in reserves where the NCC does not have the same rare opportunity to control red deer populations e.g. Rothiemurchus section of Cairngorms NNR, Strathfarrar NNR.

12.5.2 The Cost of Red Deer on Beinn Eighe NNR.

To date the NCC and Forestry Commission have erected 29,240 m of deer fence at a total current value of about £117,000 (equivalent to an expenditure of £3,900 per annum since declaration) to restrict deer access to planting areas. This is a continuing expense for as long as the planting programme continues and, comprehensive as it is, still fails to protect any recognised montane communities or provide the

conditions under which natural Scots pine woodland can regenerate (Chapter 9). Re-afforestation of bared areas on Beinn Eighe NNR with Scots pine has, in terms of finance and commitment, probably been the biggest single project on any mainland NNR. In the 1978-79 year, for example, allocations for woodland related activities on Beinn Eighe attracted 11.9% of total man-days and £2000 in contract expenditure (NCC, 1978b). Yet the management of red deer, which are of no established conservation value to the reserve ecosystem, attracted 16.4% of total man-days and £5000 in contract expenditure. The cost of having red deer on Beinn Eighe NNR, relative to their conservation worth, is disproportionately high.

12.5.3 The Gairloch Conservation Unit.

The Gairloch Conservation Unit (GCU) embracing about 35,000 ha of uplands and including Beinn Eighe NNR with its 130 ha of natural Scots pine woodland, was promoted by the NCC and established with the agreement of the neighbouring landowners in 1967 (Boyd, 1967; NCC, 1975). The main objective was to rationalise the management of the communal red deer herd and "...to improve the habitat for them (red deer) by providing more food and shelter " (NCC, 1975). The NCC's special management responsibilities in NNRs and the unique opportunity to permit Scots pine woodland, grassland, shrub heath and moss heath communities to evolve as an ecosystem free from the all-pervasive and dominating influence of large herbivores (and especially red deer) are not accommodated within the GCU's objectives. On the contrary "Management of the red deer population aims (only) to meet the demands for stalking, venison and recreational enjoyment without reducing the value of the natural resource" (ibid.). As established above the prime natural resource of Beinn Eighe is its flora and the potential

for its development. Although long-established steady grazing pressure is unlikely to further reduce the value of grassland and some montane communities (c f. Welch, 1974) woodlands at least will continue to degrade and there is no prospect of an improvement in any community to more original conditions and hence increased diversity within the NNR system (significant areas of ungrazed upland communities are not represented in any mainland NNR).

12.5.3.1 Practical commitments under the GCU. The main practical commitments are a) NCC involvement in regular counts over the GCU (carried out nine times since 1967).

b) A commitment to maintain red deer numbers at a level that does not harm the sporting and production interests of the adjacent landowners. Table 12.3 demonstrates that within the reserve no significant changes have occurred in the stocking rate of red deer since 1968. The average population for the whole unit for the same periods (1968/72, 1973/77, 1978/82) at 1427, 1007 and 1348 animals respectively, confirms the results.

It is entirely unlikely that the same deer herd, managed on an exploitive basis to maximise grazing and sporting potential up until 1967, could meet the vastly differing requirement for the same area managed primarily for conservation purposes. Yet there is no evidence for a change in population overall or within Beinn Eighe NNR.

c) Predictably, the commitment to "...improve the habitat...by producing more food and shelter" (NCC, 1975) has been met only by the NCC who are establishing some 366 ha of new woodland on what was previously moorland. One exclosure of 16 ha has already been opened up to deer. Excluding Beinn Eighe NNR the total wooded area on the GCU is less than 60 ha and apart from a few hectares of mixed

species established on Torridon (L. MacNally, pers. comm.) there has been no new woodland planted since the GCU was formed.

12.5.3.2 Proportional stocking of red deer on Beinn Eighe NNR. With browse sensitive species included in woodland, shrubland and montane communities the expectation would be for a lower stocking of red deer in an area whose prime objective was conservation in comparison with a similar area where the objective was production of protein. The mean total stocking on the GCU for eight completed counts between 1967 and 1982 is 1319 deer in an area of 35,000 ha. On a pro rata basis (excluding the 506 ha Torridon addition in 1974) the share for Beinn Eighe NNR is 160 which is close to the actual number of deer utilising the reserve (Table 12.3). As far as stocking rates are concerned no concessions have been made to foster the botanical values of the reserve.

12.6 Red Deer Management on Rannoch Moor NNR.

In the excellent management plan for Rannoch Moor NNR (NCC, 1979c) the authors establish that maintenance of existing types and diversity of valley/soligenous and blanket mires and maintenance and enhancement of rare species, including Rannoch rush (Scheutzeria palustris) and several other locally occurring species, are important objectives of management. To achieve these objectives it is concluded that with respect to grazing the status quo should be maintained until such time as natural grazing levels are ascertained even though "...the mire communities of Rannoch Moor are probably relatively easily damaged by such activities as burning, grazing, use of tracked vehicles, trampling etc...." (ibid.).

In winter Rannoch Moor NNR supports a long-term average of

11.1 deer/100 ha (Table 12.1) and under certain weather conditions up to 700 deer may be present on the reserve for a few hours to several days (M. Pearson, pers. comm.). Periodically enormous pressures must therefore be exerted on palatable and trampling-sensitive plants.

The nationally rare Rannoch rush has recently been found at several stations on the reserve (R. Smith, pers. comm.) and although Sledge (1949) reported it to be a "...frequent and characteristic species..." on certain sites on Rannoch Moor there is no direct evidence to suggest that it has declined markedly in recent years outside afforested areas. However, it does sometimes grow "...on bare, black semi-liquid organic mud..." which are precisely the sites sought by red deer stags for their wallows. Furthermore, it is extremely sensitive to drying out of its habitat (Druce, 1932) and although the causes of hagging (and hence local drainage) on Rannoch Moor are not known (NCC, 1979c) the trampling effects of large numbers of red deer may be a contributory cause. Certainly deer are known to concentrate on bare peat areas and to use already eroded areas for shelter (Staines, 1976) thus exacerbating erosion if not initiating it, and the management aim to "...maintain the existing hydrological regime by preventing physical damage to the (mire) surface" is not assisted by the traditionally large numbers of deer. Nor are the prospects of survival of the Rannoch rush (and the associated Carex limosa) which are both dependent on the well-being of these mire areas.

In a similar way the stand of Betula nana, which occurs only locally in Scottish NNRs, is heavily and persistently browsed by red deer. It nowhere exceeds 25 cm in height (the height of the surrounding vegetation) although when subjected to a more moderate browsing regime will grow to 1 m tall (Clapham et al., 1952).

Thus whilst the status quo with respect to browsing might permit

the survival of these rare and/or local species there is no evidence to suggest that browsing by red deer is helpful to their survival. There is every indication, however, that at least part of the primary objective - that of enhancing their status on Rannoch Moor NNR - will not prove possible under the current browsing regime.

12.7 Red Deer Management on the Invereshie/Inshriach Section of Cairngorms NNR.

The Scots pine woodland and juniper shrublands are ecologically irreplaceable, and unique in that they are owned by the NCC. The NCC desires their "natural development" (NCC, 1981c) but this is currently prevented by browsing and trampling of red deer (ibid.) Although the culling rates on this section have recently been increased (D. Gowans, pers. comm.) such measures can only be marginally effective in controlling deer numbers on an area of land surrounded on three sides by well-stocked deer forest and which is used extensively by large numbers of wintering deer (sometimes over 400 according to RDC records; frequently over 200 - D. Gowans, D. Holland, pers. comm.). A more radical approach to deer control is required and is discussed in the following section.

12.8 Discussion.

Miles (1981) has demonstrated that most uplands in Scotland are "degraded ecosystems" which are "biologically impoverished". Most Highland NNRs contain relicts of once more abundant shrub heath, scrubland and woodland ecosystems brought to, and maintained in their perilous state, at least in part, by over-grazing and browsing (see 12.2). The equivalent of 15.1% of woodlands in NNRs receive

temporary protection by enclosure but no significant parts of upland and scrubland ecosystems are protected. In the Policy Guidelines for Cairngorms NNR (NCC, 1981c) it is suggested that sub-alpine heaths and scrub should be enclosed but only on Inchnadamph NNR, with a tiny 8.8 ha enclosed, have such communities been protected. Yet where present they are invariably amongst the reasons for selection of the sites as NNRs.

The maintenance and improvement of diversity in NNRs is well established as a basic conservation guideline e.g. Ratcliffe, 1977 and the NCC has a scientific, ecological and moral responsibility to provide conditions for the development of diverse floras. Highland NNRs comprise mostly heavily grazed biomes and the release of selected reserves from browsing will add a new and unique dimension to the diversity of Highland ecosystems in NNRs.

Both Nicholson (1974) and Mitchell et al. (1977) comment that in the Highlands red deer, rather than the flora and the soils which support them, are regarded as the resource and even on Beinn Eighe NNR deer are regarded as a "natural resource" by the GCU (NCC, 1975). This leads to a fundamental incompatibility between nature conservation and estate management. It is suggested that substantial changes are best pursued on owned NNRs and in fact the NCC has biased its allocation of resources for enclosure towards owned reserves. On an individual reserve basis the continued presence of red deer on Beinn Eighe, Rannoch Moor and Invereshie/Inshriach section of Cairngorms NNR might possibly be justifiable. But as part of Scotland's NNR system where red deer (and domestic stock) influence and frequently dominate the ecosystem on 36 of 42 mainland NNRs, where compromises between reserve objectives and estate management inevitably result and where real changes can only be guaranteed on owned NNRs the case

for seriously considering the elimination of herbivores on some owned NNRs is strong.

Although Cooper and Mutch (1979) point out that deer management as it is now practised cannot be regarded as a truly indigenous land use deer are part of the natural ecosystem and must be assured of a place in the NNR system. However, the conservation values of large numbers of red deer on Beinn Eighe, Rannoch Moor and Cairngorms NNR have not been established and with up to 300,000 red deer in Scotland distributed over 2,500,000 ha (ibid.) they are well represented in all habitats and on other NNRs.

The degraded montane shrub heaths and associated floras (Poore and McVean, 1957) are of primary conservation value on Beinn Eighe NNR and their preservation is a primary objective of management (Boyd and Campbell, 1965). They are currently unprotected from the browsing and trampling effects of red deer which certainly assist in the maintenance of their relict condition. Browsing at current levels is directly antipathetic to the NCC's stated objective of restoring and expanding the relict of native Scots pine woodland. A third, and by subsequent experience, unjustifiable objective - that of "...maintenance of the deer herd..." (ibid.) consumes a disproportionate share of finance and man-hours. Since 1967, deer management has involved the NCC in several onerous responsibilities under the GCU. In conservation terms it is difficult to establish how Beinn Eighe NNR has benefitted from the liason and in 15 years only the NCC has honoured the GCU's objective of habitat improvement for red deer.

In Chapter 9 it is suggested that a deer-proof fence of some 12 km length would isolate 3600 ha of Beinn Eighe NNR, including the main plant communities, from red deer. This proposal is confirmed in respect of the additional arguments presented above. Part of the cost would

be met by re-deploying existing fencing material (see 9.3). With respect to plantation forestry Cooper and Mutch (1979) state that estate owners should "...accept some responsibility for the problems they exacerbate...(and)...should participate in the cost of forest protection." The same argument might be pursued by the NCC for the protection of important floras. It is not suggested that the NCC withdraw from the GCU but its role within the Unit would require to be substantially modified.

There are a number of strategies by which pressure on a fence could be minimised. Deer numbers on Beinn Eighe NNR are comparatively stable at around 165 beasts and this indicates that at no time is the area attractive to most of the 1300 or so animals on the GCU. Staines (1970) has shown that the same wintering territories are repeatedly used and that deer will even by-pass new obstacles to get to their traditional areas. Hefting behaviour is confirmed by studies on Rhum by Lowe (1966) and Staines (1974) quotes data from Rhum indicating that hinds are particularly faithful to home ranges. Red deer have proved difficult to move out of their home ranges e.g. Staines (1974), and Dunnet (1975) had only limited success in changing the behaviour of stags in winter by diversionary feeding implying fidelity to an area. Such observations suggest that if deer traditionally using Beinn Eighe NNR were shot rather than displaced pressure to colonise the reserve by "outside" animals would be small. The main pressure on the fence would be from exploring and displaced stags and shooting pressure would prevent any build-up in animal numbers.

Such a policy would have minimal effects on deer on adjacent properties. Neighbours in the GCU could assist the NCC by establishing shelter on their properties and by developing "greens". Welch (1971)

found that utilisation by red deer over a 12 month period was 67% greater on Agrosto-Festucetum given lime and phosphate than on similar, adjacent, untreated sward.

It has been proposed that red deer have no proven conservation value on Rannoch Moor NNR and that they pose a threat to rare and local flora and possibly to the hydrology of the mires. As a consequence of the arguments presented it is suggested that current deer numbers should be drastically reduced. Rannoch Moor is already 70% enclosed by 7.6 km of Forestry Commission deer fence on the east and south sides. Total enclosure would be assured by the erection of 1.3 km of fence at the north end and 2 km on the south-west side (the north-west boundary is Loch Laidon). Possibly closing the 2 km gap between the Forestry Commission fence and Loch Laidon (the south-west side) would be sufficient to prevent access by most deer.

One of the main objectives of management on Cairngorms NNR is to encourage the regeneration and extension of the native Scots pine forest and sub-alpine scrub by the management of red deer (NCC, 1981c). "Rigorous protection policies are needed for the fragile montane ecosystems..." and regeneration of tree species is only locally successful (on Rothiemurchus section) because of browsing (ibid.). Partly because the estates involved are sporting and venison-producing estates it is unlikely that owners will accede to the reduction in deer numbers necessary to permit the free regeneration of shrub and tree species on a wide scale (c f. Dulverton, 1980; Nicholson, 1974). Despite this the NCC makes it clear that it "...is committed to the integrity of the NNR as an ecological and management unit." (NCC,1981c). The Invereshie/Inshriach section contains the finest juniper shrubland complex on the reserve and good examples of Scots pine woodland in need of regeneration because of wartime logging (see 9.2.1, 9.5). Only on

this owned section can long-term protection and enhancement be guaranteed and it is therefore suggested that this section be managed as a special unit within the Cairngorms NNR. Thus in section 9.2.1 and Fig. 9.1 examples are given whereby much of the area of major conservation interest on Invereshie/Inshriach can be conveniently isolated from red deer. It is considered that the above arguments strengthen the case for such action and the fence-lines suggested could be readily modified to accommodate additional uplands of particular conservation value.

PART FOUR

SUMMARY AND CONCLUSIONS

CHAPTER 13

SUMMARY AND CONCLUSIONS

In this chapter the main results of the study are considered in their broad context and some general conclusions are drawn which relate mainly to the management of NNRs.

In meeting the first objective of this study, that of establishing, in land administering terms, the roles of the six major conservation groups in Scotland, it has been demonstrated that the NCC administers more land for essentially conservation purposes than the National Trust for Scotland, Scottish Wildlife Trust, Royal Society for the Protection of Birds, Local Authorities and the Forestry Commission combined. Of the total 125,362 ha classified as formal conservation areas in Nature Reserves and equivalent areas some 75.2% is administered by the NCC as NNRs.

The outstanding feature of the NNR system is that few reserves are owned by the NCC. Of 56 NNRs in Scotland only 12 are owned, or predominantly owned, by the NCC: of the total area of 94,317 ha of NNRs only 26.6% (12,084 ha) is owned. The balance is subject almost entirely to NRAs and in Chapter 3 evidence is presented which shows that both NRA and NCC-owned NNRs have suffered degradation of their conservation values despite the fact that their level of protection is popularly considered to be high. Undoubtedly, NRA NNRs are of fundamental importance to the conservation system in Scotland and in Part 2 some characteristics of NRA NNRs are examined in pursuance of the second major objective of the study.

Management concessions made by owners of the sample NRA reserves are minimal and in keeping with the trifling compensation paid by the NCC for concessions. Nevertheless, it has been demonstrated that the quality of reserve management for conservation purposes is directly related to the intensity of wardening by NCC wardens. Competent wardens may engender goodwill amongst owners and tenants and concessions made by owners and tenants may exceed those required under the terms of the NRAs. It would seem, therefore, that money allocated to reserves for wardening generally results in increased value of the site as a conservation area. Minimally wardened sample NNRs including Invernaver, Inchnadamph, Rassal Ashwoods, Kirkconnell Flow, Mound Alderwoods (and NCC-owned Rannoch Moor) would all be likely to benefit from increased wardening and, by virtue of its size alone, Caenlochan NNR probably justifies a full-time warden.

In comparing the quality of management for conservation purposes in NCC-owned and NRA reserves (the third objective of this study) it has been shown that NCC-owned reserves are generally superior. However, two intensively wardened NRA NNRs with accommodating owners and few serious conflicts over land use compare favourably with the best managed NCC-owned NNRs. Contrarily, the management of Rannoch Moor NNR does not compare well with other NCC-owned sample NNRs (although it has by far the best management plan and rationale).

The fundamental differences between the management of NCC-owned and NRA reserves lie mainly in the attitude to, and management of, animals and birds. With the exception of Rannoch Moor NNR, shooting of gamebirds and waterfowl and undirected pest control is not permitted on the sample NCC-owned reserves whilst at least some, and often all, of these activities are permitted on all sample NRA reserves except perhaps Craigellachie NNR. The management of red deer (relating mainly

to the establishment of control areas and isolation of browse-sensitive communities) is also measurably superior on NCC-owned NNRs.

In Part 3 five widely occurring management problems within the sample NNRs, including those identified above, are discussed with reference to the NCC's performance and, where relevant, to the special role of NCC-owned NNRs; this being the fourth objective of the study.

Commercial plantations of mixed species have been established on Cairngorms and Beinn Eighe NNRs. It is concluded that the owner of Glen Feshie has made concessions to nature conservation interests in the selection of tree species and the temporary setting aside of areas for natural regeneration. Important additional concessions including major reductions in deer numbers and changes in the establishment and management of Scots pine woodlands, both of which are desirable, can only be expected if fairly compensated for. The Forestry Commission plantation on Beinn Eighe NNR was not justified in terms of conservation benefits before establishment although some concessions to conservation values have been made in the planting pattern. It is concluded that the NCC, in collaboration with the Forestry Commission should examine the possibility of enhancing the conservation value of the stand by judicious felling and by the establishment of native hardwoods on selected sites. The NCC and the Forestry Commission are similarly urged to resolve the question of the long-term integrity of the unique Scots pine genotype in the Beinn Eighe and West Coulin native Scots pine stands which will be threatened as planted Scots pine of non-local provenance matures.

In order to extend the range of Scots pine on Beinn Eighe and Cairngorms NNRs the NCC has pursued an active and expensive programme of enclosure of afforestable sites. Neither reserve appears to operate under a comprehensive and long-term programme for enclosure and planting

and this is reflected in the lack of consistency in past planting policies and operations. The management of several exclosures, especially on Beinn Eighe NNR, has been unsatisfactory. The long outdated management plans for both reserves offer little or no guidance on such basic considerations as annual planting targets, seed collection requirements, source of planting stock, species selection and mix, land preparation methods, fertilising regime, planting pattern, silvicultural operations and animal control within exclosures. All require long-term planning and long-term commitment. Idle (1981) promotes the case for continuity in the management of NNRs and argues that because reserves tend to outlive the managers, a well prepared and current management plan is "...the best...guarantee of the correct management being done, despite individual preferences and opinions." Of the sample NNRs only Rannoch Moor and Tentsmuir Point have current management plans. Plans for Caerlaverock, Morrone Birkwoods, Rassal Ashwoodsand St. Cyrus NNRs are incomplete and/or in draft form, do not exist for Mound Alderwoods NNR and were written between 15 and 24 years ago, and have not been subsequently updated, for the remaining nine sample NNRs. Wood and Heaton (1976) suggest that written guidelines must be provided for managers when faced with an array of options and objectives, and reserve wardens have an unenviable task in performing their duties in the absence of such a standard. It is concluded that the NCC should make a greater commitment to the preparation of prescriptive management plans to provide for continuity in the allocation of resources and the rational movement towards long-term goals. A more comprehensive approach to management, including the protection from browsing of upland communities, may also result if comment is solicited from scientists and land managers during preparation of the plan.

Part of this long-term planning must inevitably include consideration of the viability of hardwood woodlands on existing Highland NNRs. The condition of the woodlands on Rassal Ashwoods, Inverpolly and Morrone Birkwoods NNRs continues to decline although in each case their protection is a primary object of management. Energetic management since 1978 has resulted in major improvements in the status of a small part of the woodlands and potential woodland in Morrone Birkwoods NNR but protection of woodland in Rassal Ashwoods NNR lags behind that permitted even in the NRA whilst the Inverpolly NNR woodlands are substantially unprotected. It is concluded that on each of these reserves urgent and substantial changes are required in either the land management regime, which is unlikely, or in the extent of enclosure. Failure to substantially modify the status quo will result in the disappearance of some woods, the contraction of others, and the unnecessary continuation of their threatened and relict status.

Game and waterfowl are widely shot on NRA NNRs. With the exception of ~~Caenlochan~~ Caerlaverock NNR shooting of birds and small mammals on NNRs is not monitored by the NCC. All NRA NNRs have game species list incorporated in the NRAs defining up to 14 species which may be unconditionally killed by owners, guests or tenants. In practice, on most NRA reserves the approach to game shooting (except deer) is casual and the pressure inconsistent but light. Rarely is the shooting of birds and small mammals of any consequence in the economy of the areas included in NNRs although some owners would place considerable emphasis on the recreational value of their rights to bird shooting. Game species lists are inadequately researched and casually compiled and frequently species not present on the reserve are included on the lists. Unconditional shooting rights over a wide range of game species on NNRs would not appear to be in the interests of nature conservation

and it is concluded that game shooting (except of red and roe deer to control their populations) is an anachronism reflecting past management practices which are generally incompatible with the present use of the land. Only in exceptional circumstances should the shooting of gamebirds and small mammals, which is incompatible with IUCN standards for this type of reserve, be tolerated.

Undirected pest control is similarly unacceptable on NNRs. All NRA NNRs have a pest species list included in the NRA and owners or their representatives are permitted to destroy nominated species without reference to the NCC or to the general objectives of the NNR. On NRA NNRs pest species lists include from 2 to 17 species of vertebrates and together with game lists may include a high proportion of the larger vertebrates occurring on the reserve. On several major Highland reserves shooting tenants are specifically enjoined to kill and trap the 20 species of pests appearing on the combined pest lists notwithstanding that the main purpose of reservation is essentially to maintain a numerous and diverse population of fauna and flora. It is concluded that the generalised persecution of a range of species nominally classed as pests is an anachronism reflecting traditional, but no longer tenable, management practices. It is similarly incompatible with IUCN standards for this type of reserve. Control of particular species on the basis of demonstrated need may be acceptable and is in fact carried out on several non-sample NNRs.

Gamebird shooting and undirected pest control is permitted only on Rannoch Moor NNR amongst the sample of NCC-owned NNRs and revision of the sporting lease is suggested. Similar operations are also permitted on the owned section of Glen Tanar NNR.

Available evidence suggests that current red deer populations on Highland NNRs dominate the reserve ecosystems and dictate the evolution

of the flora and associated fauna. Apart from excluding red deer from limited areas to be afforested deer management on NNRs differs little if at all from deer management on neighbouring production-oriented areas. Although it is unreasonable to expect owners to relinquish income generated by deer shooting and the sale of venison without generous compensation, on Beinn Eighe and Rannoch Moor NNRs and on the owned section of Cairngorms NNR drastic reductions in deer numbers are possible, not only to more genuinely achieve the objects of management, but also to introduce a new element of diversity into the Highland NNR system that is likely to be available in few other areas in Scotland. The natural regeneration and spread of Scots pine on Beinn Eighe and Cairngorms NNRs (assisted by judicious planting) is a matter of prime conservation significance and in practical terms is most readily achieved by a substantial overall reduction in the number of red deer. Few other sites in the Highlands provide the opportunity to free juniper, heath and alpine communities from excessive browsing pressure. Similar considerations apply to rare and local plants, and to mires and their plant associations, on Rannoch Moor NNR.

Red deer are a natural component of the Highland ecosystem and if Beinn Eighe, Cairngorms and Rannoch Moor NNRs are each considered in isolation a case for the preservation of red deer can be developed. But viewed in the context of a Highland NNR system where red deer are well represented in all habitats the case cannot be sustained. Helliwell (1971a) points out that some species have an emotive value out of proportion to their economic or conservation value relative to other species and cites red deer and golden eagles in the Scottish Highlands. This factor may have influenced the attitudes of some reserve managers. In practical terms there would appear to be few difficulties in substantially reducing deer numbers on each of these

reserve areas. The main problem would therefore appear to be social or cultural rather than practical or philosophical. However, in the removal of red deer from the Ariundle Oakwoods (part of Loch Sunart NNR), and from part of the Glen Affric pinewoods by the Forestry Commission, useful precedents have been established.

Finally, it is concluded that the NCC should make maximum use of the status of owned NNRs in considering reserve management options. In general, manipulations or operations that are not practicable on NRA reserves should be worked into the management planning for NCC-owned NNRs (providing such operations assist in the achievement of the reserve objectives). Apropos this it is suggested that the owned portion of Cairngorms NNR be treated as a reserve within a reserve despite the current policy of complete integration (NCC, 1981c), even to the extent of having its own management plan. It is also suggested that consideration be given to allocating more than the current 6% of the NCC's budget to land acquisition. An increase in the number of NCC-owned NNRs will reduce the number of land use conflicts in Scotland's NNR system.

APPENDIX 1A

AREA OF HABITAT TYPES BY TENURE IN NNRs IN SCOTLAND. CORRECT TO NOVEMBER 1981.

O = owned; NRA = nature reserve agreement; L = lease.

RESERVE	UPLAND			WOODLAND						PEATLAND			COASTAL			OPEN WATER			TOTAL		
				Scots pine			Hardwood/Other														
	O	NRA	L	O	NRA	L	O	NRA	L	O	NRA	L	O	NRA	L	O	NRA	L	O	NRA	L
Allt nan Carnan								7												7	
Beinn Eighe[1]	4045	529		184															4229	529	
Ben Lawers		3974																		3974	
Ben Lui	424	374																	424	374	
Blawhorn Moss										69									69		
Caenlochan		3332	303						4											3332	30
Caerlaverock														5501						5501	
Cairngorms[2]	2541	21307		544	1332												225		3085	22864	
Cairnsmore of Fleet	1314																		1314		
Claish Moss										563									563		
Coille Thocabhaig		26						55												81	
Corrieshalloch							1	2	2										1	2	
Craigellachie		125						135												260	
Dinnet oakwood								13												13	
Glasdrum	67						102												169		
Glen Diomhan								10												10	
Glen Nant								59												59	

Glen Roy	1168												1168	
Glen Tanar		2269	182	1734									182	4003
Gualin		1387					1135							2522
Haaf Gruney									18					18
Hermaness		784							180					964
Inchnadamph		1287									8			1295
Invernaver		340							200		12			552
Inverpolly	15	9497				354	6		50		935		15	10842
Isle of May									57					57
Keen of Hamar									30					30
Kirkconnell Flow[4]							155							155
Loch a'Mhuilinn		42				20					5			67
Loch Druidibeg	717								557		78		1042	635
Loch Leven						40			227		1330			1597
Loch Lomond					63	65			80		208		63	353
Loch Maree Is.				200										200
Loch Sunart woodlands		43			70	50							70	93
Monach Isles									577					577
Milton Wood						24								24
Morrone Birkwoods		192				33								225
Morton Lochs										24			24	
Mound Alderwoods						179					88			267
Muir of Dinnet[3]		440		227		475	133				140			1415
Nigg and Udale Bays									31	609				31

North Rona & Sula Sgeir													130					130		
Noss													313					313		
Rannoch Moor									1423						76		1499			
Rassal Ashwoods		69					16											85		
Rhum	10389											240			55		10684			
St Cyrus													92					92		
St Kilda														853						853
Sands of Forvie													41	1032				41		1032
Silver Flow											191									191
Strathfarrar		1308			881													2189		
Strathy Bog											49									49
Taynish						216						145		9			361			9
Tentsmuir Point												122	383				122	383		
Tynron Junipers								5												5
Whitlaw Mosses										15								15		
Habitats by tenure	20680	47325	303	910[1]	4374[2]	0	452	1537[3]	11	2055	1444	240	507	8467	2503	480	3029	25084	66176	3057
Total habitats		68308			5284			2000			3739			11477			3509		94317	
Habitat as % of total conservation area		72.4			5.6			2.1			4.0			12.2			3.7			
Total area by tenure																		26.6	70.2	3.2
Habitats by tenure (%)	30.3	69.3	0.4	17.2	82.8	0	22.6	76.9	0.5	55.0	38.6	6.4	4.4	73.8	21.8	13.7	86.3			

Notes 1, 2, 3, 4: see after Appendix 1C

APPENDIX 1B

AREA OF HABITAT TYPES BY TENURE IN LOCAL NATURE RESERVES IN SCOTLAND. CORRECT TO NOVEMBER 1981.

O = owned; NRA = nature reserve agreement; L = lease.

RESERVE	UPLAND			WOODLAND						PEATLAND			COASTAL			OPEN WATER			TOTAL		
				Scots pine			Hardwood/Other														
	O	NRA	L	O	NRA	L	O	NRA	L	O	NRA	L	O	NRA	L	O	NRA	L	O	NRA	L
Aberlady Bay														119			463			582	
Castle and Hightae Lochs								10								127			127	10	
Eden Estuary																	413			413	
Gladhouse Reservoir					24											177			177	24	
Munlochy Bay								31						119			300			450	
T O T A L S					24			41						238		304	1176		304	1479	

APPENDIX 1C

AREA OF HABITAT TYPES BY TENURE IN FOREST NATURE RESERVES IN SCOTLAND. CORRECT TO APRIL 1981.

Ariundle[5]							47												47		
Black Wood of Rannoch				649			40												689		
Glen Nant							44												44		
T O T A L S				649			131												780		

Notes:
1. Includes 54 ha planted Scots pine woodland in exclosures 8, 9, 10 in Beinn Eighe NNR.
2. Includes 392 ha plantation and 79 ha 'conservation woodland' in Cairngorms NNR.
3. Includes 57 ha Sitka spruce in Muir of Dinnet NNR.
4. Kirkconnell Flow NNR is classed as peatland although secondary birch and Scots pine woodland extends over 126 ha.
5. Ariundle FNR is owned by the Department of Agriculture and Fisheries for Scotland but included under Forestry Commission holdings for convenience.

APPENDIX 2A

MANAGEMENT RATING FORM (continued)
Use with Appendix 2B Criteria Scoring Guide
Refer to Chapter 4 for use

Reserve name:

NRA with :

Section :

Sources of information

1. Management plan
2. NCC files
3. Reserve warden
4. NCC staff
5. Estate staff
6. Owner/factor
7. Other

Criteria scores

1 = status quo } see 4.3.3
2 = status quo }
±3 = marginal change
±4 = significant change
±5 = extreme change

Habitat (circle)

1. Coastal
2. Woodland
3. Peatland
4. Upland

Notes: 1 non-native = not native to the site.
2 undirected = not specifically directed towards improving conservation values.

Management input	Rating criteria - improvement	Criteria scores 1 2 +3 +4 +5	Rating criteria - deterioration	Criteria scores -3 -4 -5
01 Afforestation / woodlands (commercial)	011 Replace non-native[1] with native species 012 Replace foreign with local provenance 013 Otherwise rationalise, e.g. increase edges, mix species		014 Establish new plantations with close, uniform spacing 015 Replace native with non-native species 016 Plant non-local provenances	
02 Peat/mineral exploitation	021 Reduce level of exploitation 022 Modify techniques to favour conservation values 023 Otherwise rationalise, e.g. rehabilitate exploited area, work seasonally ...		024 Initiate exploitation of resources 025 Change to, or select, techniques less favourable to conservation interests 026 Reduce input into rehabilitation operations	
03 Fishing-sporting	031 Rationalise number of permits 032 Rationalise bag limits 033 Reduce boating access/facilities		034 Undirected[2] increase in number of permits 035 Undirected increase in bag limits 036 Increase boating access/facilities	

APPENDIX 2A (continued)

04 Fisheries-commercial	041 Reduce size of plant/operation 042 Reduce output of plant/operation 043 Incorporate pollution reducing devices; reduce site disturbance / general damage	044 Establish plant/operation 045 Increase capacity of plant/size of operation 046 Increase output of plant/operation
05 Shooting - gamebird	051 Establish control/sanctuary areas 052 Rationalise numbers shot in interests of nature conservation 053 Rationalise species shot in interests of nature conservation	054 Undirected increase in shooting days 055 Undirected increase in proportion of population shot, or removal of bag limits 056 Undirected increase in range of shootable species
06 Shooting - waterfowl	061 Establish control/sanctuary areas 062 Rationalise numbers shot in interests of nature conservation 063 Rationalise species shot in interests of nature conservation	064 Undirected increase in shooting days 065 Undirected increase in proportion of population shot or removal of bag limits 066 Undirected increase in range of shootable species
07 Pest control	071 Reduce undirected 'control' pressure 072 Reduce number of species taken 073 Rationalise 'control' programme in interests of nature conservation	074 Undirected increase in control pressure 075 Undirected increase in number of species taken 076 Introduction of non-specific control measures
08 Deer management	081 Establish non-grazed controls 082 Isolate sensitive areas 083 Adjust animal numbers to meet objectives for habitat	084 Undirected increase in deer numbers 085 Introduce supplementary winter feeding 086 Permit widespread deer-induced damage to develop
09 Domestic grazing	091 Isolate sensitive areas 092 Establish non-grazed controls 093 Otherwise rationalise grazing pressure to meet objectives for habitat	094 Permit sheep/cattle damage to develop 095 Undirected increase in stocking rate 096 Intensify grazing, by enclosure, for commercial purposes only
10 Fertiliser use	101 Reduce undirected general use 102 Monitor effects of use 103 Otherwise rationalise use for conservation purposes, e.g. seedling establishment	104 Undirected increase in general use 105 Change methods of application 106 Undirected increase in variety, rates of fertiliser application

APPENDIX 2A (continued)

11 Pesticide use	111 Reduce undirected general use 112 Monitor effects of use 113 Otherwise rationalise use for conservation purposes, e.g. release chosen seedlings, control pest species	114 Undirected increase in general use 115 Change methods of application 116 Undirected increase in variety, rates of pesticide application
12 Muirburn	121 Reduce frequency of burns 122 Free areas from burning 123 Otherwise rationalise burning in interests of nature conservation	124 Undirected increase in size of burns 125 Decrease period between burns 126 Damage non-target communities
13 Tracking (vehicular)	131 Reduce maintenance on tracks 132 Close down existing tracks 133 Otherwise rationalise track system in interests of nature conservation	134 Undirected increase in track maintenance 135 Open up new tracks for non-conservation purposes 136 Increase in use of tracked or four-wheel-drive vehicles
14 Drainage	141 Block up man-made drains 142 Reduce maintenance on man-made drains 143 Otherwise rationalise drainage system in interests of nature conservation	144 Undirected construction of drains 145 Undirected maintenance of drains 146 Change from mechanical to chemical methods of maintenance
15 Establishment of new species	151 Re-establish locally extinct or near-extinct native species 152 Control/prevent establishment of non-native species 153 Otherwise rationalise in interests of nature conservation	154 Introduce non-native species 155 Encourage existing non-native species 156 Permit non-native species to invade
16 Vegetation manipulation	161 Establish controls/enclosures 162 Facilitate, or restrict, establishment, survival, spread of selected species, communities by manipulation, including ground preparation, planting, silvics. 163 Otherwise rationalise in interests of nature conservation, e.g. construct firebreaks, spraying.	164 Permit new threat to floral values to develop, e.g. loss of necessary grazing, rabbit population explosion, etc. 165 Permit characteristic species, communities to become more uncommon, insecure 166 Permit an aggressive native species to dominate at expense of habitat diversity

APPENDIX 2A (continued)

17 Secure rare/ threatened/ local species or communities	171 Carry out surveys 172 Provide protection 173 Secure by cultivation or by harmonising land use	174 Decrease in the abundance of rare/unusual species or communities 175 Increase in level of threat 176 Undirected change in land use pattern
18 Public access	181 Identify Reserve, control entry 182 Make sensitive/special areas less accessible 183. Fence boundaries	184 No entry restrictions, increasing recreational use 185 Areas deteriorating through over-use 186 Location of track system results in threat to species, community
19 Wardening	191 Appoint warden for Reserve 192 Establish warden close to Reserve 193 Provide interpretative facility	194 Decrease intensity of wardening 195 Make warden's post more remote from Reserve 196 Permit interpretative facility to deteriorate
20 Literature	201 Management plan available 202 Reserve handbook/brochure for distribution 203 Nature Conservation Review description	204 Failure to produce management plan 205 Failure to produce information brochure 206 Failure to secure NCR listing

APPENDIX 2B

CRITERIA SCORING GUIDE

01 Afforestation/woodlands (commercial)

All criteria	Score ±3 if <10% plantation (habitat-014) is affected. Score ±5 if whole plantation (habitat-014) is affected.

02 Peat/mineral exploitation

021, 026	Score ±3 if <10% change, ±5 if operation abandoned.
022, 023	Score ±3 if marginal effect, ±5 if most affected values enhanced.
024	Score ±3 if local use only, ±5 if commercial operation.
025	Score ±3 if no practicable alternatives, ±5 if less damaging cost-comparable alternative ignored.

03 Fisheries - sporting

031, 033, 034 036	Score ±3 if marginal change (<10%), score +5 if permits, access withdrawn, score -5 if permits, access made available.
032, 035	Score ±3 if <10% change, ±5 if >50% change.

04 Fisheries - commercial

041	Score +3 if <10% reduction, -3 if plant/operation abandoned.
042, 045, 046	Score ±3 if <10% change, ±5 if >50% change.
043	Score +3 if reduces pollutants/site disturbance by <25%, +5 if >75% reduction.
044	Score -3 if seasonal, low impact, based on existing fishery, -5 if mechanised and polluting.

05 Shooting - gamebirds; 06 Shooting - waterfowl

051, 061	Score +3 if <10% area/type/habitat affected, +5 if >50%.
052, 062, 055, 065	Score ±3 if <10% change in proportion of population shot, or limits instituted or removed for one common species, ±5 if >50% change or limits instituted or removed for all species.
053, 063	Score +3 if one common species over part area/type/habitat considered, +5 if all species over whole area/type/habitat considered.
054, 064	Score -3 if <10% increase, -5 if >50% increase.
056, 066	Score -3 if one common species added to list, -5 if one uncommon or two common species added.

APPENDIX 2B (continued)

07 Pest control

071, 072, 074	Score ±3 if one species concerned, ±5 if all species concerned.
073	Score +3 if on 'demonstrated need' basis for one species, +5 if so for all species.
076	Score -5.

08 Deer management

081	Score +3 if <1 ha or <1% (whichever is smaller) of area/type/habitat is enclosed, +5 if >10 ha or >5% ... is enclosed.
082	Score ±3 if <10% area/type/species/habitat affected, ±5 if whole area ... affected.
083	Score +3 if <10% area/type/habitat involved, +5 if whole area ... involved.
084	Score -3 if <10% increase, -5 if >25% increase.
085	Score -3 if temporary, -5 if permanent.
086	Score -3 if most unprotected tree seedlings develop, -5 if all failing to develop or if uncommon species or community is continuing to deteriorate.

09 Domestic grazing

091, 092, 094	Score as for 082, 081, 086, respectively.
093	Score +3 if <10% area/type/habitat involved, +5 if whole area ... involved.
095	Score -3 if <10% increase, -5 if >25% increase.
096	Score -3 if <10% habitat enclosed, -5 if >25%.

10 Fertiliser use; 11 Pesticide use

101, 104, 111, 114	Score ±3 if <10% change in use, score ±5 if use abandoned, or started on a significant scale.
102, 112	Score +3 if on casual basis, +5 if planned and formalised.
103, 113	Score +3 if <10% area/type/habitat or programme is involved, +5 if whole area ... involved.
105, 115	Score -3 if change from foot to machine, -5 if change from foot to aerial methods of application.
106, 116	Score -3 if additional chemicals applied to <10% of area/type/habitat, -5 if applied to whole area ....

12 Muirburn

121	Score +3 if reduced and burnt less than once in 12 years, +5 if burnt less than once in 25 years (substitute 1 and 3 years, respectively, for grasslands).

APPENDIX 2B (continued)

122	Score +3 if fragments freed, +5 if communities or viable segments so managed.
123	Score +3 if <10% area/type/habitat affected, +5 if whole area ... affected.
124	Score -3 if burn size increased, now <10 ha, -5 if now >20 ha.
125	Score -3 if increased and burned more than once in 25 years, -5 if more than once in 7 years.
126	Score -3 if <1% community damaged, -5 if >5%.

13 Tracking (vehicular)

131, 132, 134	Score ±3 if affects <10% of non-essential track system, ±5 if affects whole system.
133, 136	Score +3 if affects <10% of area/type/habitat, +5 if affects whole area ....
135	Score -3 if not intended for non-conservation oriented activities, -5 if wholly to facilitate sporting.

14 Drainage

141, 142	Score +3 if done as a matter of course, +5 if justified on scientific grounds.
143	Score +3 if effective over <10% of area/type/habitat, +5 if over whole area ....
144, 145, 146	Score -3 if affects <10% of area/type/habitat, -5 if affects whole area ....

15 Establishment of new species

All criteria	Score ±3 if isolated specimens only involved, ±5 if viable and self-sustaining populations.

16 Vegetation manipulation

161, 162	Score ±3 if fragmented, minor scale, ±5 if formal, well organised, documented.
163	Score +3 if affects <10% area/type/habitat, +5 if affects whole area ....
(164), 166	Score -3 if (threat) affects <10% area/type/habitat, -5 if affects whole area ....
165	Score -3 if locally insecure, -5 if nationally insecure.

17 Secure rare/ threatened/ local species

171	Score +3 if casual information on species available, +5 if detailed, documented, complete.
172	Score +3 if casual wardening is only improvement in security, +5 if 50% known sites secured against threat.

APPENDIX 2B (continued)

173	Score +3 if seed collected, +5 if new populations established artificially or +3 if experimental monitoring under way to delimit requirements, +5 if active management to maintain over range.
174	Score -3 if <25% individuals disappear, -5 if >50%.
175	Score -3 if threat increased over <10% area/type/habitat, -5 if over whole area ....
176	Score -3 if change over <10% known area/type/habitat, -5 if over whole area ....

18 Public access

181	Score +3 if signposted only, +5 if locked gates, stiles, signs encourage use of pre-selected entry points.
182, 185, 186	Score ±3 if <10% area/type/habitat affected, ±5 if whole area ... affected.
183	Score +3 if inconspicuous posts indicate boundary along side with public access, +5 if small reserve enclosed by fence, large reserve fenced along main access.
184	Score -3 if reserve little used, -5 if heavily used.

19 Wardening

191	Score +3 if part-time hon. warden or <15 day visits p.a. by NCC staff, +5 if full-time NCC warden spends over 50% of time on reserve.
192	Score +3 if NCC warden resident within 10 to 25 miles of reserve, +5 if resident within 1 mile.
193	Score +3 if irregular off-site lectures, +5 if on-site interpretative facility.
194	Score -3 if <20% decrease in time on reserve by NCC warden, -5 if full-time NCC warden replaced by part-time hon. warden.
195	Score -3 if on-site warden moved 1 to 10 miles from reserve, -5 if moved >25 miles.
196	Score -3 if warden less available for casual lectures, -5 if on-site facility closed down.

20 Literature

201	Score +3 if management plan >15 years old, +5 if <5 years old.
202	Score +3 if information covers a specific feature only, +5 if all significant biological/environmental features covered.
203	Score +3 if superficial mention of some reserve features only, +5 if reference made to all significant biological and environmental features.
204, 205	Score -3 if failure to produce management plan within 10 years, -5 if not for more than 15 years.
206	Score -5.

APPENDIX 2C

COMBINED SCORES (see 4.5) FOR ALL MANAGEMENT INPUTS FOR THE SAMPLE OF 32 HABITAT-SECTIONS IN THE SAMPLE OF NNRs.

From scores for LHS of Management Rating Score Sheet (App. 2A).
The owned section of Cairngorms NNR is included as a separate, owned, reserve.

NNR/tenure/habitat/number		Management inputs																		
		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
Owned NNRs																					
Woodland																					
Beinn Eighe	28	8	8	8	8	125	8	125	16	50	50	8	8	50	8	40	125	100	125	125	75
Cairngorms	30	8	8	8	8	125	125	125	20	8	8	8	8	2	8	8	20	100	20	100	80
Upland																					
Beinn Eighe	27	5	8	8	8	125	8	125	20	50	10	8	125	8	20	16	100	15	50	125	75
Cairngorms	29	8	8	8	8	125	125	125	32	8	4	8	50	3	8	8	50	24	20	100	20
Peatland																					
Rannoch Moor	31	8	8	2	8	1	1	1	1	50	20	8	50	8	8	4	6	15	6	15	25
Coastal																					
Tentsmuir Point	32	8	8	20	125	125	125	56	8	8	8	50	50	125	25	50	75	20	20	80	25
NRA NNRs																					
Woodland																					
Cairngorms	05	2	8	8	8	75	125	4	1	8	8	8	8	2	8	8	4	12	20	75	60
Cairngorms	07	8	8	8	8	1	8	4	1	50	8	8	8	2	8	8	4	30	20	75	80
Craigellachie	08	20	8	8	8	125	125	16	25	50	8	8	50	2	8	8	50	45	80	60	15
Inverpolly	13	8	8	8	8	8	8	1	16	16	8	18	8	8	8	20	12	80	32	125	100
Inverpolly	16	8	8	8	8	8	8	64	16	16	18	8	8	8	8	20	16	36	24	100	100
Inverpolly	18	8	8	8	8	1	8	1	9	20	8	8	8	8	8	16	16	60	24	100	100
Morrone Birkwoods	21	8	8	8	8	3	8	16	20	8	8	8	50	2	8	4	10	80	32	60	25
Mound Alderwoods	22	8	8	2	8	1	1	5	2	2	8	8	8	8	16	8	4	24	12	12	5
Mound Alderwoods	23	8	8	2	8	1	1	1	2	2	8	8	50	8	16	8	4	24	12	12	5
Rassal Ashwoods	24	8	8	8	8	1	8	16	25	40	8	30	50	4	8	4	40	56	64	12	15

APPENDIX 2C continued

Upland																					
Caenlochan	02	8	8	8	8	1	8	16	1	50	2	8	8	8	4	4	2	20	16	36	15
Cairngorms	04	8	8	1	8	75	8	9	2	8	3	8	5	2	8	8	50	12	20	75	80
Cairngorms	06	8	8	8	8	56	8	4	1	50	20	8	125	1	8	8	4	12	20	100	80
Inchnadamph	09	8	8	1	1	1	8	1	9	9	8	8	12	8	4	12	24	56	16	60	75
Inverpolly	12	8	8	1	4	8	8	1	6	3	8	8	100	4	8	20	32	9	32	125	100
Inverpolly	15	8	8	2	8	8	8	64	5	5	8	18	100	2	8	20	32	9	24	100	100
Inverpolly	17	8	8	2	8	1	1	8	6	20	3	8	100	8	8	4	24	15	24	100	100
Morrone Birkwoods	20	8	8	8	8	1	8	16	16	8	8	8	50	8	8	4	16	12	32	60	20
Peatland																					
Caenlochan	01	8	8	8	8	1	8	1	3	2	8	8	1	8	8	8	4	24	2	16	12
Inverpolly	14	8	8	8	8	1	8	1	4	1	8	8	50	8	8	8	20	20	8	125	5
Kirkconnell Flow	19	2	8	8	8	1	1	1	2	8	8	30	8	50	40	2	5	4	20	24	15
Coastal																					
Caerlaverock	03	8	8	4	4	125	125	100	8	100	8	30	8	20	2	8	125	125	60	125	75
Invernaver	10	8	8	2	2	8	8	1	8	3	8	8	12	8	8	8	8	12	1	12	20
Invernaver	11	8	8	2	2	8	8	1	8	1	8	8	12	8	8	8	2	12	1	12	15
St Cyrus	25	8	8	8	5	8	8	3	8	100	8	50	125	40	8	8	20	125	100	100	15
St Cyrus	26	8	8	8	5	8	8	3	8	50	8	50	125	40	8	8	20	125	100	100	15

APPENDIX 2D

INPUT MANAGEMENT SCORES (see 4.5) FOR ALL MANAGEMENT INPUTS FOR THE 32 HABITAT-SECTIONS IN THE SAMPLE OF NNRs.

Based on scores for LHS of Management Rating Score Sheet (App. 2A).

$$\text{Input management score} = \frac{\text{combined score for input}}{\text{potential score for input}}.$$

The owned section of Cairngorms NNR is included as a separate, owned, reserve.

NNR/tenure/habitat/number		Management inputs																		
		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
Owned NNRs																					
Woodland																					
Beinn Eighe	28	100	100	100	100	100	100	100	12.8	100	100	100	100	100	100	80	100	80	100	100	60
Cairngorms	30	100	100	100	100	100	100	100	16	100	100	100	100	4	100	100	100	80	100	80	64
Upland																					
Beinn Eighe	27	4	100	100	100	100	100	100	16	100	20	100	100	100	100	100	80	12	100	100	60
Cairngorms	29	100	100	100	100	100	100	100	64	100	20	100	12	6	100	100	100	48	100	80	16
Peatland																					
Rannoch Moor	31	100	100	1.6	100	.8	.8	.8	.8	100	100	100	100	100	100	20	30	12	12	12	20
Coastal																					
Tentsmuir Point	32	100	100	100	100	100	100	44.8	100	100	100	100	100	100	50	100	60	20	16	64	20
NRA NNRs																					
Woodland																					
Cairngorms	05	4	100	100	100	60	100	3.2	.8	100	100	100	100	4	100	100	8	9.6	100	60	48
Cairngorms	07	100	100	100	100	.8	6.4	3.2	.8	100	100	100	100	4	100	100	20	60	100	60	64
Craigellachie	08	100	100	100	100	100	100	12.8	20	100	100	100	100	4	100	100	100	36	64	48	12
Inverpolly	13	100	100	100	100	100	100	.8	12.8	12.8	100	36	100	100	100	100	100	64	64	100	80
Inverpolly	16	100	100	100	100	100	100	.8	12.8	12.8	36	100	100	100	100	100	32	28.8	48	80	80
Inverpolly	18	100	100	100	100	.8	100	.8	7.2	100	100	100	100	100	100	80	80	48	48	80	80
Morrone Birkwoods	21	100	100	100	100	2.4	100	12.8	16	100	100	100	100	4	100	20	20	64	64	48	20
Mound Alderwoods	22	100	100	4	100	.8	.8	4.0	4	4	100	100	100	100	80	100	8	48	60	9.6	4
Mound Alderwoods	23	100	100	4	100	.8	.8	.8	4	4	100	100	100	100	80	100	8	48	60	9.6	4
Rassal Ashwoods	24	100	100	100	100	.8	100	12.8	20	80	100	60	100	20	100	45	80	44.8	51.2	9.6	12

APPENDIX 2D continued

Upland																				
Caenlochan	02	100	100	100	100	.8	100	12.8	.8	100	4	100	100	100	20	20	4	16	12.8	28.8	12
Cairngorms	04	100	100	.8	100	60	100	7.2	4	100	2.4	100	4	4	100	100	100	9.6	100	60	64
Cairngorms	06	100	100	100	100	44.8	100	3.2	.8	100	100	100	100	.8	100	100	20	9.6	100	80	64
Inchnadamph	09	100	100	.8	.8	.8	100	.8	7.2	7.2	100	100	100	100	20	60	48	44.8	80	48	60
Inverpolly	12	100	100	.8	20	100	100	.8	12	2.4	100	100	80	20	100	100	64	7.2	64	100	80
Inverpolly	15	100	100	4	100	100	100	51.2	4	10	100	36	80	10	100	100	64	7.2	48	80	80
Inverpolly	17	100	100	4	100	.8	.8	6.4	12	100	2.4	100	80	100	100	20	48	12	48	80	80
Morrone Birkwoods	20	100	100	100	100	.8	100	12.8	12.8	100	100	100	100	100	100	20	32	9.6	64	4.8	16
Peatland																				
Caenlochan	01	100	100	100	100	.8	100	.8	2.4	4	100	100	.8	100	100	100	20	48	4	12.8	9.6
Inverpolly	14	100	100	100	100	.8	100	.8	20	.8	100	100	100	100	100	100	100	100	100	100	4
Kirkconnell Flow	19	100	100	100	100	.8	.8	.8	4	100	100	60	100	100	80	4	4	3.2	100	19.2	12
Coastal																				
Caerlaverock	03	100	100	3.2	3.2	100	100	80	100	80	100	60	100	40	4	100	100	100	48	100	60
Invernaver	10	100	100	4	4	100	100	.8	100	2.4	100	100	9.6	100	100	100	10	9.6	.8	9.6	16
Invernaver	11	100	100	4	4	100	100	.8	100	.8	100	100	9.6	100	100	100	24	9.6	.8	9.6	12
St Cyrus	25	100	100	100	4	100	100	2.4	100	80	100	100	100	80	100	100	16	100	80	80	12
St Cyrus	26	100	100	100	4	100	100	2.4	100	100	100	100	100	80	100	100	16	100	80	80	12

APPENDIX 2E

HABITAT MANAGEMENT SCORES FOR THE 32 HABITAT-SECTIONS IN THE SAMPLE.
(See 4.3 and 4.5)

NRA RESERVES	Number (Table 4.1)	Sum of potential scores for 20 management inputs = P	Sum of combined scores for 20 management inputs = C	Habitat management score ($= \frac{C}{P} \times 100$)
Caerlaverock	03	1543	1068	69.2
St Cyrus	25	1180	755	64.0
St Cyrus	26	1180	705	59.7
Craigellachie	08	1276	719	56.3
Inverpolly	15	1021	537	52.6
Inverpolly	13	970	500	51.5
Inverpolly	16	925	427	46.2
Cairngorms	06	1174	537	45.7
Inverpolly	18	940	427	45.4
Inverpolly	12	1171	493	42.1
Cairngorms	05	1087	452	41.6
Inverpolly	14	823	315	38.3
Cairngorms	07	907	347	38.3
Rassal Ashwoods	24	1096	413	37.7
Inverpolly	17	1288	456	35.4
Morrone Birkwoods	21	1117	374	33.5
Cairngorms	04	1234	398	32.3
Morrone Birkwoods	20	1000	307	30.7
Inchnadamph	09	1408	329	23.4
Mound Alderwoods	23	933	196	21.0
Caenlochan	02	1129	231	20.5
Kirkconnell Flow	19	1363	245	18.0
Mound Alderwoods	22	933	150	16.1
Caenlochan	01	1000	146	14.6
Invernaver	10	1180	153	13.0
Invernaver	11	1180	140	11.9
NCC-OWNED RESERVES				
Beinn Eighe	28	1264	1070	84.7
Tentsmuir Point	32	1435	1011	70.5
Cairngorms	30	1162	797	68.6
Beinn Eighe	27	1393	909	65.3
Cairngorms	29	1171	742	63.4
Rannoch Moor	31	1363	244	17.9

APPENDIX 3A

PROFORMA FOR PEST SPECIES

Pest Species Check List

Reserve name: Habitat section:

Sources of information: NRA/AMP Warden NCC staff Factor Tenant Owner Management Plan Other

Species	Present/absent on Reserve	Takeable as pest?	Taken as pest?	Any restrictions on control?	For all species present on reserve nominate abundance as per accompanying Abundance Rating Card (see Table 11.1)			
					Rare	Occasional	Common	Very common
Adder								
Brown rat								
Capercailzie								
Cormorant								
Crow - carrion								
- hooded								
Deer - roe								
Fox								
Gull -								
greater black-backed								
lesser black-backed								
Hare - blue								
- brown								
Jackdaw								
Jay								
Magpie								
Merganser								
Mink								
Pigeon - wood								
Rabbit								
Seal								
Squirrel - grey								
- red								
Stoat								
Weasel								

APPENDIX 3B

PROFORMA FOR GAME SPECIES

Game Species Check List

Reserve name: Habitat section:

Sources of information: NRA/AMP Warden NCC staff Factor Tenant Owner Management Plan Other

Species	Present/absent on reserve	Takeable as pest?	Taken as pest?	Any restrictions on control?	For all species present on reserve nominate abundance as per accompanying Abundance Rating Card (see Table 11.1)			
					Rare	Occasional	Common	Very Common
Blackgame								
Capercailzie								
Deer - red								
- roe								
Geese - greylag								
Grouse - red								
Mallard								
Partridge								
Pheasant								
Plover - golden								
Ptarmigan								
Snipe								
Stockdove								
Teal								
Wigeon								
Woodcock								

APPENDIX 4

PROFORMA: RED AND ROE DEER IN NNRs

Reserve: Section:

1. Are RED DEER present _____ absent _____

2. Is current population damaging to:-

	Yes	No
shrub heaths	_____	_____
woodland	_____	_____
other	_____	_____

3. Population. Estimate for table below:

Average population	Winter maximum	Summer maximum	Average cull	Shooting controlled by:- NCC	Owner	Other

4. For what purposes are red deer managed (tick any combination)

sporting purposes	_____
venison production	_____
to manipulate vegetation for reserve objectives	_____
as part of the reserve ecosystem	_____
as a liability/threat to reserve values	_____

5. Are deer provided with supplementary feed:-

Yes _____ No _____

6. What is the largest concentration of red deer seen on the reserve _____

7. RDC/NCC counts of deer population:

Year	19__	19__	19__	19__	19__	19__	19__	19__	19__
Season									
Male									
Female									
Total									

8. Are ROE DEER present _____ absent _____

9. Are they common _____ -occasional _____ rare _____

10. Is shooting controlled by NCC _____ Owner _____ Other _____

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