PROBLEMS IN MAINTAINING BREEDING HABITAT , WITH PARTICULAR REFERENCE TO PEATLAND WADERS

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Some of the threats to breeding wader populations are briefly reviewed. It is noted that land-use changes including drainage, agricultural intensification, peat-extraction and afforestation can threaten populations previously thought to be protected by their widespread nature. Methods have been developed and tested allowing sample surveys of breeding waders on peatland habitats to be interpolated throughout the area from which the sites were sampled. These interpolations and compilation of other survey information demonstrate the outstanding international importance of the peatlands of Sutherland and Caithness in northernmost mainland Scotland. These support 66% of the EEC's breeding population of Greenshanks, 35% of Dunlins, 17% of Golden Plovers, 20% of Black-throated Divers, 14% of Red-throated Divers, 20% of Wigeon, 16% of Common Scoters, and 4% of Merlins as well as internationally important populations of several other species. The peatlands are also a unique natural habitat of outstanding importance to other aspects of nature conservation.
About 19% of the original breeding population of moorland waders has been lost to afforestation, mainly in the last 5 years. This estimate allows only for direct habitat loss; wader usage is depressed also in a wide zone extending outward from plantations. Afforestation, which is favoured as an investment due to the taxation situation, is rapidly expanding over the peatlands on which the waders (and other birds) depend.
The conservation of extensive areas of conservation interest, as opposed to safeguard of relatively restricted sites, poses exceptional problems for conservation in Britain.

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INTRODUCTION

Most of this Workshop is concerned with studies on, and the conservation of, populations of waders while these are away from their breeding grounds. At these times, waders tend to form concentrations. As previous papers in this symposium have demonstrated, this means that significant progress on estimation of population size and assessment of particular sites has been made even in those parts of the world with few observers and great access difficulties. The fact that sites can be identified and assessed, for example in terms of the quantitative guidelines of the "Ramsar" Convention on Wetlands of International Importance especially as Waterfowl Habitat, aids measures for their conservation. Some of these approaches will be outlined in following papers.

The Wader Study Group was, however, concerned that some consideration be given to the situation of waders on their breeding grounds. WSG has recently reviewed the information on distributions and numbers of waders breeding in Europe and adjacent arctic areas (Piersma 1986). In this paper, we outline briefly some of the threats posed to breeding populations of waders and then consider, as an example particularly relevant to a conference held in Scotland, the situation in the peatlands of Sutherland and Caithness. Here the one remaining extensive terrestrial natural habitat in Britain is being destroyed by rapid afforestation with non-native conifers.

PROBLEMS IN MAINTAINING BREEDING WADER POPULATIONS

Some breeding populations of waders form concentrations, for example Black-winged Stilts *Himantopus himantopus* and Avocet *Recurvirostra avosetta* as well as temperate coastal populations of some mainly arctic-breeding species. As for many of the wintering populations considered in other parts of this volume, site-safeguard measures may be effective, especially where habitat loss has reduced the area of importance to fragments (e.g. wet meadows in England and Wales; see Smith 1983) or where recreational disturbance at restricted sites is the main problem (see e.g. Pienkowski 1984).

Most arctic, sub-arctic and north-temperate populations of waders are, however, spread patchily over wide areas, presenting immense difficulties for survey. Unlike many populations in winter, these birds do not gather in flocks and are not concentrated in restricted sites or along linear coasts. There has been a tendency in some quarters to assume that this dispersion over vast arctic areas ensures safety from the effects of major habitat loss. Increasingly ambitious engineering proposals for arctic areas cast doubt on these assumptions. Furthermore, less remote populations breeding in temperate and sub-arctic areas are perhaps even more subject to threats and are far more important components of the overall populations of breeding birds than had been supposed

previously. This is both because breeding densities tend to be higher than in arctic regions and because the species composition is rather different. These points are well illustrated in the Wader Study Group's recent review of breeding waders in Europe (Piersma 1986).

In lowland areas, increased drainage and intensification of agriculture have led to declines in breeding meadow-bird populations in western Europe. In the Netherlands, Beintema *et al.* (1985) have shown that drainage has resulted in reduced potential for feeding by Snipe *Gallinago gallinago* which probe wet, soft ground. Drainage, together with reseeding and fertilizer application has led, via an earlier start to grazing and higher stocking rates, to increased losses of nests and young by trampling. Drainage and intensification is similarly destroying wader breeding habitat in lowland England and Wales (Smith 1983) and valleys in Scotland (Galbraith and Furness 1983; Galbraith, this volume).

Probably the most unexpected current threat to breeding wader populations has been the loss of peatlands of Ireland and north and west Britain. In Ireland commercial peat extraction has led to nearly 50% of Irish peatlands being lost as natural ecosystems (Ryan and Cross 1984). In Britain, Ratcliffe and Hattey (1982) demonstrate a 59% loss of mire habitat in lowland Wales since the turn of the century, whilst Bragg *et al.* (in press) record 87% absolute loss of lowland raised mire habitat throughout northern England and southern Scotland since the middle of the last century. Furthermore, much of this surviving 13% was found to be so badly damaged by burning and peripheral drainage that, of the original 14 257 ha of mire recorded for 1840, only 900 ha could today be classed as high quality mire. This represents a loss of 94% since the middle of the last century. Blanket bog is also under intense threat in a few areas due to peat extraction or agricultural intensification, but mainly from afforestation. For example at least 40% of the hill ground, mainly blanket peat, on the Kintyre peninsula in south-western Scotland has been lost to forestry and about half of the remainder is thought to be in forestry ownership. Of even greater concern is the future of the peatlands of Sutherland and Caithness in the extreme north of Scotland. In the rest of this paper we shall consider the threat to this area, and the attempts to map the numbers and distributions of breeding birds and thereby detail the importance of these peatlands. These methods may have wider applicability.

THE PEATLANDS OF SUTHERLAND AND CAITHNESS AND AFFORESTATION

The peatlands of Sutherland and Caithness represent the last remaining primaeval terrestrial habitat in Britain (apart from relatively restricted mountain plateau systems). Blanket mire is the only British terrestrial habitat of global standing, equivalent to South American tropical rain-forest and the African great plains, such as Serengeti. The International Mire Conservation Group, an independent organisation of peatland specialists from a wide range of countries around the world, has confirmed this area as "one of the world's outstanding ecosystems" and called on the UK Government to implement immediate protection measures.

The only part of Britain singled out by the World Conservation Strategy (IUCN *et al.* 1980) as a priority biogeographical province for the establishment of protected areas was the Scottish Highlands. At the same time, the first extensive published review (Gore 1983) of the world's peat systems revealed blanket bog to be an extremely rare global resource requiring priority conservation action. Caithness and Sutherland contain the largest continuous expanse of blanket peat in Europe; indeed the only comparable areas in the world are in the extreme wilderness areas of Kamchatka and Tierra del Fuego. Until recently, Britain held 1/7 to 1/10 of the world's blanket mire, but now large areas in Britain have been irretrievably lost to forestry. Trees are *not* the natural climax vegetation in blanket mire areas. Remains of trees within the peat date from times - mainly in the Boreal Period which ended about 7 500 years ago - when climate was markedly drier (see Lindsay 1987).

From the end of the 1970s, private sector companies began acquiring land on behalf of investors wishing to take advantage of tax benefits currently available to large-scale afforestation in UK. The combination of grants from the Forestry Commission (the UK government forestry agency) and, more importantly, tax rebates on establishment costs make such investments financially attractive (EFG 1986, Fountain Forestry 1986). This is because a private investor can claim establishment costs against taxed income from other sources. In this way a capital asset is created for as little as 30% of its true establishment costs, the remaining 70% being met by public subsidy. Without these taxation arrangements, the real return on investment on afforestation would be tiny (Grove 1983, Moore 1985a, 1985b, RSPB 1985, NCC 1986, Lowe *et al.* 1986, National Audit Office 1986). Even with these tax benefits, most investment companies appear to feel that plantations in the far north of Scotland are too risky and do not advise their clients to invest in them (*e.g.* EFG 1986). This may be because (a) the silviculture is unproven over a full rotation and crops may fail; or (b) the marketing and infrastructure are poor and likely to remain so, relative to more densely populated areas. Despite this, the loss of peatlands to afforestation by the one company involved proceeds rapidly.

Public expenditure in afforestation in this area has been criticized also in terms of its failure to create employment. RSPB (1985) estimated that forestry employment in the area costs the UK taxpayer £238 000 per job compared to £4 400 per job encouraged by the Highlands and Islands Development Board. Afforestation also poses threats to existing employment based on traditional low-intensity farming and game-management systems. This is because these do not receive the same tax benefits, and game-management additionally has to pay rates (local taxation based in this case on previous income from game-management).

With this background, forestry interests can out-compete any others in the artificial land-market created. Land acquisition has been so rapid that, for example, in the central part of the landscape one-third of the peatland habitat is now in forestry ownership. Over the two districts of Sutherland and Caithness as a whole, large areas have been acquired by forest interests, and at least 79,350 ha have been either planted or are programmed for planting in the immediate future. Very large areas have been planted in the last 4-5 years (Figure 1). Current plantings cover very significant areas of the peatland habitat

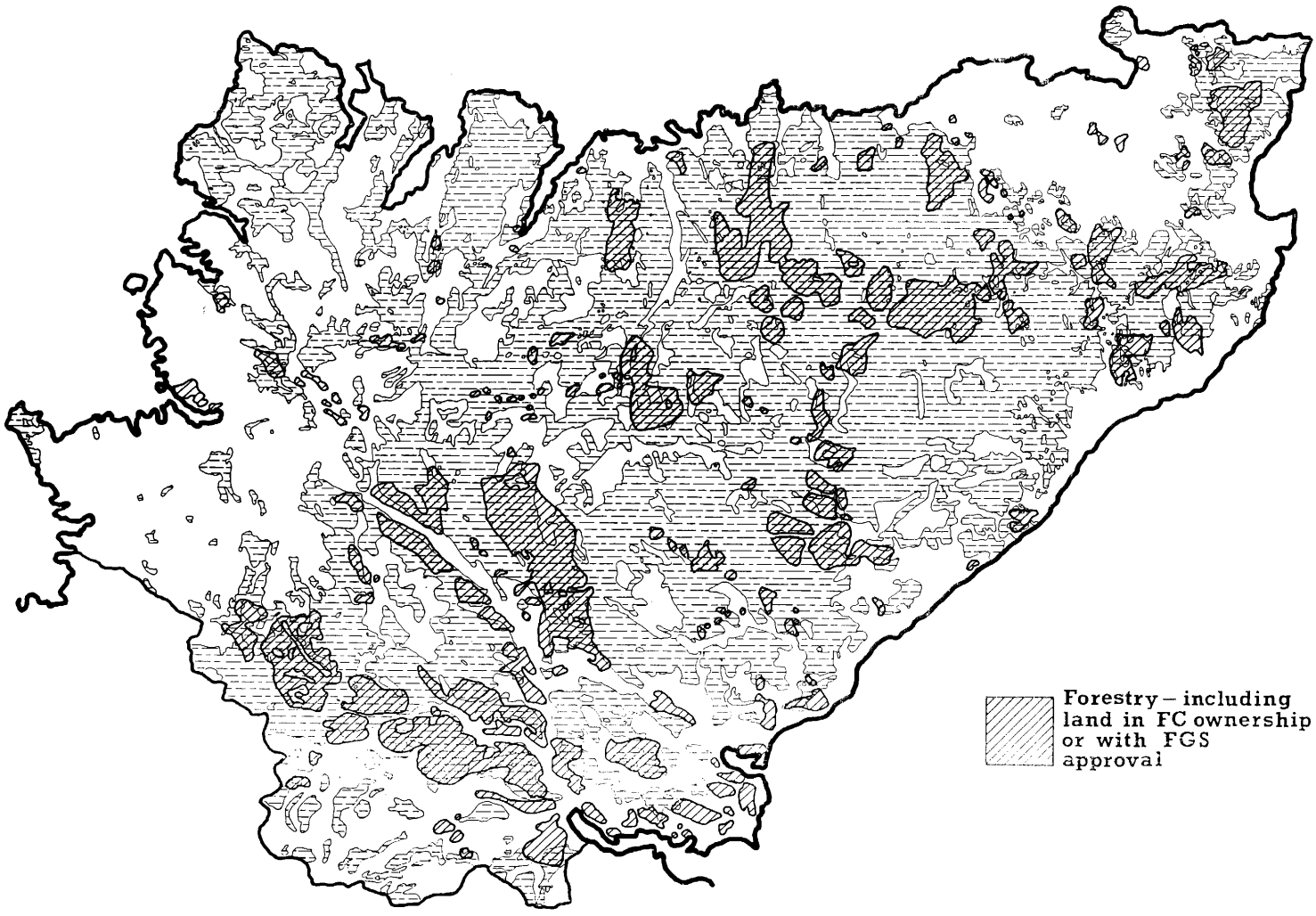

Figure 1. Peatland distribution in Caithness and Sutherland.

previously suitable for breeding waders. Because of its effect on turbidity and acidity of streams, afforestation poses threats also to salmon and trout fisheries, and fish-eating birds including divers.

METHOD OF SURVEYING BREEDING WADER DISTRIBUTION NUMBERS

The forestry industry had previously indicated that most of the peatlands of Sutherland and Caithness were unplantable, at least on any economical basis (and indeed much of the industry still does (EFG 1986)). However, by the late 1970s extensive planting seemed an increasing possibility. Accordingly in 1979, the Nature Conservancy Council (NCC) began a programme of sample surveys of the breeding birds, particularly waders, in these areas (e.g. Reed, Langslow and Symonds 1983). This was the Upland Bird Survey (UBS), recently restructured as the Moorland Bird Study (MBS). In the following year, NCC started a parallel study of peatland vegetation (the Northern Scotland Peatland Survey).

From 1979 to 1984 UBS quantitatively surveyed, in at least one year each, 69 sites in Caithness and Sutherland of an average size of 674 ha (174 ha sd). The method used was a territory-mapping method based on several visits (usually 4) in the course of the breeding season. A series of transect lines across the site, 200 m apart were walked by a pair of observers such that no part of the site was more than 100 m from an observer. The transect pattern was adhered to on each visit but reversing the direction of walking on each occasion. As weather affects the number and behaviour of birds seen or heard, visits were not attempted if there was wind greater than Force 5 (or less in an exposed area), rain, low cloud or fog.

On each visit, observers recorded on maps the birds seen or heard from the transect line. At the end of the day, a single composite map was produced and the observations transfered also to summary maps for the site. At the end of the season it was thus possible to estimate the number of territorial pairs of each species from the cluster of sightings on the summary maps.

The avoidance of bias has been considered in great detail, for example in respect of seasonal timing of visits, diurnal timing of visits and year-to-year variation (Reed and Langslow 1984, Reed 1987, Reed *et al.* 1983, 1985). In several areas the method was tested against intensive studies involving nest-finding. There was a high degree of correspondence, although in all cases the mapping method underestimated numbers, particularly of Dunlins *Calidris alpina*. The same was true when a similar method was used in

the NCC/WSG survey of the Outer Hebridean machair (Jackson and Percival 1983, Fuller 1985).

Because of limited resources, it was impracticable to survey the whole of the peatlands of Sutherland and Caithness. In fact 19% of suitable moorlands were investigated. These sites were selected to represent the range of topographic and vegetational variation of the blanket bogs in the area. In order (i) to test the success of this sampling, (ii) to allow interpolations to unsurveyed areas within the region, and (iii) to enable investigations of the effect of habitat management, vegetation throughout each study site was mapped and then summarised in 200 m x 200 m contiguous squares. As well as vegetational composition, details were recorded of structure and of physical features of the habitats, such as presence of pools and dubh lochans (small, dark peat pools), vegetation age and height and amount of regrowth following burning. The selection of breeding waders for particular areas within a site could thus be related to detailed habitat information (Reed 1985, Reed and Langslow 1986).

During these analyses, it became clear that likely densities of waders on a site could be assessed on the basis even of the information available on 1:25 000 Ordnance Survey maps. For example, Dunlins, Golden Plovers *Pluvialis apricaria* and Greenshanks *Tringa nebularia* all favour flat areas of blanket bog with pool complexes and few, if any, rocky outcrops. In particular, high Greenshank numbers are usually found where these pools are widely but regularly spaced over large areas. Intermediate densities of all species are found on gently sloping ground with a lower density of pools and some rocky outcrops. Dry, steeply sloping peatlands are poor for all species, and sites within 800 m of established forestry plantations hold lower numbers than otherwise expected (Stroud and Reed 1986). It is not possible by this method to assess vegetational and other characteristics not dependent on physical features, especially those affected by management, such as burning, heavy grazing or drainage. Thus an otherwise 'good' site may be degraded without this being detectable on map analysis.

An examination of the factors affecting wader distribution and numbers showed that categorisation of four landforms was posssible. These were: flat, wet *Sphagnum* dominated areas with many dubh lochans; gently rolling hills with fewer pools and wet areas than the previous category; steep, dry moorland with little or no open water; and montane, and scree dominated rocky ground. Wader densities were found to be highest in the flat, wet areas and lowest in the steep, dry areas. Stroud *et al.* (in press) describe in detail these categories of landform and the typical wader breeding densities found there.

In order to test the predictions made from map evidence, the sample sites were split into two randomly assigned groups. One group was categorised into landform types as above, and the numbers of waders found in each category calculated. The other group was categorised according to the same rules but by a non-ornithologist, familiar with peatlands, but with no expectations of wader densities associated with each category, or knowledge of the survey results. If information from maps provided a sound basis for estimating the densities of breeding waders, classification of the second sample of sites should have resulted in a similar distribution of breeding densities.

This indeed was the case, and, for example, sites assigned to the wettest category were found to have similar densities of breeding waders to peatlands of this type elsewhere in Caithness and Sutherland. Full statistical details are given by Stroud *et al.* (in press). These results allow reliable interpolation of the data throughout the area in which sampling took place, and some results are noted in the following section. Work is now in progress to develop further the interpolation techniques, utilizing also satellite imagery to allow more features to be taken into consideration.

ASSESSMENT OF BREEDING POPULATIONS AND THE IMPACTS OF AFFORESTATION

The development of the interpolation techniques described above and their application is

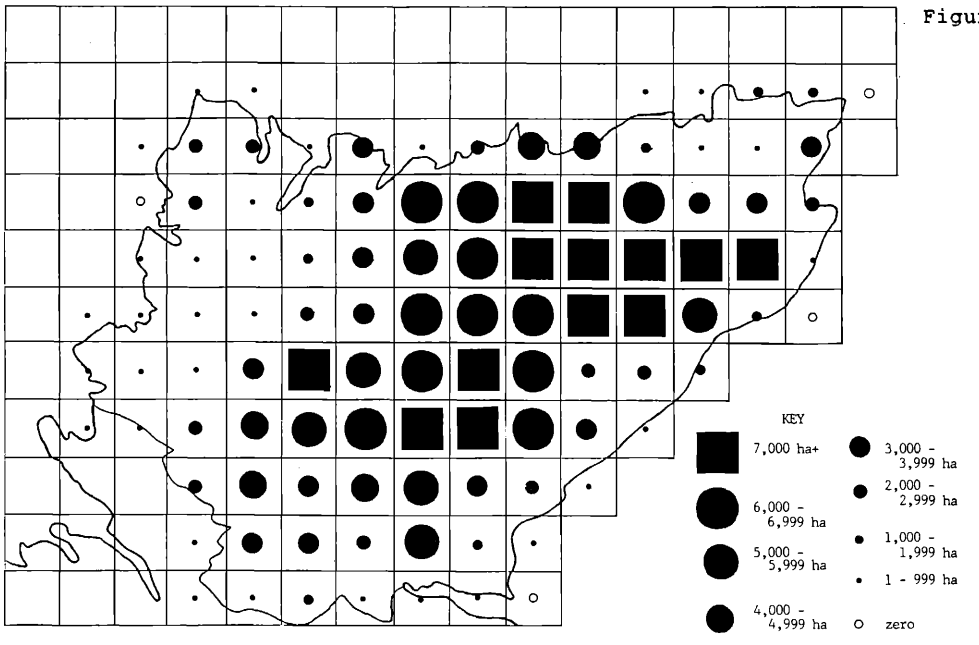

Figure 2. Approximate extent of original peatland cover suitable as habitat for moorland breeding waders before afforestation diminished its distribution.

Table 1. Estimated proportions of national and EC populations of selected breeding birds in Caithness and Sutherland (see Stroud *et al.* in press for sources).

Species	Estimated numbers of pairs breeding in Caithness and Sutherland	Proportion (%) of British breeding population in Caithness and Sutherland	Proportion (%) of EC breeding population in Caithness and Sutherland
Red-throated Diver *Gavia stellata*	150	14	14
Black-throated Diver *Gavia arctica*	30	20	20
Greylag Goose *Anser anser*	300	43	-(a)
Wigeon *Anas penelope*	78	20	20
Common Scoter *Melanitta niger*	30	39	16
Golden Eagle *Aquila chrysaetos*	30	6	<1(b)
Merlin *Falco columbarius*	30	5	4
Peregrine *Falco peregrinus*	35	5	<1(c)
Golden Plover *Pluvialis apricaria*	4000	18	17
Dunlin *Calidris alpina*	3800	39	35
Greenshank *Tringa nebularia*	630	66	66
Arctic Skua *Stercorarius parasiticus*	60	2	2

Notes: (a) EC population size uncertain due to unknown proportion of feral birds in other populations. The population in NW Scotland is the only one thought to be natural, because of separation from others.

(b) Most of the EC population of Golden Eagles is of the South European race *homeyeri*; Britain holds all of the EEC population of the nominate race, 6% of which occur in the Caithness and Sutherland peatlands.

(c) Most of the EEC population consists of the Mediterranean race *brookei*. The Caithness and Sutherland peatlands hold 5% of the EEC population of the nominate race.

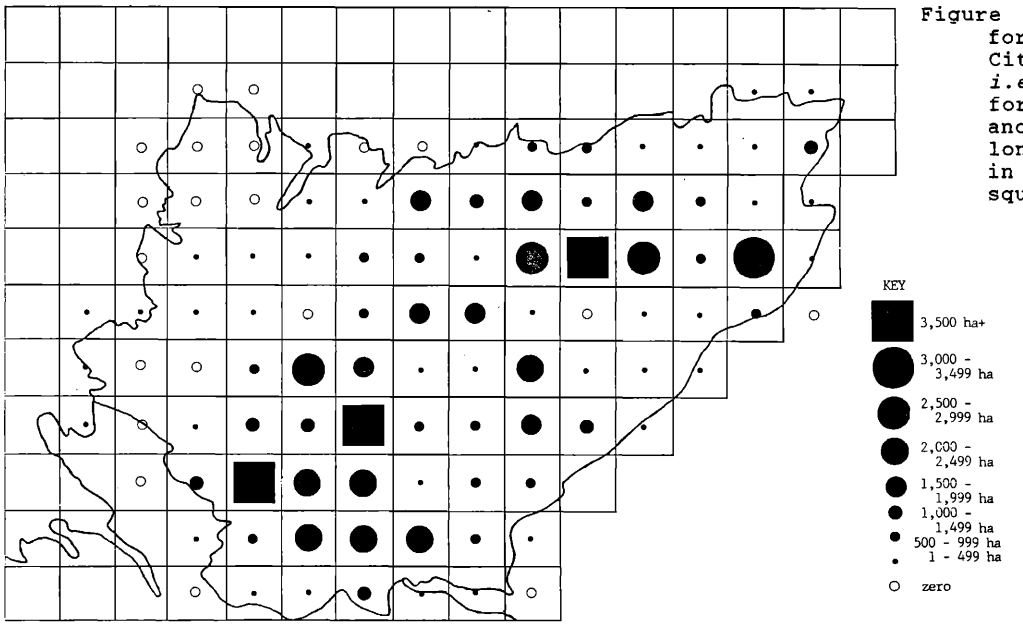

Figure 3. Extent of recent forestry plantations in Cithness and Sutherland, *i.e.* total measured forest area minus area of ancient, semi-natural and long-established woodland in each 10 km grid square. January 1986.

detailed by Stroud *et al.* (in press). The following account is taken from that study.

The total breeding wader population of the peatland area of Sutherland and Caithness can now be estimated. This is given in Table 1 along with estimates of the population of other species (see Stroud *et al.* in press for sources). It can be seen that the peatlands of Sutherland and Caithness support breeding populations of outstanding international importance. Several other species are omitted from Table 1 either because assessments are not yet complete or for reasons of confidentiality. This assemblage of northern breeding species occurs nowhere else in Britain nor indeed the World.

Based on the information summarized in the previous section it is possible to assess the extent of original peatland cover suitable as habitat for moorland breeding waders before afforestation in each 10 km x 10 km square (Figure 2). This demonstrates the widespread nature of the nature conservation interest in the area; this is true also of aspects other than the birds.

Forestry has already made considerable inroads into this resource mainly in the last 10 years (Figure 3). By applying the interpolations verified above to maps of the area prior to afforestation, it can be estimated that afforestation has already displaced 17% of the original population of Greenshanks, 17% of Dunlins and 19% of Golden Plovers. Detailed studies on Greenshank indicate that displaced birds are unlikely to be accommodated elsewhere (Thompson *et al.* 1986).

The problem is considerably more severe in that, apart from the direct loss of habitat caused by afforestation, the nature conservation value of adjoining areas is also depressed. Stroud and Reed (1986) found that the usage by waders of a zone extending at least 800 m out from plantation edges was significantly less than in areas further from forests. Current work as yet unpublished has also demonstrated that peatland vegetation is also affected adversely in a wide zone adjacent to plantations.

The problem is exacerbated in that afforestation is concentrated in those areas of flat-lying ground which support the best examples of peatland and which hold highest densities of breeding moorland birds (Figures 2 and 3). This is because afforestation is easiest on the flat ground which also provides the best breeding wader habitat (see above).

CONCLUSIONS

In order to safeguard populations of waders, as for other interests, one first needs to locate the populations. To do this over a wide area requires the development of new survey techniques. The methods used in the present study have been found to be readily adaptable to rather different habitats, including the WSG/NCC study of the Hebridean machair. The most recent development of the technique is its use for interpolation of wader densities throughout the area from which samples were drawn. Following the initial success of this, we shall be developing this technique in other areas also. This may be of considerable potential in some other regions of dispersed breeding populations of waders and other birds.

The exceptional importance of the bird populations and other nature conservation interest maintained over a wide area of unique natural habitats and the rapid threat posed by afforestation favoured by the tax situation, pose an unprecedented problem for nature conservation in Britain. This arises partly because of the difficulty in conserving wide areas by legislation designed mainly for the safeguarding of more restricted sites. This is the case even when, as in the present situation, such conservation would have the effect also of maintaining traditional land-use and human communities in the face of an invasive and irreversible land-use change.

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REFERENCES

Beintema,A.J., Beintema-Heitbrink,R.J. and Muskens,G.J.D.M. 1985. A shift in the timing of breeding in meadow-birds. *Ardea* 73: 83-89.

Bragg,O.M., Lindsay,R.A., Robertson,H. and Heaton,A. (in press). *A historical review of lowland raised mires.* Focus on Nature Conservation. Nature Conservancy Council, Peterborough.

EFG. 1986. *Forestry: an introduction for investors.* Economic Forestry Limited, London and Edinburgh.

Fountain Forestry 1986. Forestry Investment and Taxation: The Professional's Guide. 4th Edition. Fountain Forestry, London.

Fuller,R.J. 1985. Studies on breeding waders in the Southern Isles of the Outer Hebrides 1985. *Nature Conservancy Council Chief Scientist Directorate Report* no. 606.

Galbraith,H. and Furness,R.W. 1983. Breeding waders on agricultural land. *Scottish Birds* 12: 148-153.

Gore,A.J.P. 1983. *Ecosystems of the World.* 4b. Elsevier, Amsterdam.

Grove,R. 1983. *The future for forestry: the urgent need for a new policy.* British Association of Nature Conservationists.

IUCN, UNEP and WWF. 1980. *World Conservation Strategy: Living resource conservation for sustainable development.* IUCN/UNEP/WWF /FAO/UNESCO.

Jackson,D.B. and Percival,S.M. 1983. The breeding waders of the Hebridean machair: a validation check of the census methods. *Wader Study Group Bull.* 39: 20-24.

Langslow,D.R. and Reed,T.M. 1984. Inter-year variation in wader populations. *Bird Census & Atlas Studies*: 123-132.

Lindsay,R.A. 1987. British peatlands in their international context. *International Mire Conservation Symposium, Heriot-Watt University, Edinburgh.*

Lowe,P., Cox,G., MacEwan,M., O'Riordan,T. and Winter,M. 1986. *Countryside conflicts. The politics of farming, forestry and conservation.* Gower/Maurice Temple Smith.

Moore,P.J. 1985a. The real world of private forestry. *Ecos* 6: 2-7.

Moore,P.J. 1985b. The unacceptable face of private forestry. *Ecos* 6: 34-40.

Nature Conservancy Council. 1986. *Nature conservation and afforestation in Britain.* NCC, Peterborough.

National Audit Office. 1986. Review of Forestry Commission objectives and achievements. London, HMSO.

Pienkowski,M.W. 1984. The impact of tourism on coastal breeding shorebirds in western and southern Europe: an introduction to general discussion. *In* P.R. Evans, H. Hafner and P. L'Hermite (eds.), *Shorebirds and large waterbirds conservation,* pp. 36-41. Commission of the European Communities, Brussels.

Piersma,T. (compiler) 1986. Breeding waders in Europe: a review of population sizes and bibliography of information sources. *Wader Study Group Bull.* 48, Suppl.: 1-116.

Ratcliffe,J.B. and Hattey,R.P. 1982. Welsh lowland peatland survey. Nature Conservancy Council Research Report.

Reed,T.M. 1985. Grouse moors and breeding waders. *Game Conservancy Annual Report* 16: 57-60.

Reed,T.M. 1986. Within-season variation in the detection of Redshank on upland moorlands. *Ibis* in press.

Reed,T.M. and Langslow,D.R. 1984. The timing of breeding in the Golden Plover *Pluvialis apricaria.* In: Taylor, K., Fuller, R.J., & Lack, P.C. (Eds.) *Bird Census and Atlas Studies: Proceedings VIII International Conferences on Bird Census and Atlas work.*Pp: 167-174. BTO, Tring.

Reed, T.M. and Langslow,D.R. 1986. Habitat association of breeding waders. *Act. Seria Biologica* in press.Reed,T.M., Langslow,D.R. and Symonds,F.L. 1983. Breeding waders of the Caithness flows. *Scottish Birds* 12: 180-186.

Reed,T.M., Barrett,J.C., Barrett,C.F. and Langslow,D.R. 1983. Diurnal variability in the detection of Dunlin *Calidris alpina. Bird Study* 30: 244-246.

Reed,T.M., Barrett,C.F., Barrett,J.C., Mayhow,S. and Minshull,B. 1985. Diurnal variability in the detection of waders on their breeding grounds. *Bird Study* 32: 71-74.

Royal Society for the Protection of Birds. 1985. *Forestry in the flow country - the threat to birds.* RSPB, Sandy.

Ryan,J.B. and Cross,J.R. 1984. The conservation of peatlands in Ireland. *Proceedings of the International Peat Congress, Dublin*: 388-406.

Smith, K.W. 1983. The status and distribution of waders breeding on wet lowland grasslands in England and Wales. *Bird Study*: 177-192.

Stroud,D.A. and Reed,T.M. 1986. The effect of plantation proximity on moorland breeding waders. *Wader Study Group Bull.* 46: 25-28.

Stroud,D.A., Reed,T.M. Pienkowski,M.W. and Lindsay,R.A. in press. *Birds, Bogs and Forestry: the peatlands of Caithness and Sutherland.* Focus on Nature Conservation. Nature Conservancy Council, Peterborough.

Thompson,D.B.A., Thompson,P.S. and Nethersole-Thompson,D. 1986. Timing of breeding and breeding performance in a population of Greenshanks (*Tringa nebularia*). *J. Anim. Ecol.* 55: 181-199.