THE EFFECT OF PLANTATION PROXIMITY ON MOORLAND BREEDING WADERS

by David A. Stroud and Tim M. Reed

INTRODUCTION

The blanket bogs in upland Britain are a habitat of high conservation value (Ratcliffe 1977), and are currently suffering rapid loss and fragmentation by coniferous afforestation (Langslow 1983, Nature Conservancy Council 1986). These open moorlands and bogs are important breeding areas for both scarce raptors requiring large territories (e.g. Ratcliffe 1980, Marquiss *et al.* 1985), and for waders and grouse with specific habitat requirements (Ratcliffe 1976, Nethersole-Thompson and Nethersole-Thompson 1979, Reed *et al.* 1983, Hudson and Watson 1985, Reed 1985, Thompson *et al.* 1986).

In Britain, as elsewhere, coniferous plantations harbour corvids (Petty 1985) and foxes (Hewson & Leitch 1983), predators of ground nesting birds on adjacent moorland (Erikstad *et al.* 1982). Proximity of coniferous plantations could thus depress numbers of breeding waders on adjacent expanses of otherwise suitable blanket bog. Such an effect could occur indirectly, with birds avoiding moorland adjacent to plantation edges because of a high potential predation risk, and/or directly because numbers and nesting success are reduced by forest harboured nest predators (Langslow 1984). In a study of the effects of surrounding forestry on isolated moorland areas in southern Scotland Rankin & Taylor (1984) indicated that a minimum moorland area of 270 ha was required to maintain a representative moorland bird community. They also demonstrated that the degree of afforestation in surrounding areas can affect diversity and abundance of moorland species, as may the degree of convolution of the plantation edge.

The environmental effects of afforestation tend to be considered in terms of the extent of ground lost to plantations within an area. Both Marquiss *et al.* (1978) and Rankin & Taylor's (1984) studies indicated that plantations can affect bird populations on adjacent but unplanted ground. In view of the often high edge: area ratio of many commercial plantations, we carried out several studies to see the effect of plantation proximity on adjacent areas of moorland in several areas of Britain.

In this paper we test two predictions:

a. waders in summer avoid moorland close to coniferous plantations;

b. there is an inverse relationship between the use of moorland and the proximity of plantations.

Both these predictions are demonstrated in this study, and we discuss the implications of such edge effects for moorland conservation.

This work formed part of studies carried out by the Nature Conservancy Council (NCC) since 1979 on the distribution and abundance of moorland breeding waders in Northern Scotland, Wales, the northern Pennines and other upland areas of Britain (Reed *et al.* 1983, Barrett *et al.* in prep., Reed in prep.). The aims of the surveys were to estimate breeding densities of upland waders in different areas of Britain, and to obtain predictive information on the relationship between the density and species richness of upland bird communities and the vegetation and topographic features (Langslow 1984, Reed 1985).

METHODS

Upland Bird Survey (UBS) plots were usually between 600 - 800 ha in area. Transect lines 200 m apart were drawn on 1: 10 000 scale maps for each site and placed so that no part of the site was more than 100 m from an observer walking these transects (Reed 1982). Once decided, the transect pattern was adhered to, with subsequent visits repeating the same transects. Surveys were undertaken by two observers walking in parallel up and down the transects, recording bird sightings in code ('registrations') directly onto 1: 10 000 maps. A minimum of four such site visits were made through the breeding season (April - July).

Vegetation communities were mapped on 1: 10 000 maps and summarised in 200 m x 200 m quadrats. Within each of these quadrats, dominant plant communities were recorded according to the National Vegetation Classification (NVC). As well as information on species composition, physical characteristics of the vegetation, such as age, height, and proportional regrowth following fire management were also recorded.

At the end of each survey season, information was available on the vegetation of each 200 m quadrat as well as the number of bird registrations recorded within it. The vegetation data were then analysed for each site using a TWINSPAN multivariate programme (Hill 1979), to produce eight separate end groupings or 'community types' representing quadrats within the study area with very similar vegetational communities and characteristics. The distribution of community types within sites was then related to bird species distribution to determine habitat preferences for individual breeding wader species.

Nine study sites adjacent to coniferous plantations were surveyed between 1982 and 1984: 6 sites in Sutherland and 3 in Co. Durham. At each site, bird populations were surveyed and frequencies in quadrats were compared for quadrats 3 distances from the forest edge: <400 m, 400 - 800 m and >800 m.

Initial comparison of breeding densities in edge squares with those further away indicated lower breeding numbers close to plantation edges. However, this comparison implicitly assumes that, as waders select preferentially for particular habitat types, the availability of habitats is the same in edge and non-edge squares. Were this not to be so, any apparent avoidance of edge squares could be due to lack of suitable habitat, rather than to the proximity of plantations. Most moorland contains a mosaic of wetter and drier, taller and shorter vegetation so the assumption is immediately questionable. In order to see if habitat availability differed according to

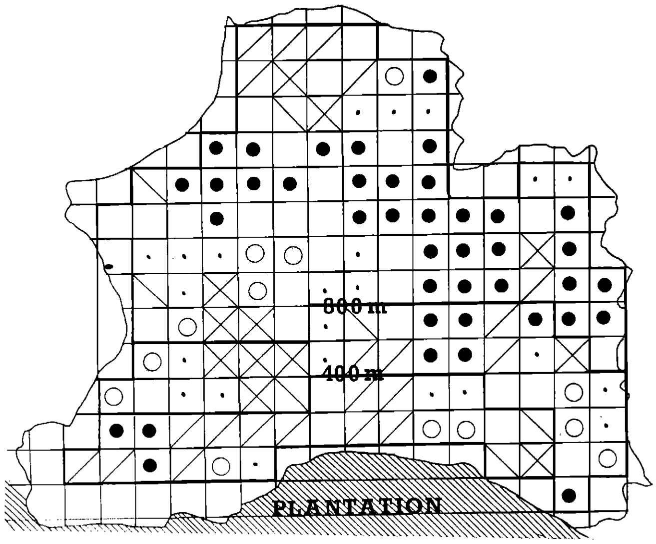

Figure 1. A study site close to forestry showing 400 and 800m edge zones, with the non-uniformity of plant communities across the site. Different vegetation types are indicated by different shading or cross-hatching.

distance from the forest edge, habitat type frequency was compared between distance bands.

Test of Vegetation Homogeneity

Each 200 m square was classified according to its TWINSPAN community type (Figure 1). At each site the proportion of each of the eight vegetation types was calculated for edge and non-edge blocks. The relative proportions of edge communities differed significantly from those of non-edge blocks (Table 1) in all comparisons. Thus vegetation types were not evenly distributed across sites. Consequently, investigation of occupancy of edge areas and comparison with non-edge areas had to control for this non-uniformity.

Demonstration of Edge Effects

To control for vegetation differences we calculated the proportion of quadrats of each vegetation type holding a particular bird species. For each vegetation type, the percentage occupation by birds of squares close to and away from the forest edge were then compared.

For each site, the number of squares of each vegetation type in each distance zone (see below) was counted. The number of squares of each type in each zone in which one or more registrations of each wader species ocurred was also counted. Thus the proportional occupancy by each species of wader in each vegetation type could be compared between zones near and far from the plantation. The null hypothesis used was that there was no difference in proportional occupancy close to and away from the forest edge. For each species, up to 8 comparisons were made per site. If the null hypothesis was correct, then one would expect an equal number of comparisons to have greatest occupancy close to the edge as further away.

RESULTS

In two separate tests, comparisons of edge with non-edge (>800 m) were made for <400 m and 400 - 800 m zones. Avoidance of forest/moorland boundaries was shown by Curlew, Golden Plover, Dunlin, Lapwing and Redshank, with Greenshank being equivocal (Table 2). Further from the edge (400 - 800 m), the pattern persisted, but with Curlew being affected to a lesser extent. When the results of all the comparisons are tested for significant deviation from the null hypothesis of equal occupancy with respect to the edge (Table 2), the abundance of waders in the zone <400 m and 400 - 800 m from the forest edge was significantly lower ($P<0.05$) than the zone further (>800 m) from the plantations.

DISCUSSION

Man has increasingly fragmented formerly extensive and comparatively uniform terrestrial habitats. Effects of this habitat fragmentation have been investigated both theoretically and experimentally, with island biogeographical theory (MacArthur & Wilson 1967) providing useful insights.

Most field studies have considered fragmented habitat 'islands' to be delimited by discrete boundaries which separate the 'island' from the fragmenting 'sea'. Thus species: area relationships have been calculated on the basis of the strict area of the habitat fragment. Yet boundaries between two habitats are dynamic with a distinct ecotone often present. Thus one habitat can cause ecological effects deep into an adjacent one. In this way, the functional area of an 'ecologically undisturbed' habitat island is often much less than its actual area.

There is perhaps most information on the effects of fragmentation on forest birds, both as it affects the birds of remaining forest patches (e.g. MacClintock, Whitcomb & Whitcomb 1977, Robbins 1980, Lynch & Whigham 1984, Helle

Table 1. Results of test for spatial uniformity of vegetation community types across survey plots from six sites in Sutherland. The composition of distance zones by eight vegetation types is tested for similarity near to, and far from the forest. Values are X^2 tests with 7 degrees of freedom.

	Proportional composition of Block of 200 m squares >400 m cf. <400 m from forest edge	Proportional composition of Block of 200 m squares >800 m cf. <800 m from forest edge
Site A	110.43 **	128.29 **
Site B	226.36 **	256.03 **
Site C	82.48 **	44.22 **
Site D	160.48 **	277.51 **
Site E	231.31 **	198.97 **
Site F	39.58 *	27.88 *

* $P<0.01$, ** $P<0.001$

Table 2. The number of comparisons of proportional occupancy of different vegetation types with respect to distance from plantation edge. X^2 tests have 7 degrees of freedom.

SPECIES	<400 m from forest edge c.f. >800 m from forest edge — Number of comparisons where there was: Highest occupancy in edge squares	Highest occupancy in non-edge squares	number of comparisons	400 – 800 m from forest edge c.f. >800 m from forest edge — Number of comparisons where there was: Highest occupancy in edge squares	Highest occupancy in non-edge squares	number of comparisons
Curlew	5	15	20	10	14	24
Golden Plover	7	21	28	12	22	34
Greenshank	4	5	9	7	6	13
Dunlin	3	9	12	3	12	15
Lapwing	1	7	8	0	8	8
Snipe	1	7	8	0	5	5
Redshank	0	4	4	0	6	6
All species	21	68	89	32	73	105
	X^2=14.55 P<0.05			X^2=14.37 P<0.05		

1985, Opdam *et al.* 1985), and the birds of enclosed clearings (Rankin & Taylor 1984). Robbins (1980) and Lynch & Whigham (1984) found that even a small amount of forest fragmentation reduced local abundance of some migratory birds in remaining patches. They attributed this to birds' aversion for surrounding open areas. Previous authors had found that a deep zone at the edge of forests were reached by edge-adapted predators, competitors and nest-parasites.

Gates & Mosher (1981) considered approaches to estimating functional habitat edge width for birds, and presented evidence to show that the functional (ecotonal) edge was often considerably wider than the structural edge as measured by conventional mapping. Such considerations are important for fragmented habitats of high conservation value. As fragmentation increases, the area of remaining patches falls. Yet, functional edge width as proposed by Gates & Mosher (1981) implies that areas of ecologically undisturbed habitat can be even smaller than patches recorded on purely structural grounds (Moore and Hooper 1975).

It is obviously very important that any edge effect due to forestry on adjacent blanket bog is quantified. In many areas of Britain, moorland has been rapidly fragmented by forestry. This is often serious in direct terms of habitat loss, yet additionally the lowering of quality, to breeding birds, of adjacent land needs consideration. In particular, protected areas may need to be much larger if they are to retain their ornithological interest. Several protected areas in Sutherland have already been totally surrounded by forestry plantations.

We have predicted that if the edge effect is real, lowest bird occupancy would be expected at the edge of moorland with forestry and this would be most pronounced in the zone closest to the forest. The degree of forest edge avoidance might be expected to vary between species. For example, the edge effect may be less pronounced in species with cryptic nests. In terms of abundance and distribution, there is significant avoidance of moorland up to at least 800 m from coniferous plantations.

Many birds of open ground show aversion to otherwise suitable areas when all round visibility is restricted (e.g. Madsen 1985, Owen 1973). Such behaviour is commonly held to reduce the risk of surprise attack by predators. Avoidance of the forestry/moorland edge may simply be a function of restricted visibility in this sense.

Andren *et al.* (1985) found that predator abundance and nest predation rate increased in forest clearings with high forest fragmentation. In particular, corvid density increased with an increase in the proportion of forest edge to open habitat (in their case agricultural).

In a study of moorland patches within afforested ground, Rankin & Taylor (1984) found that patch area and number or diversity of habitats within sites had a dominant influence on number of breeding bird species and their population densities. They also found that population densities of Snipe and Lapwing were negatively correlated with the degree of convolution of the forest edge. They too suggested that the avoidance of trees could have a sound evolutionary basis in relation to predator detection and avoidance.

We find that our two predictions are fulfilled. Thus the edge effect of forestry either deters or renders more vulnerable to predation birds near the forest edge. Clearly when considering the potential effects of afforestation on nesting birds we now have to appreciate that the attractiveness to birds of adjacent unplanted areas is reduced substantially. The counties of Caithness and Sutherland contain at least 72 000 ha of coniferous plantations. These have a total edge of 1 989 km. Some 15 161 ha of these plantations are on blanket bog (1984 figures). These plantations have a calculated edge of at least 420 km. With a depressant effect on adjacent land to at least 800 m away, this directly affects some 33 600 ha of adjacent blanket bog – a significant proportion (18%) of the remaining 185 341 ha of unaffected blanket peat in the flow country. More localised and intensive studies are now needed to examine breeding performance in relation to distance from the forest edge. Indeed, an edge effect involving reduced population breeding success may be even more important than an effect on simple breeding numbers or overall densities.

SUMMARY

The effect of conifer plantation proximity on the distribution of breeding waders was

investigated for six moorland sites in Sutherland, Scotland and three moorland sites in the northern Pennines, England. The distribution of vegetation at all sites was different in areas close to plantations, when compared with areas further away. Since waders select prefentially for different plant communities in the breeding season, the effect of this non-uniformity of habitat had to be controlled for. Both before and after allowing for these differences in vegetation, significantly fewer waders were found to use areas close to forestry plantations. Depression of use was greatest in areas closest (<400 m) to plantations. The effect was still demonstrable further (400 - 800 m) from the moorland edge. The effects of forestry edge effects on moorland breeding waders are discussed as they affect the conservation of moorlands in Britain.

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David A. Stroud and Tim Reed, Nature Conservancy Council, Northminster House, Peterborough, PE1 1UA, U.K.