Loss of heather moorland in the Scottish uplands: The role of red grouse management

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ABSTRACT

Scottish upland moorland dominated by heather *Calluna vulgaris* is the primary habitat for red grouse *Lagopus lagopus scoticus*, and has been declining since the 1940s. At the same time red grouse numbers have also fallen. We compared land cover change on sites managed for grouse shooting (1945-1990), and on sites which were managed for grouse in the 1940s but on which management had stopped by the 1980s. Land cover type for sites (N = 229) containing >10% heather cover in the 1940s were examined during the 1940s, 1970s, and 1980s. Grouse management existed on 49% of sites in the 1940s, a number which had fallen to 20% by the 1980s. In the 1940s there were no significant differences in land cover type between areas that were managed for grouse, and areas that were not. However, differences emerged during the 1970s and 1980s; areas where grouse management had ceased by the 1980s showed an expansion in woodland cover from 6% in the 1940s to 30% in the 1980s, and a reduction in heather cover from 53% to 29%. In areas where active grouse management had been maintained, woodland increased from 3% to 10% and heather decreased from 51% to 41% during the same period. These changes may be, in part, a consequence of government agricultural and forestry policy. When profitable, grouse management reduces the attractiveness of such subsidies and thereby results in a slower loss of heather.

INTRODUCTION

Heather (*Calluna vulgaris*) dominated moorland is one of the most characteristic vegetation types in Scotland. It is largely restricted to the uplands of Britain and Ireland with a few other areas on the European mainland and the west coast of Norway (de Smidt 1995). It is a semi-natural habitat largely created by wide-scale deforestation that started around 2000 BC by mesolithic hunter-gatherers (Stevenson & Birks 1995). This, coupled with a wetter and cooler climate, increased the extent of open heath, rough grass, and bogs. Early settlers

also used fire and grazing as management tools to clear woodland and suppress tree regeneration, creating the current open landscapes (Stevenson & Birks 1995).

Scotland's heather moorland is still primarily managed by rotational burning and by grazing. Although this habitat is artificially maintained, it is of international importance as it supports a unique diversity of flora and fauna. The combined presence of arctic-alpine, alpine, and boreal-British invertebrates is found in no other habitat (Thompson, MacDonald, Marsden & Galbraith 1995). Some animals, such as the mountain hare *Lepus timidus*, are currently entirely dependent on heather moorland. Other species that depend heavily upon this habitat include ptarmigan *L. mutus*, red grouse, golden plover *Pluvialis apricaria*, dunlin *Calidris alpina*, and hen harrier *Circus cyaneus*. Of the 19 upland heather moorland communities described by the U.K. national vegetation classification, 11 are confined to Britain, or are better represented in Britain than elsewhere (Thompson et al. 1995). As signatories of the Rio Convention on Biodiversity (1992) the retention of this unique habitat is a high conservation priority in the UK.

Tudor & Mackey (1995) estimated that almost 20% of the heather moorland in Scotland was lost between the 1940s and 1970s, a decline which has subsequently continued. This has been due to the conversion of heather to forestry or grass (Grant &Hunter 1971).

From the 1500s to 1800s, upland land management centred largely on cattle *Bos taurus*, sheep *Ovis aries* and deer *Cervus elaphus* grazing. However, from the early 1880s, driven grouse shooting became fashionable and large areas of uplands were managed to produce a harvestable surplus of grouse (Lovat 1911). Since the 1940s there has been a reduction in the number of active grouse moors, those employing gamekeepers and those where significant numbers of grouse are shot (Barnes 1987). Grouse numbers in Scotland were probably at their peak before the 1940s and have subsequently fallen (Barnes 1987) in many areas to such an extent that they no longer provide a significant harvest. The possible reasons for such a

decline include decreases in the number of gamekeepers, increases in the number of predators, loss of suitable habitat (quantity and quality), spread of diseases such as the virus louping ill (transmitted by the sheep tick *Ixodes ricinus*), and fragmentation of the remaining heather cover (Hudson 1992). On some moors, raptors, such as hen harriers and peregrines (*Falco peregrinus*) may kill large numbers of grouse, but since many species of raptors are recovering from low populations in the 1950s, they are unlikely to be responsible for the long-term reduction of grouse numbers (Thirgood, Redpath, Newton & Hudson 2000). When grouse are abundant, income from shooting can be the primary source of income for many upland estates, but with the loss of this income many moors have been sold or converted to alternative forms of land use, such as commercial forestry.

These changes in grouse management are likely to have important implications for land cover in Scotland (McKelvie 1985), although to date there have been no quantitative data with which to assess these changes. Grouse numbers remain low on many of the remaining Scottish moors and the economics of continued grouse management are precarious (McGilvray 1995). It is, therefore, important to assess the implications that the reduction in grouse management may have on the future retention of heather moorland in the Scottish uplands. In this paper we examine the decline in red grouse management. Using land cover data from the National Countryside Monitoring Scheme (NCMS) we investigated the relationship between heather cover and the decline in grouse management. We discuss the implications of continued declining grouse management, given the current system of agricultural subsidies.

METHODS

National Countryside Monitoring Scheme

The land cover data utilised in the present study have been extracted from the National Countryside Monitoring Scheme, currently administered by Scottish Natural Heritage (SNH). The NCMS has recorded land cover in Scotland based on aerial photography. Surveys were conducted for the 1940s (mean=1947), 1970s (mean=1973) and 1980s (mean=1988). The stratification of the NCMS is based on 12 geographical regions. Within each, the total land area was classed into categories or stratum, such as: upland, lowland or intermediate farmland, and urban although the definitions vary between regions. NCMS sample squares (originally 5x5 km squares but reduced to 2.5x2.5 km) were randomly sampled from each strata to give coverage of each category in each region, typically five sample squares (sites) per category. The intensity of sampling, therefore, varied between regions, and within regions between strata, so we corrected NCMS data for sampling intensity when we calculated national estimates. A total of 7.5% of Scotland (464 sample sites) was included in this scheme, and land cover for the same sample sites were recorded during each survey.

Within each site, land cover was classified into 31 areal and five linear categories (Tudor & Mackey 1995). For our project SNH provided the percent cover of each habitat type for each site during the three survey periods. We re-classified these habitat types into six broad categories: heather, upland vegetation (excluding heather), woodland, farmland, other, and unclassified. The unclassified category (cloud cover, outside of photograph, and open sea) only represented a small proportion of the total area sampled by the survey, and was excluded from further calculations. All measures of the remaining five habitat types are presented as percentages of the total remaining area.

In this study we evaluated only those sites with sufficient heather cover (at least 10%) in the 1940s to potentially sustain grouse populations at that time, a total of 229. These sites were classed into four geographical areas to compare changes in land cover in different parts of Scotland (Fig 1).

North and West (63 sites) - Caithness & Sutherland, Ross & Cromarty, Lochaber and the Western Islands (Orkney and Shetland were not included)

Cairngorm and Monadhliath (69 sites) - Inverness & Nairn, Badenoch & Strathspey, Grampian and Tayside

South-East (33 sites)- Fife, Central, Lothian and the Borders

South-West (64 sites) - Strathclyde, Dumfries and Galloway

Classification of grouse management status

Grouse management information was obtained from two sources. The Game Conservancy Trust has been systematically collecting bag records (numbers of grouse shot) from estates across the country since the early 1960s (Hudson 1992). In addition, bag records from the 1920s and 1930s (collated by Capt. P. Wallace) were used to classify areas into those with active grouse management and those with no significant grouse management. These records were of variable quality; some only provided qualitative information on grouse shoots, others gave quantitative data on the number of grouse shot. They were particularly valuable when providing details of moors where grouse shoots no longer occur, and where no long-term strings of bag records were available. The records from both sources were estate specific and did not directly relate to NCMS sites. The combination of Game Conservancy and P. Wallace records and estate details were used to classify estates coinciding with the NCMS sites into one of four categories. These were based on red grouse harvests and grouse management in each sample site in the period 1920-1945 and again during 1976-1990. Sites were included only where grouse management information was available for each period. Where bag records were unavailable, qualitative descriptions were used as an indicator of grouse management status. Sample sites with active grouse management were defined as those where “driven” red grouse were shot or where appreciable numbers were shot by

"walking-up" ("driven" and "walked-up" are high and low intensity methods of shooting respectively). Estates where small numbers of grouse were shot intermittently and those without an active gamekeeper were not considered actively managed for grouse. Estates were in the following four categories:

Grouse management - estates with active grouse management in both periods.

Previous grouse management - estates with grouse management during 1920-45 but not during 1976-90.

No grouse management - estates with no significant grouse management in either period.

Unknown - estates where the grouse management status was unclear in either period.

Statistical analysis

The analysis of data on the relative proportions of different habitat types is not straightforward. The individual proportions of different habitat types cannot be considered independent because, by definition, they sum to one (the unit-sum constraint). To overcome this, compositional analysis was used (Aitchison 1986). This converts the *n* proportions to *n-1* log ratios ($ln(x_i/x_j)$) using the *i*th habitat type as denominator. These log ratios are then independent of each other and standard multivariate statistics can be applied. This transformation cannot deal with zero proportions for a given habitat type. These were replaced with a small value (0.001), an order of magnitude smaller than the minimum detectable value (Aebischer, Robertson & Kenward 1993) implying that they were present but to a very small extent in each site. Two groups of sites, grouse management and previous grouse management, were investigated for differences in the proportion of land cover types within the three time periods (1940s, 1970s and 1980s). The null hypothesis for these analyses was that there was no difference in land cover type between the two types of grouse management status in any of the time periods. That a small proportion of land within the

sample sites was unclassified introduces some error into these analyses, and it is possible that certain habitat types have been under/overestimated. However, since there is no reason why this bias should differ between the two categories of grouse management under investigation (present and previous grouse management), the null hypothesis should be unaffected. Data were analysed using SYSTAT version 5.0, and a significance level of 0.05 was adopted.

RESULTS

Changing grouse interests in Scotland

Correcting for differences in sampling intensity, of the 229 NCMS sites examined, 49% were known to have been parts of estates with active grouse management in the 1940s. By the end of the 1980s, this proportion had fallen to 20%, a 59% reduction (Table 1). These numbers assume that estates classified as unknown were not managed for grouse during either period and are therefore minimum estimates of the extent of grouse management.

Land cover change in Scotland in relation to grouse interests

The major trend in percentage change in land cover since the 1940s has been a decline in heather cover and replacement by woodland, mainly conifer plantations, and to a lesser extent, other upland vegetation, predominantly unimproved grassland and farmland. We identified estates owning land within the sample sites for 198 samples (86% of the total). Of these, grouse management status in the two periods (1920-1945 and 1976-1990) was known for 121. Of 103 sites known to be active grouse moors in the 1940s, 57 have remained so, and on 46 sites grouse shooting has now ceased. In the 1940s there were no significant differences in the land cover of the two categories (F=0.29, df=4,120, p = 0.65; Fig. 2). By the 1970s, a significant difference was apparent (F=3.27, df=4,120, p = 0.02) and this difference became more pronounced during the 1980s (F=7.30, df=4,120, p<0.001). The

relative change in land cover types between the 1940s and the 1980s differed between estates on which grouse are still shot and those where shooting has stopped (F=8.86, df=4,120, p<0.001). In each of the four geographic areas there has been a general trend for heather to be lost and replaced with forestry or other upland vegetation but with some differences between areas. After removing the effect of geographic area from these analyses there was a similar picture of diverging land cover between areas losing or maintaining active grouse management (1940s: F=2.17, df=4,117, p = 0.12; 1970s: F=5.17, df=4,117, p=0.001; 1980s: F=7.02, df=4,117, p<0.0001; change 1940s -1980s: F=4.08, df=4,117; p<0.01). Since the 1940s, NCMS sites maintaining grouse management have lost on average 24% of heather cover, in contrast to 41% heather loss in those sites where grouse previously were shot (1920-1945) but where the shooting has now stopped (1976-1990).

Grouse shooting and heather cover

By weighting the different sampling intensities within and between areas we obtained estimates of land cover in Scotland (Table 2). The NCMS data used in this study (based on sites containing at least 10% heather cover in the 1940s) suggested that in 1940, 51.9% of heather ground in Scotland was used for grouse shooting, but by the 1980s this figure had dropped to 25.3%. Over the period from the 1940s to the 1980s, the rates of heather loss were lowest in areas maintaining grouse management and highest in areas where management had been lost (Table 2).

DISCUSSION

The extent of grouse shooting in Scotland declined between the 1940s and the 1980s (Barnes 1987, Hudson 1992). Correcting for regional differences in NCMS sampling, our data suggested that the number of sites actively managed for grouse declined by 59%. The

total area of heather has decreased by 34% although there have been considerable differences between areas and in relation to grouse interests. Land cover changes within sites where grouse management status was unknown largely follow those never managed for grouse. This suggested that the majority of the sites for which there was no information were also not managed for grouse in either period.

It is difficult to assess the extent to which continued grouse shooting has been the cause or merely the consequence of heather retention. One possibility is that grouse shooting only continues on areas where heather has been retained for some other unrelated reason. The alternative, that interest in grouse shooting has promoted heather retention, seems more likely. Grouse shooting, when productive, is often the primary source of income or the main attraction of ownership on many upland estates (McGilvray 1995). It is apparently rare for a productive grouse moor to be converted to some other form of land use, implying that decisions to alter land cover appear to follow declines in grouse populations. In the 1940s, land cover types did not differ significantly between the sites that are still managed for grouse and the sites where grouse management stopped by the 1980s. Certainly, there is little evidence that grouse shooting stopped because those sites contained less heather or because low numbers of grouse were shot there originally. A more detailed examination of the timing of land cover change in relation to grouse bags on individual estates would be useful in this respect.

The causes of long-term declines in grouse numbers on the moors where grouse shooting still occurs are certainly complex (Hudson 1992). One hypothesis is that the reduction in heather cover in the uplands (estimated here as 34% between the 1940s and the 1980s on those areas originally containing at least 10% heather cover) is a major factor. Our data suggest that the true rate of heather loss on the remaining grouse moors is lower, around 24%, and this in itself is unlikely to account for all of the reduction in grouse harvest on the

remaining heather dominated parts of these moors between the 1940s and 1980s. The main causes of heather loss appear to be increased grazing pressure, both from sheep and deer, combined with afforestation (Tudor & Mackey 1995, Fuller & Gough 1999). Much heather loss in recent decades can be attributed to the consequences of government agricultural and forestry policy (Barr 1997). Tax incentives made large-scale alien coniferous plantations an attractive investment option until a change in the tax law in 1988. From the 1940s to the 1970s coniferous forest increased by over 4,500km^2 in Scotland alone, largely at the expense of heather moorland, blanket mire, and unimproved grassland (Tudor & Mackey 1995). Current agricultural subsidies are typically production-linked incentives that sometimes result in overstocking and overgrazing (White & Wadesworth 1994). Changes in government subsidies for agriculture and forestry that incorporate biodiversity and nature conservation appears to be the best hope for the Scottish uplands, particularly heather moorland, and some progress has been made in this direction (Ward, MacDonald & Matthew 1995). Nevertheless, our results suggest that where there is sufficient motivation, for whatever reason, the rate of heather loss can be reduced in many areas, and grouse management appears to be one way of achieving this.

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REFERENCES

Aebischer, N.J., Robertson, P.A. & Kenward, R.E. 1993: Compositional analysis of habitat utilization from animal radiotelemetry data. - Ecology 74: 1313-1325.

Aitchison, J. 1986: The statistical analysis of compositional data. - Chapman and Hall, London.

Barnes, R.F.W. 1987: Long-term declines of red grouse in Scotland. - Journal of Applied Ecology 24: 735-741.

Barr, C.J. 1997: Upland landscapes: Current status and prospects for key habitats in England, Part 3. - Department of the Environment, Transport and Regions, Great Britain.

de Smidt, J.T. 1995: The imminent destruction of northwest European heaths due to atmospheric nitrogen deposition. - In: Thompson, D.B.A., Hester, A.J. & Usher, M.B. (Eds.); Heaths and Moorland: Cultural Landscapes. Her Majesty's Stationary Office, Edinburgh, pp. 206-217.

Fuller, R.J. & Gough, S.J. 1999: Changes in sheep numbers in Britain: implications for bird populations. - Biological Conservation 91: 73-89.

Grant, S.A. & Hunter, R.F. 1971: Interaction of grazing and burning on heather moors. II. Effects of primary production on production and level of utilisation. - Journal of the British Grassland Society 26: 173-81.

Hudson, P.J. 1992: Grouse in space and time. - The Game Conservancy, Fordingbridge.

Lovat, Lord. 1911: The grouse in health and disease. - Smith & Elder, London.

McGilvray, J. 1995: An economic study of grouse moors. - The Game Conservancy, Fordingbridge.

McKelvie, C.L. 1985: A future for game? - Allen & Unwin, London.

Stevenson, A.C. and Birks, H.J.B. 1995: Heaths and moorland: long-term ecological change, and interactions with climate and people. - In: Thompson, D.B.A., Hester, A.J. & Usher, M.B. (Eds.); Heaths and moorland: Cultural landscapes. Her Majesty's Stationary Office, Edinburgh, pp. 234-239.

Thirgood, S., Redpath, S., Newton, I. and Hudson, P.J. 2000: Raptors and red grouse: conservation conflicts and management solutions. - Conservation Biology 14: 95-104.

Thompson, D.B.A., MacDonald, A.J., Marsden, J.H. & Galbraith, C.A. 1995: Upland heather moorland in Great Britain: a review of international importance, vegetation change and some objectives for nature conservation. - Biological Conservation 71: 163-178.

Tudor, G.J and Mackey, E.C. 1995: Upland land cover change in post-war Scotland. - In: Thompson, D.B.A., Hester, A.J. & Usher, M.B. (Eds.); Heaths and moorland: Cultural landscapes. Her Majesty's Stationary Office, Edinburgh, pp. 28-42.

Ward, S.D., MacDonald, A.J. and Matthew, E.M. 1995: Scottish heaths and moorland: how should conservation be taken forward? - In: Thompson, D.B.A., Hester, A.J. & Usher, M.B. (Eds.); Heaths and moorland: Cultural landscapes. Her Majesty's Stationary Office, Edinburgh, pp. 319-333. Edinburgh: HMSO.

White, B. and Wadesworth, R. 1994: A bioeconomic model of heather moorland management and conservation. Ecological Economics 9: 167-177.

TABLE 1. Number of NCMS sites in each of the four geographical area (North and West: N+W; Cairngorm and Monadhliath: C+W; South-East: SE; South-West: SW), subdivided by grouse management status and illustrating the changing status over time (figures in parentheses in the total column are corrected for regional differences in NCMS sampling intensity).

Status	**N+W**	**C+M**	**SE**	**SW**	**Total**
grouse management	5	36	13	5	59
previous grouse management	21	15	8	22	66
no grouse management	13	6	9	18	46
unknown	24	12	3	19	58
TOTAL	63	69	33	64	229
% grouse management in 1940s	41%	74%	64%	42%	54 (49) %
% grouse management in 1980s	8%	52%	20%	8%	26 (20) %

TABLE 2. Estimated distribution of upland areas and heather cover, in relation to grouse management status, in Scotland during the 1940s and 1980s. The column to the right shows the % heather loss in relation to management status between the 1940s and the 1980s. For this purpose sites managed for grouse in the 1940s are divided into those that remained under grouse management by the 1980s and those on which management has ceased (the figure in brackets indicates the total area of heather covered by these two categories).

	area of heather (ha)	**total upland area (ha)[1]**	**% heather**	**% heather loss**
1940s				
grouse management	636,400	3,060,100	49.3	n/a
grouse management (stopped by 1980s)	872,300			
no grouse management	532,300	1,517,700	35.1	n/a
unknown	867,700	1,636,600	43.0	n/a
TOTAL	2,908,700	6,214,400	46.8	n/a
1980s				
grouse management	484,600	1,216,800	39.8	23.9
previous grouse management	512,300	1,818,400	28.2	41.3
no grouse management	360,600	1,546,300	23.3	32.3
unknown	557,100	1,635,800	34.0	35.8
TOTAL	1,914,600	6,217,300	30.8	34.2

[1] Discrepancies in the total figures are due to changes in cloud cover between periods

FIGURES

Fig 1. The four broad Scottish geographical areas used in our study

Fig 2. Changes in upland land cover in Scotland in the 1940s, the 1970s and the 1980s, based on 229 NCMS sample sites known to have contained >10% heather in the 1940s, for: A) sites which have remained active grouse moors (N=57), and B) sites where grouse management stopped over this period (N=46). The five land cover types used are heather, upland vegetation (excluding heather), woodland, farmland and other.

Fig. 1 Robertson, Park & Barton

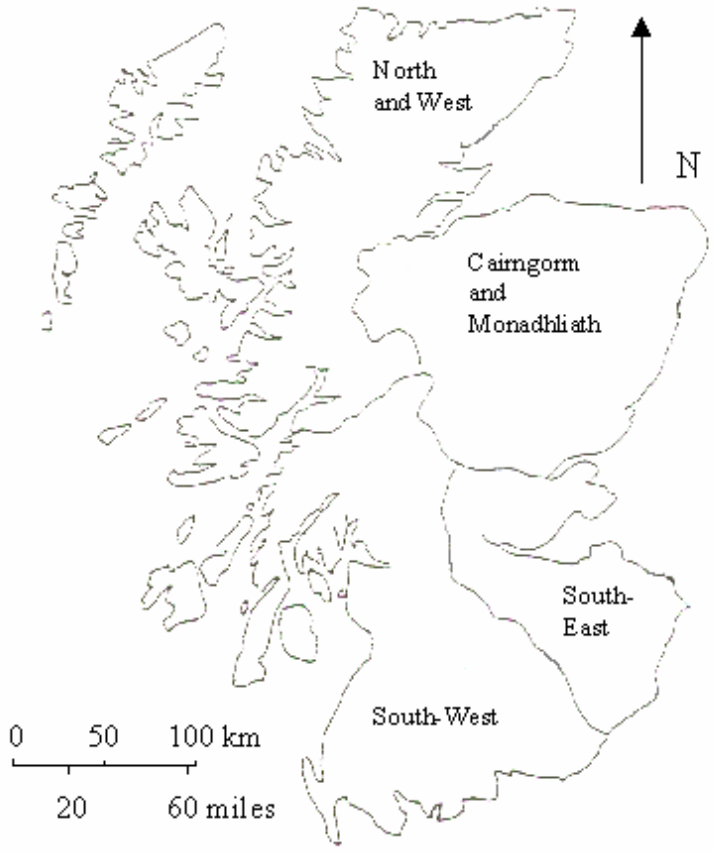

Fig. 2 Robertson, Park & Barton