VEGETATION CHANGES ON ILKLEY MOOR BETWEEN 1964 AND 1984, AND POSSIBLE ENVIRONMENTAL CAUSES

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INTRODUCTION

In recent years there has been concern about the decrease in the quality and quantity of Britain's heaths and moorlands. This concern has prompted attempts to monitor change in moorland vegetation, and programmes of action designed to halt the decline, both nationally and locally (Bunce, 1989; Hudson & Newborn, 1989a).

In northern England the decline has been brought about partly by a reduction in the areal extent of the moors but mainly by changes in their species composition, with *Calluna vulgaris* (L.) Hull (heather) declining and grasses, *Empetrum nigrum* L. (crowberry) and other species increasing. These changes have been attributed to changed management practices, such as less effective burning regimes and increased sheep grazing (Bunce, 1989). However, there are few detailed quantitative studies of long-term vegetation change. This paper draws upon historical records to determine the nature and extent of change in the vegetation of Ilkley Moor over a twenty-year interval.

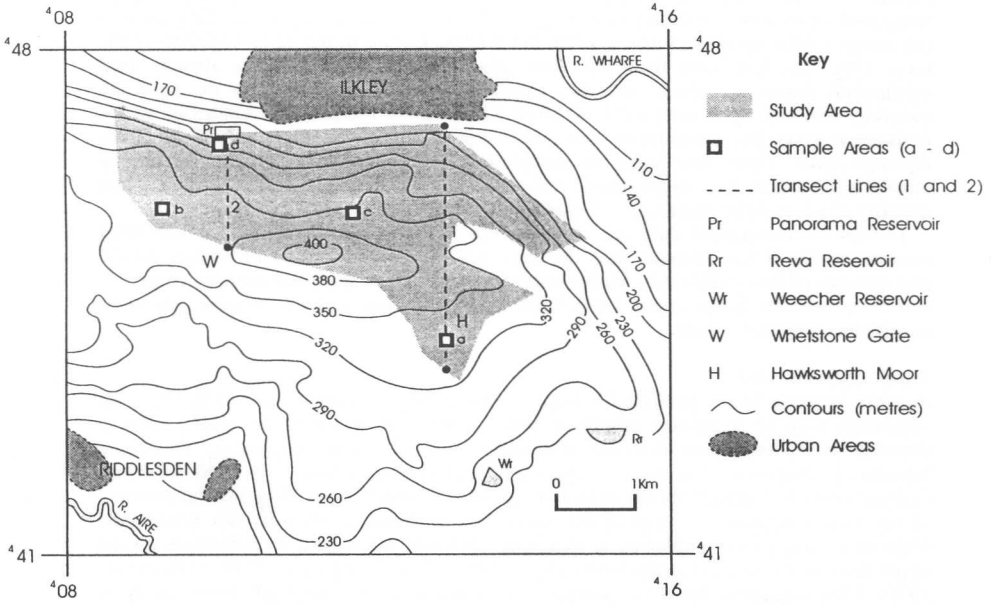

FIGURE 1
Location map showing the positions of the transect lines (1 and 2) and sample areas (a-d) mentioned in the text. The numbers on the edges relate to the National Grid.

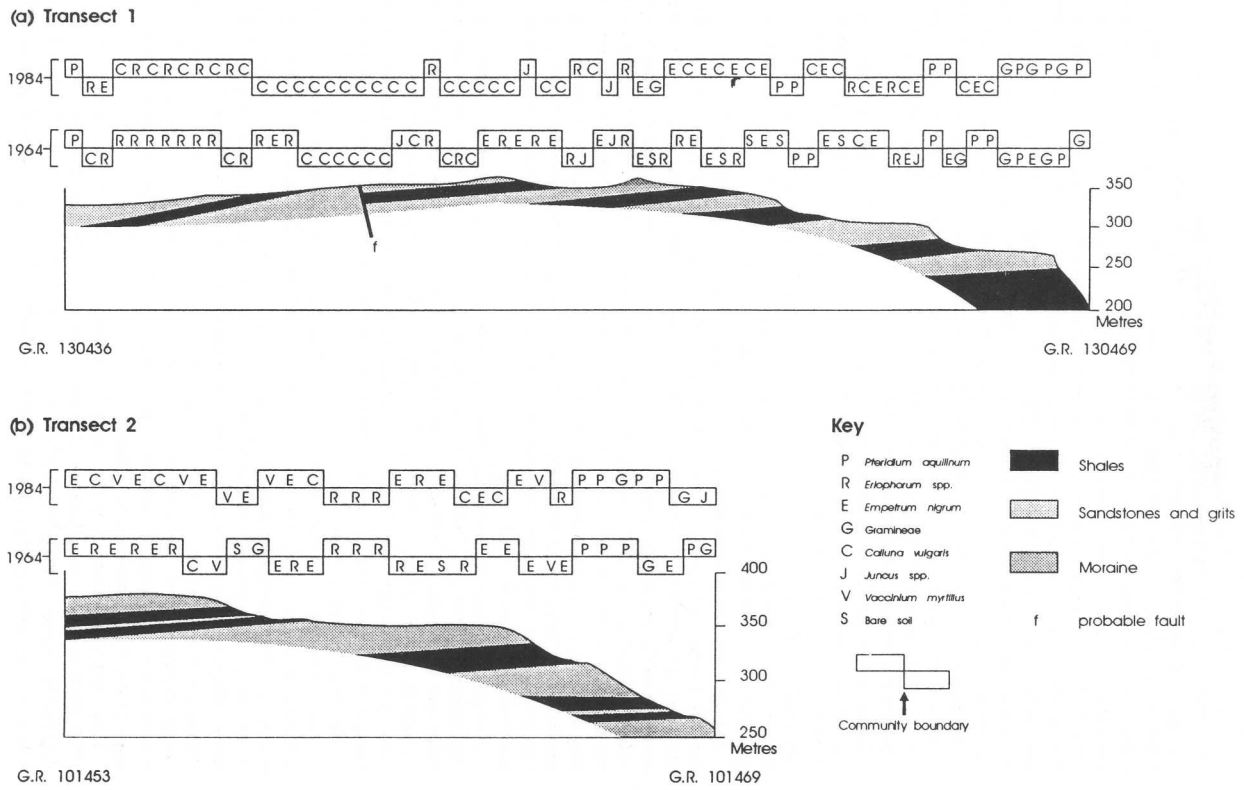

FIGURE 2

Composite cross sectional transects of Ilkley Moor showing topography, generalised geology and vegetation communities as mapped in 1964 and 1984. The letters within each community type give an approximate indication of the relative abundance of the species present. The locations of the transects are given in the text and in Figure 1.

precipitation, bright sunshine and temperatures were obtained for Lister Park in Bradford, which is less than 9 km from the moor. Data from these three sources have been combined to provide a more complete picture of conditions on the moor than would be given by information from any one recording station.

Records of sheep numbers between 1950 and 1988 were obtained from the Ministry of Agriculture, Fisheries and Food (MAFF) annual June returns. These provide details of livestock numbers on agricultural holdings within all the parishes which together constitute the moor. Records of sheep numbers actually on Ilkley Moor came from direct counts made between 1974 and 1978, and were obtained from Bradford Metropolitan District Council.

Results

Table 1 provides data for the estimated percentage areas of the moor occupied by major plant species. The reclassified 1964 data show very little difference (<3%) in the indicated species abundances from the data obtained with the original categories – compare columns (b) and (c). This contrasts with the marked differences between the 1964 and 1984 data – compare columns (b) and (a). This gives confidence that the differences are not merely an artefact of using different mapping procedures in the two surveys.

It is apparent that the estimated cover value for *Calluna* has increased appreciably (from 8.2% to 25.9%) whilst those for *Vaccinium* and *Pteridium* have also increased but by a smaller absolute amount (from 2.5% to 8.4% and 17.3% to 22.5% respectively). However, in percentage terms *Vaccinium* has increased even more than *Calluna* (Table 1). *Empetrum* and *Eriophorum* species have decreased considerably (by an estimated 13.4% and 10.8% respectively). Whilst there is an indication that Gramineae and *Juncus* species have each decreased slightly, the decrease is close to the 3% variation associated with the community reclassification and therefore should be interpreted with caution.

Notable tracts (30ha in total) of the whole moor were recorded as bare ground or burnt areas in 1964, probably reflecting a more active burning regime at that time. By 1984 these had been colonised by vegetation, and no bare ground or burnt areas were recorded. For these colonised areas, *Empetrum* accounted for an estimated 33% of the new cover, *Calluna* for 28% and *Vaccinium* for 16%; the remaining species each had 10% cover or less.

TABLE 1

Percentage of vegetation cover (excluding bare ground) accounted for by species and higher taxa in (a) 1984, (c) 1964 and (b) 1964 as reclassified. Percentage change calculated by ((a)-(b)/(b))x100.

Species	1984 categories (a)	1964 re-classified (b)	1964 categories (c)	% change
Calluna vulgaris	25.9	8.2	7.2	+216
Pteridium aquilinum	22.5	17.3	16.3	+30
Empetrum nigrum	19.0	32.4	35.2	-41
Eriophorum spp.	13.5	24.3	24.3	-45
Vaccinium myrtillus	8.4	2.5	2.1	+238
Gramineae	6.6	10.1	7.3	-35
Juncaceae	4.1	5.2	7.8	-21

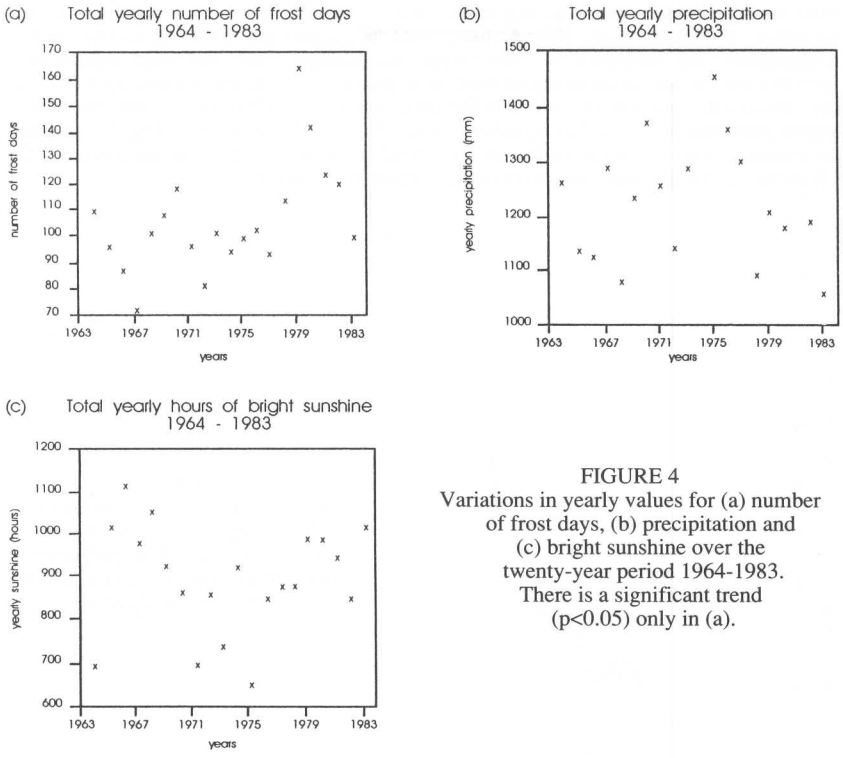

FIGURE 4
Variations in yearly values for (a) number of frost days, (b) precipitation and (c) bright sunshine over the twenty-year period 1964-1983. There is a significant trend ($p<0.05$) only in (a).

section of the central plateau, and have diminished particularly in the upper portion of the eastern moor. *Empetrum* has also declined on the upper moor, but the relationship with relief is less clear. *Vaccinium* has increased on the upper areas of the moor, particularly in the west. *Pteridium* has not extended beyond the lower portions of the moor, but in some areas it has been ousted by *Calluna* and *Empetrum* whilst elsewhere it has expanded at the expense of the *Empetrum*-grass community. Maps showing changes in the spatial distribution of the species on the moor are given in Cotton and Hale (1989).

Comparison of the vegetation maps of different portions of the moor in 1964 and 1984 reveals many changes. On the upper moor (Fig. 3a), *Calluna* has become much more abundant, having spread into large areas that were formerly dominated by *Empetrum* and *Eriophorum*. *Empetrum* now only occurs rarely in the area. On the upper sandstone scarp changes are equally pronounced (Fig. 3b). *Vaccinium* has spread along the crest of the scarp and in 1984 formed a distinct zone. *Calluna* too has become more abundant, with both species occupying areas where *Eriophorum* and *Empetrum* were formerly abundant. On the poorly drained plateau of the middle moor (Fig. 3c), ericaceous species have spread into areas formerly occupied by *Eriophorum*. *Juncus* species have decreased in the area. The biggest change on the lower moor (Fig. 3d) is the general increase in the abundance of *Pteridium*. However, locally Gramineae and Juncaceae have become more abundant and *Empetrum* has declined in the lowest portions of the area.

Gimingham, 1987). Hudson and Newborn (1989a) maintain that, as a rough guide, a grazing density of 1 sheep per hectare is the maximum that will normally allow *Calluna* to maintain itself in the vegetation; while the Nature Conservancy Council have given predictions for heather moorland condition at different stocking densities (Cranbrook, 1991). They predict that heather moorland should be in 'good' condition (i.e. >50% heather cover) when stocked, on average, at <2 ewes per hectare; in 'poor' condition (25-50% cover) at 2-3 ewes per hectare; 'suppressed' (<25% cover) at 3-4 ewes per hectare; and absent at >4 ewes per hectare. They suggest that heather moorland would be likely to disappear in the longer term if stocking rates persist at >2 ewes per hectare . Ilkley Moor therefore had, by 1984, reached a stocking rate at which some deleterious vegetation changes might be expected to occur.

Our results indicate that pronounced vegetation changes have occurred on Ilkley Moor in the period 1964 to 1984. However, the nature of these changes differs from the response to similar increases in grazing intensity recorded elsewhere. When sheep are present at densities of over 1 per hectare, *Calluna* decline has been associated with the spread of *Nardus stricta* L. and other less palatable species such as *Empetrum* (Welch, 1984). In contrast, on Ilkley Moor our data indicate that *Calluna*, *Pteridium* and *Vaccinium* have increased while *Empetrum* and *Eriophorum* species have declined. Examination of the changes in the plant communities on Ilkley Moor (Fig. 3a-d) reveals that different moorland habitats have changed in different ways. Hence, it is probably unwise to regard Ilkley Moor as one single unit when making comparisons with other findings. Clearly, erroneous conclusions could be reached by assuming that observations on change on one moor are directly applicable to the whole of another moor where the habitats may differ. Possible explanations for the observed changes in individual species abundance and distribution on Ilkley Moor are given separately below.

Empetrum Decline

The decrease in *Empetrum* on most of the moor might have arisen from climatic change. On Ilkley Moor *Empetrum* is close to its south-eastern limit of distribution within Britain (Bell & Tallis, 1973). Consequently, any tendency toward warming or drying might be expected to affect it adversely on this site, particularly on the lower slopes of the moor where a marked decrease was noted (Fig. 3d). The annual climatic data, however, show no systematic tendency for change in bright sunshine, temperature or precipitation. There was a slight increase in the number of frost days, but it is unlikely that this would have caused a decline in a species with a northerly distribution. The increase in stocking rates probably would not have led to greater grazing pressure as *Empetrum* is relatively unpalatable. However, increased sheep numbers could have led to an increase in trampling to which this species, with its prostrate stems, would be particularly susceptible (Dalby, 1961; Rawes, 1983).

Pteridium Consolidation

The distribution of *Pteridium* on Ilkley Moor is thought to be limited by altitude and exposure (Fidler *et al.*, 1970). Over the 20 year period the upper limit of the major areas of *Pteridium* has remained below the 350 metre contour, though it has consolidated its hold within the areas it occupied previously. This increased occupancy may be because increased sheep grazing pressure does not greatly affect *Pteridium* due to its unpalatability, and its spread has been widely recorded in other upland areas of Britain (Anderson & Yalden, 1981; Hudson & Newborn, 1989b).

Eriophorum Decline

It is known that sheep have distinct grazing preferences for different species at different times of the year (Hunter, 1962). Therefore, replacement of the *Eriophorum* species by *Calluna* in parts of the moor may well be associated with preferential seasonal (summer) grazing. However, details of such preferences are not entirely understood (Grant *et al.*,

Notable differences in the fate of species within different communities have been observed in different sections of the moor. Consequently, regarding a moor as one uniform whole may be inappropriate.

Variations in the burning management regimes may account for many of the vegetation changes on the moorland, its current vegetation communities probably reflecting the extensive disturbance that was recorded in the 1960s. Current management practice in operation since 1984, which includes the reduction of grazing pressure, may not maintain the presently improved moorland quality. Indeed, it is possible that the relative abandonment of *Calluna* burning since the 1960s may lead to a deterioration of the vegetation in the coming decades despite the reduced grazing unless there is further active management.

SUMMARY

Records of the vegetation of Ilkley Moor date back to 1903. Detailed maps of the vegetation of 1,000ha of the moor, completed in 1964 and 1984, were compared using a grid of almost 9000 points to determine the vegetation change, notably of the species *Calluna vulgaris* (L.) Hull, *Empetrum nigrum* L., *Pteridium aquilinum* (L.) Kuhn, *Vaccinium myrtillus* L., *Eriophorum angustifolium* Honck. and *Eriophorum vaginatum* L. Although different community classifications were adopted in the two surveys, data derived from the two maps could be compared directly without undue distortion of results. Comparison of the two surveys indicated marked increases in percentage occupancy of *C. vulgaris*, *V. myrtillus* and *P. aquilinum*, and decreases of *E. nigrum* and *Eriophorum* species. The specific changes also varied on different parts of the moor.

Trends in various environmental parameters over the period 1964 to 1984 were assessed to try to explain these changes. There is no evidence to show that drainage operations have been an important factor, nor that there have been any consistent climatic trends that might have affected the vegetation composition. The vegetation changes cannot be explained solely in terms of alterations in grazing pressure by sheep, although the local sheep numbers were found to have increased substantially over this period. Possible effects from trampling by sheep, seasonal grazing, species unpalatability and past burning regime are discussed.

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