MOOR HOUSE

19th Annual Report, 1978

THE NATURE CONSERVANCY COUNCIL

MOOR HOUSE

1978

19th ANNUAL PROGRESS REPORT

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C O N T E N T S

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I. GENERAL

a) Introduction

The Report covers the period 1 October 1977 to 30 September 1978.

J. Parkin, who had been Warden for three years, left in the Autumn. He is now at the Swale Reserve in Kent and his place has been taken by P. Burnham, who was previously Warden of Holme Fen N.N.R. Like his predecessor, he is primarily an ornithologist.

Professor F.G.T. Holliday (Chairman N.C.C.), members the Advisory Committee for England, Dr. M. Gane (Director, England) and staff from England Headquarters visited Moor House in July.

b) Reserve Management

Our objectives are:

1. to conserve and, where possible, enhance the interest of habitats and wildlife,

2. to establish by research optimal management for wildlife,

3. to provide facilities for ecological research, especially in those areas that have a direct bearing on conservation,

4. to provide facilities for education and training.

The few tree enclosures that we have, provide habitats that are relatively sheltered and hold species that would otherwise not be present. They are also places that are ungrazed by sheep. But they are small, and, until such time as we can introduce an imaginative scheme to embrace planting trees and shrubs within an area of at least 100 ha, the effects must be local and of little conservation significance. Our findings to date are that willow, rowan and birdcherry would be the most suitable species with pines (Pinus contorta and P. mugo) for shelter.

A major threat to the Reserve remains the mining operations at Silverband. Open cast exploitation of barytes on the present scale in a National Nature Reserve is proving severely disruptive, and the danger of a catastrophic breakdown in the whole process of washing material is very real.

A further threat comes from the increase in public pressure. The erosion occurring on the Pennine Way is a problem that affects a scarce and fragile habitat, the summit areas. The problem of how, and who, is to check, and in part, re-surface this path must be solved soon or the damage will be beyond remedy.

The security of rare species is also of concern. It seems that information of sites is available too freely, and, in particular, the scientist and knowledgeable ' nateur' are guilty of spreading information. Constant wardening against marauders is required.

Bad weather conditions prevented, for the second successive year, heather burning of the two grouse moor management areas. Grouse stocks however, remain good and although a cold spring delayed heather growth there was little evidence of extensive frost damage.

The search to find optimal management procedures for upland moorland must, in the absence of more experimental work, rely on the bringing together of results of the more fundamental researches of the past and our intermittent results from existing long-term projects. The publication this year of the results of the Moor House International Biological Programme in one volume gives a sound basis for understanding the moorland system; this has also been stimulated by another recent book edited by Professor A.R. Clapham "Upper Teesdale: the Area and its Natural History", which has drawn on Moor House for a lot of its information.

Laboratory and field facilities at Moor House are being used by research workers from Aberdeen, Durham, Lancaster, Leeds, London, Manchester and Sheffield Universities and Huddersfield Polytechnic. The projects continue to add to our knowledge and some work is very relevant to conservation management. Individual reports appear later. Additionally, we have employed a few students on small projects that cover aspects of the overall programme and their reports will appear in the Reserve Records.

In-house survey of upland grade 1 sites, which include Moor House and Cross Fell, has been continued by A. Poulter working on Skiddaw, in the Lake District. Liaison with the similar work in Scotland is maintained and last year's botanical data have been prepared for further analyses.

Durham, Lancaster and London Universities have used Moor House for teaching purposes. Day visits were made by geographers and biologists from Teesside 6th Form College, by members of the Cumbria Branch of the Association for Science Education and by students from the Cumbria College of Agriculture and Forestry.

c) Natural History (P. Burnham)

The severe weather conditions at the start of the year, with total snow cover at times, made most forms of wildlife scarce on the Reserve. Dippers and grouse were the only birds regularly recorded throughout January and February. The grouse virtually disappeared during the end of these months, over a period of total snow cover, with only 200+ being recorded occasionally along the Tees. A wren was observed feeding under overhanging snow at Tees Bridge during this period of severe weather. A fox was seen hunting the fell in broad daylight on 31 January 1978 and fox tracks were regularly found around the Field Station.

Breeding birds began to move up to the Reserve during the end of February and beginning of March, but were pushed back down to the valleys after snow storms in the last two weeks of March.

Birds such as lapwings, golden plover and curlew did not return in any number until the end of April/beginning of May. This was a period of warm, sunny days mixed with sleet, snow and severe frosts. Several

of these early ground nesters are thought to have lost first eggs due to frost damage. The frosts are thought also to have killed palmate newts and frogs found dead in several ponds at this time.

A very warm period followed from 16 May until 5 June which helped establish clutches of eggs and saw the first young hatched. A brood of grouse was recorded on 28 May and a female teal with 7 young was seen in the Tees on 2 June. Five species of butterfly were recorded flying in the meadow during this time, with Greenveined White the most common. A female Orange Tip was recorded on 4 June and several male Fox moths were flying during daylight over Hard Hill from 17 May onwards.

Chicks hatching towards the end of June, beginning of July were probably effected by the wet conditions, sometimes continuous rain daily. Several species were recorded with single young. Towards the end of July and August the showery and misty weather continued, making conditions poor for Lepidoptera and only one species of dragonfly, Anax juncea, was recorded, on two dates.

By the middle of August most breeding waders had gone and by the beginning of September only single wheatears and meadow pipits were seen on the Reserve.

A new species for the Reserve was recorded during August. An osprey was seen flying down the Tees and out over Cow Green Reservoir on the 4th.

II. SCIENTIFIC

a) Climatology (R.B. Marsh)

The weather summary for 1977 is given in the appendices, along with the 25 year summary.

Since 27 September 1977 this Station has been one of only 21 recognised by the Meteorological Office for recording Solar Radiation in Britain.

The summary of data for the year of this report is given in Table 1.

TABLE 1. Comparison between 25 year average and the reporting year 1977-78.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Year
Mean Maximum	9.4	5.1	3.4	2.3	1.9	4.0	7.0	10.7	13.9	14.9	14.7	12.4	8.3
77/78	10.6	4.0	4.1	1.2	0.3	4.2	5.2	12.4	12.9	13.8	13.5	11.9	7.8
Mean Minimum	3.7	0.1	1.7	2.4	3.2	1.6	0.1	2.5	5.4	7.2	7.3	5.9	1.9
77/78	5.3	1.0	0.2	3.7	4.7	0.3	1.1	2.2	5.1	6.2	7.8	7.2	1.9
Mean ($\frac{1}{2}$(Max+Min)	6.5	2.6	0.9	0.1	0.7	1.2	3.5	6.6	9.7	11.1	11.0	9.1	5.1
77/78	7.9	1.5	2.1	1.3	2.5	1.9	2.1	7.3	9.0	10.0	10.7	9.5	4.9
Mean Earth	7.8	4.7	2.8	1.8	1.6	2.0	3.8	6.8	9.9	11.6	11.7	10.2	6.2
77/78	8.3	5.0	3.1	1.8	1.3	2.4	3.3	6.9	9.7	10.7	11.3	10.3	6.2
Mean Rainfall m.m.	183.7	198.9	217.5	208.8	149.2	132.2	122.7	122.7	108.3	139.3	155.2	165.0	1903.5
77/78	159.4	251.8	194.1	500.0	334.9	297.8	51.9	45.4	54.1	93.9	116.5	264.0	2363.8
Mean Sunshine (hrs/day)	2.50	1.42	0.91	0.95	1.74	2.72	4.01	5.28	5.98	4.78	4.57	3.34	3.18
77/78	2.77	1.60	0.77	1.09	1.17	2.08	3.06	6.36	5.42	5.39	3.20	2.18	2.92
Mean Air Frost	4	14	21	22	21	21	15	7	1	+	+	2	128
77/78	1	18	16	28	22	18	15	6	1	0	0	0	125
Mean Ground Frost	10	19	23	25	24	24	20	13	7	4	4	6	179
77/78	7	23	21	30	26	20	20	15	4	9	3	2	180
Mean Snow Lie	+	5	12	16	16	12	5	+	+	0	0	0	66
77/78	0	11	6	25	28	8	6	0	0	0	0	0	84

+ = less than $\frac{1}{2}$ day.

The yearly figures are very close to those shown in Table 2 of last years Report for the period 1968-69, and this helps to emphasise the trend of weather to revert to the more normal types of the late 1960's, the winters of the early 1970's being relatively snow-free and mild.

	1968-69	1977-78
Maximum Temp. °C	7.8	7.8
Minimum Temp. °C	1.7	1.9
Mean Temp. °C	4.7	4.9
Earth Temp. °C	6.1	6.2
Rainfall m.m. (total)	1555.8	2363.8
Sunshine h. Daily aver.	2.95	2.92
Air Frost days (total)	144	125
Ground Frost days (total)	175	180
Snow Lie days (total)	94	84

b) Studies of vegetation and sheep
(M. Rawes and R.B. Marsh)

These management studies are of a long-term nature. They cover swards representative of the Reserve and incorporate aspects related to agricultural and sporting practice such as grazing, burning, draining, manurial and seeding treatments.

Unfortunately there has been little time available during the year for this and other staff scientific projects. Lack of staff makes it impossible to maintain our previous level of scientific input.

Effect of present day sheep grazing of the open fell

Three sites, all Agrostis-Festuca grasslands, were re-examined. On Knock Fell, where records were first made 16 years ago, there have been significant, but not large, changes in species composition. Angiosperms have generally increased their cover and bryophytes decreased. Preliminary examination of the records taken on four occasions between 1962 and 1978 show there to be a pattern of fluctuating species rather than a unidirectional trend.

The other two grasslands, both alluvial grasslands, by the River Tees, have shown a similarly significant decrease in Agrostis tenuis but increases in Galium saxatile and Thymus drucei; this has been over 14 and 15 years. The changes may be linked with the fall in sheep numbers observed on these grasslands in 1977. This work was by Catherine Guy (Exeter).

Jill Farthing (Newcastle), another short-term student, made a survey of Trifolium repens on the Reserve and, when the laboratory work is complete, her results will be entered in the Reserve Record. The infrequent flowering of Trifolium, which is mainly found in swards that are heavily grazed by sheep, is an important factor in minimising the chances of genetic variation. Grazing also masks the affects of altitude and aspect, so that differences, in for instance plant size, are unlikely to be significant from one site to another. The association of Trifolium with other species is one matter of particular interest that will be briefly described in the complete report.

Effect of removing sheep grazing

The Agrostis-Festuca site on Knock Fell, which also had patches of Juncus squarrosus dominant vegetation, was fenced in 1955 and the first botanical analysis completed in 1956. Since then the site has been examined on four occasions, the last being in 1978 when the full 1000 point quadrats were repeated. The results after seven years of exclosure were published in J. appl. Ecol. 1, 281-300, and it is intended to bring this up to date with a further report. Although analyses of the 1978 data are incomplete it would appear that the trends noted earlier have been maintained, species diversity has been reduced and the vegetation has become dominated by Deschampsia caespitosa, D. flexuosa and Festuca ovina.

An examination of the faunal changes within this exclosure has been attempted previously, but with little success. A six week survey this summer by M. Hayward (Lancaster), supervised by Dr. J. B. Whittaker, has been looking at a number of groups, from soil invertebrates to small mammals, both inside and outside the exclosure. Although much of the collected material has yet to be identified and quantified it is clear that some major changes have occurred.

Effect of burning

The burning and grazing experiment on Hard Hill is to test the effects on botanical composition of two burning rotations (10 and 20 years). Although the next full botanical examination is not due until 1982 the results of R. Hobbs' sampling (p. 24) this year provide useful interim information. The fourth year (30 years) of burning will take place in 1985.

c) Natural grassland communities
(M. Rawes)

Insufficient records have been made to justify a report this year.

d) A population study of the Red Grouse (Lagopus lagopus scoticus)
(P. Holms)

The sites used and the methodology of this study have been described in previous reports.

The results are given in Table 1. The spring count of 0.74 birds/ha is slightly higher than last year (0.71 birds/ha), when the young to old ratio (August count) was 2.6:1 compared with 2.22:1 this year.

26 nests were found, the majority of chicks hatching between 24-28 May and the earliest on 18 May. Overall hatching success was good (96.4%), but the average clutch size (7.4 eggs) was the lowest since 1975. Despite this the young to old ratio (2.22:1) remains good. Only once (in 1974) in the past 8 years has the ratio fallen below 2:1.

Red grouse carry a number of body parasites, endoparasites such as tapeworms and nematodes, and ectoparasites such as mites, fleas, ticks and flies. On chicks the most common parasite found this year was the grouse fly (Ornithomyia lagopodis L.), which scurries out of the feathers on first handling the bird. Whilst the fly was found on chicks 7-15 days old the highest numbers were on late hatched chicks of 18-24 days old. Bird louse (Goniodes tetraonis (Denny)) and tick (Ixodes hexagonus, Leach) were found in small numbers.

Table 1. Grouse performance 1978.

Census Site	Area (ha)	Spring birds/ha	Average Clutch/site	Breeding success Ratio Young/Old
Bog End	10.2	0.98	7.6	2.45/1
Burnt Hill	20.3	0.79	8.0	2.35/1
The Drive	20.2	0.69	7.8	2.25/1
Hard Hill 2	14.0	0.57	-	2.08/1
Hard Hill A	21.2	0.75	7.6	2.01/1
Hard Hill B	24.5	0.69	7.3	2.41/1
Green Burn A	15.6	0.64	7.6	1.87/1
Green Burn B	14.7	0.82	5.5	2.34/1
Others			7.4	
Overall		0.74	7.4	2.22/1

e) Tree Growth
(R.B. Marsh)

Work continues on tree management and further establishment of tree enclosures includes planting of part of the Hardshins Silver Jubilee Exclosure.

In October, the thinning programme continued in two exclosures. In Nether Heath 139 Pinus contorta and 25 Picea sitchensis were removed and in the Pasture Tree Exclosure 99 Pinus contorta and P. sylvestris. Further work is necessary particularly in Bog End and Force Burn.

Following the fencing of Hardshins and the extension to Nether Hearth more tree planting was done than in the previous two years. A total of 710 trees of the following species were planted: Salix spp., Sorbus intermedia, Pinus contorta, P. mugo and Larix eurolepis.

To increase the supply of willows, cuttings of Salix phylicifdia from Green Hole and Salix sp. from Nether Hearth were taken in May. By July 560 rooted cuttings were transferred to the nursery for planting out in 1979.

In May we received 200 Birch seedlings (Betula pubescens ssp. odorata) from Sutherland. The seedlings were planted in $3\frac{1}{2}$" polythene pots.and will be moved to enclosures next year.

R. A. Jewell (University College, London University) worked for 5 weeks in the summer on the potentialities of the Reserve for colonisation. He tested seedling germination in various soil types and locations using among other seed that of Pinus contorta and P. mugo. When kept in the laboratory germination started after 10 days and by the end of 4 weeks a high proportion were seedlings.

III. RESEARCH BY THE INSTITUTE OF TERRESTRIAL ECOLOGY

a) Competition between grass species
(Helen E. Jones, Merlewood Research Station)

Results from the second experiment in this project to study the growth of Festuca ovina and Agrostis tenuis in pure and mixed stands have been analysed. In this the species, obtained from tillers of Moor House populations, were grown in the glass house in monoculture and 1:1 mixed culture, and harvested at 6 intervals over 2 seasons. One treatment was cut to 2 cm at 2 weekly intervals, the other left uncut. A set of uncut pots was placed in an enclosure at Moor House to be harvested at the same time as the final glass house set. The Moor House pots had a much lower yield than the glass house pots for both species and in the mixture, but showed evidence of rabbit grazing. Despite the grazing effect, the live to dead leaf ratio was higher than in the glass house pots. Festuca was also present as a greater percentage of the total in the mixed pots at Moor House, though this might reflect a differential grazing effect. In the glass house, it was apparent that Agrostis was more vigorous than Festuca in the uncut pots, though in the mixture, after an initial decline in the percentage of Festuca in the first two harvests, it remained as a fairly constant percentage (between 5% and 10% of above ground biomass) for the remainder of the experiment. In the cut treatment, Festuca appeared to survive as a greater percentage of the mixture, though this conclusion is only tentative as many cut plants of both species died during the very hot summer of 1976.

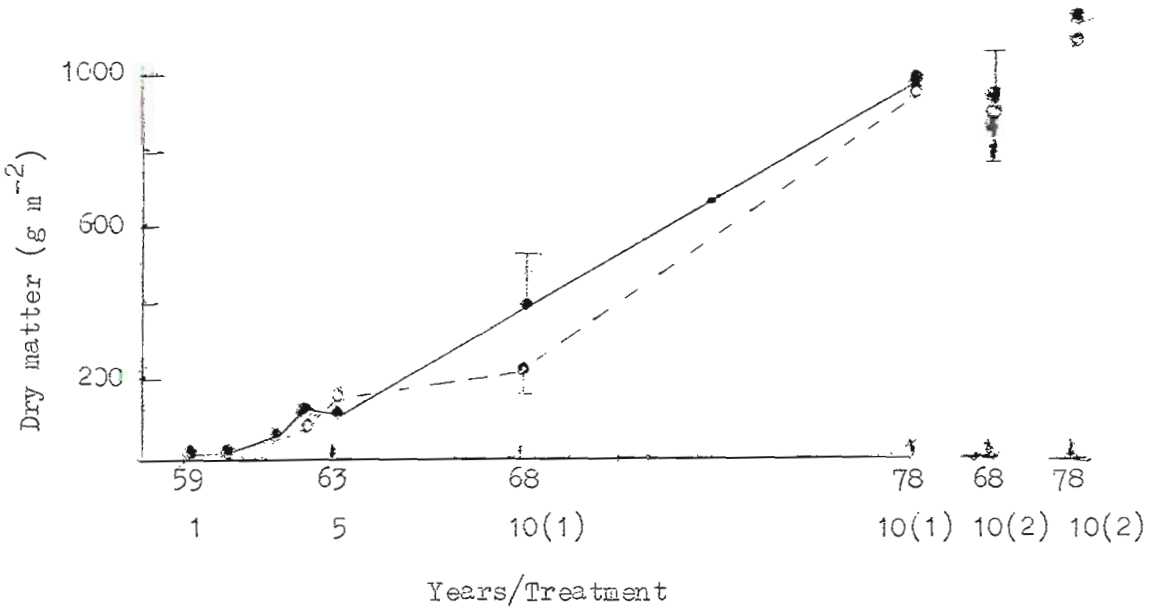
b) Plant ecological studies of peat
(A.J.P. Gore, ITE Monks Wood)

1. Final sampling was made of the long-term experiment of blanket bog productivity at Bog End. The experiment is now terminated.

Treatments 10(1) clipped and cleared in 1958 and 10(2) unclipped (see Gore 1975, p.351) were sampled again this year having been previously sampled in August 1968. Plots of treatment 10(1) were clipped and cleared in 1958 and regrowth allowed to occur. In treatment 10(2) the original vegetation was left standing, within the sheep-proof enclosure, throughout the course of the experiment. Only sample quadrats (5 x 0.25 m^2) on the two replicates of each treatment had their vegetation clipped and removed. Otherwise the plots were left undisturbed as far as possible. Sampling points in 1978 avoided those used in 1968.

The mean values of the heather (Calluna vulgaris) component of these latest samples are plotted in Fig. 1. It has therefore taken twenty years, possibly a little less, for the heather to reach a standing crop not dissimilar to the undisturbed standing crop as measured on two occasions ten years apart. This suggests that the assumption of a climax or equilibrium condition in the living plant compartment of the model developed by Gore and Olson (1967), is essentially correct. Forrest (1971) also concluded that the blanket bog vegetation on another site near Bog End, was at equilibrium. His evidence was based on the frequency distribution of age classes of heather stems. No attempt was made in the present work to find out if the age-class distributions were similar in treatments 10(1) and 10(2).

Fig. 1. Recovery of above-ground standing crop of Calluna vulgaris. Points for treatment 10(2) are estimates of undisturbed standing crop made in 1968 and 1978. Vertical bars are one standard deviation (n = 5).



References

Forrest, G.I. (1971). Structure and production of North Pennine Blanket bog vegetation. Journal of Ecology 59, 453-479.

Gore, A. J. P. (1975). An experimental modification of upland peat vegetation. Journal of Applied Ecology 12, 349-366.

Gore, A. J. P. & Olson, J. S. (1967). Preliminary models for accumulation of organic matter in an Eriophorum/Calluna ecosystem. Aquilo, Ser. Botanica. 6, 297-313.

2. Water balance studies.

The comparative Automatic Weather Station observations at Moor House and in the S. Pennines will be terminated in October 1978. Results are being assembled for analysis.

IV. RESEARCH BY FRESHWATER BIOLOGICAL ASSOCIATION

a) Fish populations
(D.T. Crisp)

Has continued to sample on the Reserve.

V. RESEARCH BY UNIVERSITIES

a) The geographical characterisation of moorland using invertebrates

(J.C. Coulson and Jennifer E.L. Butterfield, University of Durham)

We have been working on the above named project for the Nature Conservancy Council for the past two years. The aim of the project is to provide a short-cut method, based largely on pitfall catches, for N.C.C. officers to assess the invertebrate fauna of an area. Pitfalls provide a biassed sample and are not in themselves an ideal method for surveying an area. However, with the aid of quantitative soil and vegetation samples and a number of reference sites on the Moor House Reserve, which have been sampled quantitatively over a number of years, we are formulating a system whereby a site can be identified and assigned to a group of sites with which it has high affinities, purely on the basis of species present in pitfall catches.

b) Aspects of the ecology of Coleophora alticolella Zell. (Lep.)

(M. Randall, University of Durham)

The larvae of the Coleophorid moth, Coleophora alticolella, feed mainly upon the seeds of Juncus squarrosus, and also upon the seeds of Juncus effusus at lower altitudes. The life cycle of this moth has been studied at Moor House by Jordan (1958).

For the present study the sampling programme commenced in late May, when the Juncus squarrosus inflorescences first appeared, and continued until November 1977, similarly for this year (1978). Weekly samples of Juncus squarrosus inflorescences were taken at intervals on a transect from 215 m to 900 m on the Western escarpment of the Moor House N.N.R. (the Middle Tongue area and adjacent farm land). In the late summer when protective papery cases are produced by the late third and early fourth instar larvae, permanent quadrats were staked out at the 245 m, 335 m, 395 m, 460 m and 520 m sample stations. Each week the larval cases were marked with a different colour code to record their production.

As the 1978 field season is still in progress the following results are from the 1977 season. Analyses of the data have shown a slight decrease in the number of florets produced by each Juncus squarrosus inflorescence with an increase in altitude, but a marked decrease in the percentage of flowers that produced ripe seed capsules, this being a decrease of 8% with every 30 m increase in altitude.

There was a decrease in the density of the Coleophora larvae, this was a decrease of 15% for every 30 m increase in altitude, between 245 m and 450 m, consequently there was also a decrease in the percentage of ripe capsules damaged by the Coleophora larvae with an increase in altitude.

From the colour marking of the larval cases the mean date of their production, by the larvae at each sample station, was found to be delayed by 5.2 days for every 100 m increase in altitude, between 29 August 1977 at 245 m and 11 September 1977 at 460 m. This gives a guide to the effect that an increase in altitude has upon larval development.

The Coleophora larvae are attacked by hymenopterous parasitoids; in 1977 the rate of parasitization was halved with every 40 m increase in altitude, between 215 m and 395 m, with a rate of 26% at 215 m. In addition to this, fewer parasitoid species attack the Coleophora larvae at higher altitudes than at low altitudes.

In the Autumn the larvae migrate to the leaf litter where they stay until pupation and adult emmergence the following spring. From the colour coding experiments there appears to be an advantage for the moth larvae to develop quickly, as the larvae which reached the final instar later in the season suffered a greater rate of parasitization than those which grow to full size and migrated to the leaf litter earlier.

References

Jordan, A.M. (1958). The life history and behaviour of Coleophora alticolella Zell. (Lep.). T. Soc. Brit. Ent. 13, pp. 1-16.

(c) Habitat selection by breeding waders in Upper Teesdale
(Shirley Jones, University of Durham)

Following some preliminary studies on the common sandpiper in 1977, this study has now been extended to examine habitat selection in other wader species breeding in Upper Teesdale. As the project is financed by the Teesdale Trust the Moor House Reserve only forms part of the study area.

106 km^2 between Maize Beck and the River Tees, and Harwood Beck west to 2°26'W, were surveyed for vegetation type and height, ground roughness and colour. Oystercatcher, Ringed Plover, Golden Plover, Lapwing, Dunlin, Redshank, Common Sandpiper, Curlew, Woodcock and Snipe were counted and data collected on any nests found.

The following results apply only to the 31 km^2 of the reserve incorporated within the study area.

The first Common Sandpipers arrived during the third week of April. Thirty pairs bred on the eastern part of the reserve, six pairs more than 1977. Of the twenty adult Common Sandpipers colour-marked on the Moor House Reserve in 1977, at least nine returned and defended territories in the same areas held previously. One bird at Nether Hearth had lost or changed mates, but, in spite of this, the nest was made in the same grass tussock for the third consecutive year. Average clutch size was 3.37 eggs (nine nests).

Over the 31 km^2 of the Reserve surveyed, some preliminary analysis gives the distribution of waders as shown in Table 1.

Table 1. Number of km^2 with species present for the eastern part of the Moor House Reserve (31 Km^2)

	Habitat Type							
	Streams	Reservoirs	*Eriophorum vaginatum*	*E. vaginatum*/ *Calluna vulgaris*	*C. vulgaris*	Streamside grassland	Upland grassland with *Juncus squarrosus*	Other habitat characteristics
Oystercatcher	3							
Golden Plover			3	17				Usually near grassland areas or streams
Lapwing	1					3		All habitats characterized by short grass
Dunlin			2					Always near surface water or marshy areas e.g. reservoir, drainage channels, small pools
Redshank		1	2			2		Usually near streams and marshy areas with *Juncus squarrosus*
Common Sandpiper	12	2						
Curlew			1	7				
Snipe			1			3		Always near marshy areas; usually with *Juncus squarrosus*
No. waders			1	3	1		1	

(d) Some terrestrial Tardigrada of Moor House National Nature Reserve : including seven additions to the English fauna
(W.H. Daxter, University of Durham)

Introduction

Like Protozoa, Rotifera and Nematoda the phylum Tardigrada forms part of the hydrophilous microfauna and constitutes a small but widespread group of invertebrates. The animals examined in this study were extracted, primarily, from moss but also lichens and liverworts. It is recognized that soil Tardigrada do occur (and can occur in large numbers) but because of extraction difficulties and lack of time this habitat was left unstudied.

Procedure and Methods

Collection of plant host material within the general area was casual and host plants whether moist or dry were obtained when convenient.

The extraction procedure is begun by adding a large volume of water to the moss sample and leaving overnight. 4% acetic acid is added to narcotize the specimens which relax and fall away from the plant material. All this is then poured through a series of membranes with the tardigrades and other debris being collected on a fine nylon membrane (60 micron mesh size) at the bottom. The extracted sample is then sorted under a binocular microscope at X50 and permanent preparations made using Gum Chloral mountant. Examination and species determination often requires a microscope equipped with oil immersion and phase contrast is frequently very helpful.

Species List

Echiniscus (Echiniscus) granulatus
Echiniscus (Echiniscus) merokensis
Echiniscus (Echiniscus) merokensis var. suecicus
Echiniscus (Echiniscus) spinulosus

*Hypsibius (Diphascon) alpinus
Hypsibius (Diphascon) chilenensis
Hypsibius (Diphascon) oculatus
*Hypsibius (Diphascon) prorsirostris
Hypsibius (Diphascon) scoticus
*Hypsibius (Diphascon) spitzbergensis

*Hypsibius (Hypsibius) conjugens
Hypsibius (Hypsibius) dujardini
Hypsibius (Hypsibius) oberhaeuseri
*Hypsibius (Hypsibius) zetlandicus

*Macrobiotus coronifer

Macrobiotus dispar

Macrobiotus echinogenitus

Macrobiotus harmsworthi

Macrobiotus hufelandii

Milnesium tardigradum

*Pseudechiniscus islandicus

Pseudechiniscus suillus

*denotes first record of species in England.

Discussion

Of the above twenty-one species seven had not previously been recorded in England and of these seven some had been recorded only once or twice in the British Isles. Descriptions of specimens examined agreed well with those given in the literature, however, in one or two instances very minor differences were noted.

M. hufelandii is thought to be the most common Tardigrade in the world and is definitely the most abundant and widespread at Moor House. H.(D.) scoticus and H.(D.) spitzbergensis are also fairly common as regards both numbers and distribution. Echiniscus type animals were much less frequently encountered - P. suillus being the most abundant of this type. The presence of six members of the sub-genus Diphascon is worthy of note as this is a group which is very discerning in its choice of habitat and records of Diphascon species throughout the British Isles are limited.

It is anticipated that a more extensive collecting programme would result in more species being found and there is no reason why the Tardigrade fauna should not prove to be more varied.

Acknowledgments

I am indebted to Dr. C.I. Morgan of Glasgow for his help in identification. I appreciate the advice given by Dr. S.J. Goddard and would like to thank Miss Angela Metcalfe and Mr. M. Rawes for identifying various plant hosts.

(e) Studies on the distribution of Lumbricidae at Moor House National Nature Reserve
(P. Kirkland, University of Durham)

Introduction

The aim of this project was to serve as a comparison and follow-up to the work done at Moor House from 1952-5 by Svendsen (Svendsen J.A. "Studies on the Earthworm Fauna of Pennine Moorland". PH.D. thesis, University of Durham, 1955). Using the same methods, distribution related to soil type was investigated, but in addition, distribution related to pH and to vegetation type was looked at. Other things ignored by Svendsen looked at were: the limnic habitat, the two colour forms of Allolobophora chlorotica present, earthworm distribution on islands in the Tees, and evidence of predation by waders and moles. Thirteen of the fourteen species found by Svendsen were recorded:

Allolobophora chlorotica
A. caliginosa
A. longa (= terrestris)
A. rosea (= Eisenia rosea)

Lumbricus castaneus
L. festivus
L. rubellus
L. terrestris

Dendrobaena octaedra
D. rubida

Octolasium cyaneum
O. lacteum

Eiseniella tetraedra

Mature worms were identified using the Linnean Society key (No. 6, Gerard, B.M. 1964). Immature worms were identified using the key given by Svendsen in his thesis.

Methods

Most sites were sampled by digging a cube of soil, 19 x 19 cm by 20-25 cm deep, and hand-sorting this in a tray. When too stony, an area was hand sorted to a depth where no more worms were found. When too wet, a search was made under stones by hand or with a net.

At each site a subjective assessment of the soil was made, into one of eight types, ranging from 1, black sticky soil associated with blanket bog, to crumbly brown soil (8) associated with a limestone outcrop. The classes were arranged in order of presumed favourability to worms. Major vegetation types were also identified. The pH of each site was measured.

Most samples were taken near Metal Band hill, on the four islands and banks of the Tees,

Results

When the results from the 41 samples are combined, correlation coefficients can be calculated, and are represented thus:

	Number of worms/m^2	Number of species/m^2
pH	*	*
Soil type	NS	*

* = $0.01 > p > 0.001$ NS = not significant

In addition, density was closely related to diversity (p 0.001) but soil type was not related to pH (r not significant).

Discussion

An important point to emerge from the combined results is that soil type is apparently not related to pH. Svendsen assessed soil type in more or less the same way as was done in this study. He then related distribution of different species to soil type, and compared his results with other authors. Some of these however, had related distribution to acidity, so in some cases, Svendsen's comparisons will be invalid.

It would seem from the combined results that despite the high correlation between density and 'diversity', diversity (number of species per sample) is more related to soil type than density. That is, the 'better' soils with more structure and usually higher plant diversity, supported more species, possibly because there were more niches. The more seemingly uniform soils such as the coarse alluvium of river banks, or the black sticky soil under Juncus stands, more often supported near monocultures.

In a review of the species relating distribution and abundance to pH, soil and vegetation type, it was found that sometimes range seemed restricted by pH, while other species seemed to be more restricted by soil type.

Included in the 41 samples were two transects, one from an alluvial terrace across a temporarily dry river bed to an island, the other from the Tees bank into blanket peat. The former primarily showed the different distributions of the two colour forms of A. chlorotica. The green form occurred in very high numbers, and virtually as a monoculture, through the wettest part of the transect; while the unpigmented form appears on the banks. The possession of the green pigment is thought to be genetically determined rather than environmental (Kalmus et al 1955; Ann. Mag. Nat. Hist. 8, 795-800*). On the wettest parts of the banks and under slow-moving water, the green A. chlorotica gives way to E. tetraedra.

The second transect gave an indication as to the acid tolerant, possibly surface-dwelling species such as D. octaedra and L. rubellus. No worms were found below pH 4.46, but one ootheca was found at pH 3.66.

With respect to predation by waders, densities of around 200 worms m^{-2} were found near the river edges, where oystercatchers, lapwings and sandpipers were commonly seen feeding. The worms are mainly A. chlorotica (a medium-sized earthworm) and were commonly found just under the top layer of stones.

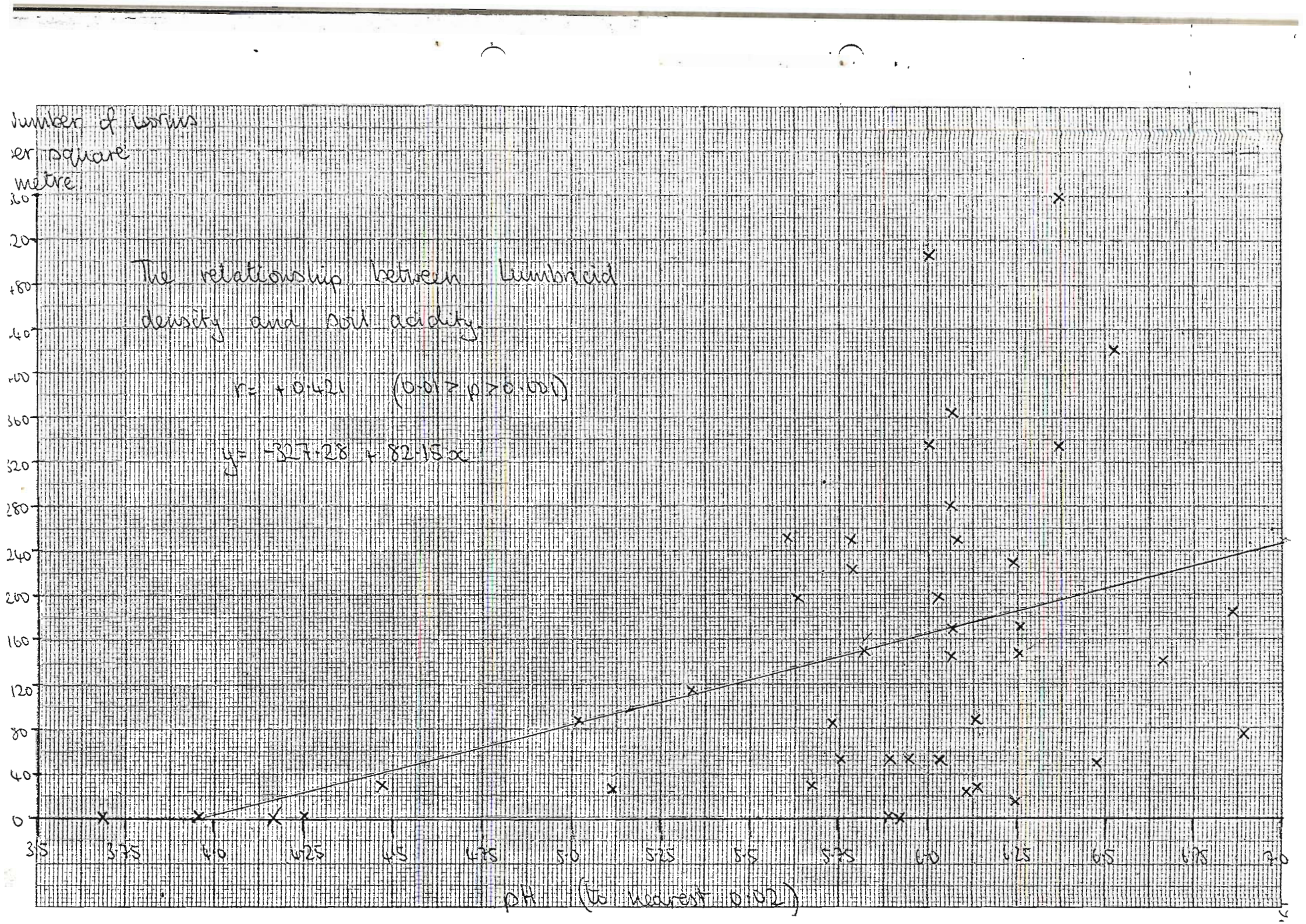
Acknowledgements

Grateful thanks go to the staff of Moor House Field Station, especially Mrs. Dunn. Also, to the Zoology Department, especially to Dr. Sue Goddard, my supervisor, and Dr. Ken Thompson of the Botany Department, for help with the vegetation identification.

Many thanks also to Ken Jones (Sheffield University) and the other four Durham students at Moor House at the same time.

* "On the colour forms of A. chlorotica", Kalmus, Satchell & Bowen. [See also reprint No. 19 of the Nature Conservancy Merlewood and Moor House collected reprints 1955-1957].

Kalmus et al, say that no comprehensive study of the distribution of colour forms has been published. They present their own findings, that the green form occurs under permanent grassland, the unpigmented form in woodland. The green pigment is 'biliverdin-like'. Green worms also have more porphyrin pigments. Breeding experiments suggested that lack of green pigment is caused by a single dominant factor.


Number of worms per square metre
The relationship between Lumbricid density and soil acidity
r = + 0·421 (0·01 > p > 0·02)
y = −327·28 + 82·15x
pH (to nearest 0·02)

(f) Long term studies on upland homoptera
(J.B. Whittaker, University of Lancaster)

These have been continued since 1961 (Neophilaenus lineatus) and 1968 (Strophingia ericae). Sampling methods are described in Whittaker (1971) and Hodkinson (1973).

1. N. lineatus - further evidence supports the conclusion of Whittaker (1971) that N. lineatus is poorly regulated at Moor House. The population on Nardus perturbed in 1967 has now recovered to the same population density as the control population.

2. Strophingia ericae - cohorts of S. ericae on Sike Hill have been studied from 1968-1971, 1972-73 and 1974-78. Each cohort takes 2 years from hatching to death and a new cohort is produced each year to give overlapping generations.

95% of the mortality takes place in 2 periods:-

1) March to November of the year following hatching,
2) March to July of the following year.

The rate of mortality in S. ericae is density-dependent in both years of a cohort's existence. The rate is consistently higher in the second year than in the first. Especially during the second year of a cohort when the next generation has been recruited, the overall population density of S. ericae is often very different from the density of a particular cohort. Nevertheless, the rate of mortality is more highly correlated with the density of that particular cohort ($r = 0.79$) than with overall population density ($r = 0.34$).

Coulson and Whittaker (1978) suggest that the fauna at Moor House is composed of two distinct elements; a lowland component of species near to the edge of their altitudinal range and an upland component of well adapted species. This study of the dynamics of one species in each category shows that their responses to severe climate are quite different.

References

Coulson, J.C. and Whittaker, J.B. (1978). Ecology of Moorland animals. In Production Ecology of British Moors and Montane Grasslands. (Eds. O.W. Heal and D.F. Perkins). Springer Verlag, Berlin.

Hodkinson, I.D. (1973). The population dynamics and host plant interactions of Strophingia ericae (Curt.) (Homoptera : Psylloidea). J. Anim. Ecol. 42 : 565-583.

Whittaker, J.B. (1971). Population changes in Neophilaenus lineatus (L.) (Homoptera : Cercopidae) in different parts of its range. J. Anim. Ecol. 40 : 425-43.

(g) Population dynamics of Neobisium muscorum (Leach.) (Pseudoscorpion : Arachnida)
(S.J. Goddard (University of Durham)

Has continued to sample on the reserve.

(h) Autecology of the genus Geum
(K. Taylor, University College London)

As a preliminary to carrying out large scale field experiments, attempts were made to establish seedlings of Geum rivale (meadow population) and G. urbanum (Helbeck Hall) on a range of soils collected on the Reserve, in pot culture in a controlled environment cabinet. Seedlings of both species showed acute symptoms of phosphorus deficiency which was alleviated by the addition of phosphorus fertiliser in other treatments.

Analyses of green leaves of G. rivale collected in December, 1977 and in the following June, to include one of the sites used in the pot culture experiment (red-brown limestone soil - meadow) are presented in Table 1. Material from the meadow population shows a lower concentration of phosphorus and potassium than leaves from well-established plants from the same population, but growing in garden soil (Nuffield Research Garden, Regent's Park, London). In contrast, the Knock Fell population shows adequate levels of all elements on mature and garden soils. Thus, future field experiments will need to include fertiliser treatments especially P and K.

The concentrations of Zinc and Lead in the leaves are low and are not related to the differences between the two sites in the 2.5% acetic acid extractable soil fraction as shown in Table 2.

Table 1. *Geum rivale* populations.

		% oven-dry wt.							
		N	P	Ca	mg	mn	K	Zn	Pb
Meadow in situ	old leaves	1.59	0.09	2.56	0.56	0.032	0.83	0.046	0.0009
	new leaves	3.60	0.33	1.24	0.42	0.039	2.19	0.150	0.016
garden	old leaves	2.24	0.22	2.66	0.52	0.003	2.34	0.005	0.012
	new leaves	3.04	0.40	1.46	0.54	0.053	3.00	0.008	0.024
Knock Fell in situ	old leaves	-	-	-	-	-	-	-	-
	new leaves	3.5	0.48	1.23	0.54	0.0056	2.73	0.21	0.028
garden	old leaves	-	-	-	-	-	-	-	-
	new leaves	4.16	0.45	1.03	0.53	0.0026	2.49	0.27	0.016

Table 2.

	Mean wt mg/100 g oven-dry soil 2.5% acetic acid extractable	
Site	Zn	Pb
Meadow	17.08	1.78
Knock Fell	3.73	0.96

(i) Seasonal dynamics of foliage in Eriophorum vaginatum
(K. Robertson, University of Leeds)

Following on from the demographic analysis described in last year's report, field equipment enabling the in site measurement of the photosynthetic characteristics of the different leaf categories has been constructed and tested, both in the laboratory and in field trials.

The trials have involved both refinements of the C^{14} pulse technique (Ashmore 1975) and tests on the performance of a chamber designed for E. vaginatum leaves.

Our current derivation for the photosynthetic rate, Fc, as determined by the 2-gas system (Incoll: 1978) is:-

$$Fc = \frac{Assay.\ f.\ Ca.}{E.\ Bq.\ A.}$$

where Assay = measured activity in sample (cs^{-1});
f = flow rate ($m^3 s^{-1}$);
Ca = CO_2 concentration in cylinder (mgm^{-3});
E = Efficiency (cd^{-1});
Bq = activity in single aliquot (pulse) (ds^{-1} = 1 Bequerel)
and A = area of leaf sample (m^2).

All of these can be accurately measured, except A, where shape factors are used.

The chamber consists of a small propafilm cylinder (volume = 4.7 $c.m.^3$), supported by a brass block with air inlet/outlet and leaf entry holes. This block is mounted upon a pair of artery forceps which, when closed, form an effective gas seal. Simulation experiments showed that the passage of the radio-active pulse was both sharp (i.e. activity within the chamber increased rapidly) and fast, a single pulse taking less than 60 seconds. The latter characteristic allows a high turnover of samples. This is essential as the sampling procedure involves sequential exposure of all the leaves from a single tiller. Thus, many samples are required for adequate replication within leaf categories.

Results from these preliminary trials show rates and responses comparable with analogous studies and will be used in conjunction with next year's field study and laboratory studies to examine the relative importance of the leaf categories to the carbon input of this plant.

References

Ashmore, M. (1975). Eco-physiological Studies of Calluna vulgaris in a moorland habitat. Ph.D Thesis, University of Leeds.

Incoll, L.D. (1978). Field Studies of Photosynthesis: Monitoring with $14CO_2$. In "Environmental Effects on Crop Physiology". Ed. Landsberg J.J.: Cutting C.V., Ac. Press.

(j) Post-fire succession in Calluna-dominated communities
(R.J. Hobbs, University of Aberdeen)

A study is being undertaken to observe the regrowth of vegetation after burning on a series of community types, and to assess how the age of the stand prior to burning affects this regrowth. Moor House was chosen as a study site for blanket bog, and it was hoped that some experimental burning could be carried out at Green Burn in Spring, 1978. Unfortunately, weather conditions severely limited the possibility of heather burning and no burns were carried out. Sites have, however, been marked out and analysed at Green Burn in the hope that some burning might be possible next season. These are situated within stands burnt in 1958, 1965, 1971 and 1972, thus providing a range of ages. Botanical analyses were carried out at each of these sites : cover values, densities, and dry weights of all the major vegetation components were established, and pattern analysis was carried out.

In order to observe slightly later stages in the post-fire succession, analyses were carried out on the replicated burning/grazing experiment on Hard Hill. Here, both Short (S) and Long (L) rotation plots were burned in 1975, and represent stands burnt at 10 years and 20 years old respectively. Cover values and densities of all vegetation components were established and pattern analysis carried out in each of the S and L plots.

Initial results indicate that differences in abundances of several species are present at 3 years after burning. While Eriophorum vaginatum shows no differences between treatments, Calluna vulgaris is more abundant in the L. plots, and Rubus chamaemorus and Eriophorum angustifolium more abundant in the S plots. Campylopus flexuosus, Pohlia nutans, Calypogeia trichomanis and Lophozia ventricosa were all most frequent in the L plots, while Dicranum scoparium was present only in S plots. Cladonia chlorophaea and C. squamosa were also more frequent in the L.plots.

In addition to the botanical survey, an assessment of Calluna performance was made by measuring terminal (long) shoot length for all treatments (100 shoots per treatment). The results meaned over 4 blocks are:

S	SF	L	LF	N	NF	
3.55	4.27	4.35	4.17	3.27	3.02	(cm)

The resulting analysis of variance indicated that the differences between the unburnt controls (N and NF) and the rest were significant, but differences between the other treatments were just below the limit for significance at the 5% level. The results do, however, indicate that the initially better performance in the S plots found in 1976 (Hobbs, 1976, Reserve Records) is no longer evident.

(k) Direct measurements of Peat Erosion
(J.H. Tallis, University of Manchester)

Metal erosion pins driven into the substrate have been widely used in recent years in studies of soil erosion. In a softer medium such as peat, less substantial substitutes are possible, and measurements of erosion using plastic drinking straws (20.6 cm length) have been attempted over the past 12 months at four blanket peat sites - two in the southern Pennines, one in Rossendale and one at Moor House. At Moor House 100 straws were pushed into exposed peat faces (into holes made by a rigid metal rod of the same diameter as the straws) forming the sides of a gully at NY 748332; c. 20 mm of each straw was left protruding initially, and the straws were re-measured at approximately 3-monthly intervals from September 1977 to September 1978.

The measurements showed clearly that there was considerable small-scale movement of peat down the sloping (20 to 75°) gully sides, so that over a 3-month period some straws suffered removal of peat from around them while around other straws there was build-up of peat. Some straws were completely buried, and unable to be measured, on one or more occasions. Some staws suffered disturbance - chewing or removal - probably by sheep, and this effect was particularly marked during the summer.

Very few straws showed continuous erosion of peat from around them during the 12-month period; alternating accumulation and erosion were more common. At each period of measurement, the excess of erosion over accumulation is presumably some measure of the amount of peat actually removed from the site. The mean amount over 12 months was 10.5 mm, with the most marked erosion occurring between 27 April (when snow was still lying) and 6 July 1978. The results show an apparent excess of accumulation over erosion between 29 September and 22 December 1977 (mean 2.4 mm), but this probably represents expansion (puffing-up) of the surface peat layers by frost action. The mean values however mask considerable variation in the behaviour of individual straws: removal or accumulation of up to 40 mm of peat at particular sites over a 3-month period was recorded on several occasions. 32 out of a total of 344 measurements showed change exceeding 20 mm in 3 months.

Comparison of the results from Moor House with those from the southern Penninos and Rossendale is still in progress.

In the following Table, + signifies accumulation and - erosion; values in parentheses for mean and standard error are values taking buried straws into account, assuming an arbitrary 2 mm of peat above the straw.

	29/9/77 to 22/12/77	22/12/77 to 27/4/78	27/4/78 to 6/7/78	6/7/78 to 22/9/78	Annual
Maximum change (mm)	-25	-39	-35	-15	-45
Minimum change (mm)	+20	+18	+17	+19	+ 9
Mean (mm)	+ 2.40 (+ 3.53)	- 4.65 (- 1.46)	- 7.07	- 1.50	-10.45
S.E. (mm)	7.03 (8.09)	13.87 (14.87)	8.39	6.43	12.62
Number of straws showing					
accumulation	61	46	13	20	10
erosion	21	47	69	31	42
no change	11	4	4	6	4
missing	7	3	14	43	44

(1) The effects of animal exclusion on soil fertility of a limestone grassland in the Moor House N.N.R.
(G.A. Ulmanis, University of Sheffield)

Methods and Progress 1977

In November a fence was erected on the grazed area adjacent to the long-term ungrazed limestone grassland at Rough Sike. This created a new area of ungrazed grassland for the 1978 season. Three adjacent experimental plots have thus been established of dimensions 3 x 11 m in the old ungrazed area, and of 6 x 11 m in the new exclosure and the grazed grassland.

A site for the 3 experimental plots, as flat as possible, was chosen, the slope being at a maximum of 4° (N-S) and 1.5° (W-E).

Measurements were made in the field, and soil samples were taken, to assess the variability of this chosen site for a number of soil features.

Although physically the site is very uniform, the plot on the long term ungrazed grassland varies in a number of features.

1. Soil Depth in all three plots varied throughout the range of 0 cms (bare clint tops) to 80 cms in the grikes, but the mean depth in the old exclosure was found to be 31 cms, whilst in the new exclosure 22 cms and in the grazed grassland plot 24 cms.

2. % Oxidizable Carbon (Wolkley-Black uncorrected) for the top 3 cm of soil varied from a 6% mean value for the old ungrazed grassland plots soil to values of 4% to 5% for the other plots.

3. Loss on Ignition for the top 3 cm of soil was at least 20% for the old exclosure plot's soil, whilst for the other plots varied around a mean of 16%.

These differences between the old exclosure plot and the others are due to the organic matter accumulation which has occurred in this ungrazed grassland.

Methods 1978

Samples of grass either from cuts or cores, and samples of soils by coring have been taken on a regular basis during the year from the three plots. In April soil water leachate collectors were set into the ground, four each in the grazed and newly ungrazed plots and two in the old ungrazed plot. Samples of this leachate were collected on a daily basis during mid April to mid May, on a weekly basis during September and October and on a more intermittent basis during the summer months. Rainwater, and when available, snow, have also been regularly collected.

Faecal samples have been intermittently taken during the year and collected on a weekly basis during September and October from four pegged out plots adjacent to the experimental plot on the grazed limestone grassland.

To date all chemical analyses of collected water have been completed, whilst those of soils, grass and faecal material are in progress.

(m) Peat-limestone interactions: chemical polish on rock surfaces and calcium-organic matter interactions in streams
(S. Trudgill, University of Sheffield)

1. Sampling of natural polished rock surfaces from boulders in stream beds; study by electron microscope.

2. Treatment of fractured rock surfaces with organic and mineral acids in the laboratory in order to attempt to replicate chemical polish; study by electron microscope.

3. Streamwater sampling and chemical treatment in order to assess the uptake of calcium on organic matter and the progress of organic matter - acidity - calcium relationships downstream.

The work is completed and awaits publication.

(n) Studies of periglacial phenomena
(L. Tufnell, Huddersfield Polytechnic)

Five of the Reserve's ploughing blocks had their movement recorded for the thirteenth consecutive year. Results were very similar to those obtained on previous visits.

Table 1. Movement of five ploughing blocks on the Reserve between August 1977 and August 1978. Block numbers correspond with those in the 1975 report.

Block No.	Amount of movement recorded (cm)
1	6.4
2	3.2
3	0.3
4	0.3
5	0.0

(o) Sampling of streams near Silver Band Mine to assess the effects of barytes quarrying.
(L. Davies and Susan Dick, University of Durham)

The following is intended as a supplement to the account given in last year's report, where methods are given. Sampling of streams for invertebrates continued, with the last samples being taken on 26 May 1978.

1. Knock Ore Gill. Again no consistent differences in numbers or composition of the fauna could be found in sets of samples from above and below the entry of the Silver Band Mine Hush. On none of the sampling dates was any surface water running down the lower part of the hush to enter Knock Ore Gill. This sampling does provide base-line figures on the fauna of the Gill in 1977-78, information that would be valuable in the event of accidental discharge of a volume of water down the Mine Hush, along which a considerable amount of fine silt (from the mine settling ponds overflow) has now been deposited cumulatively.

2. Middle Tongue Beck. The effects of the wash-out that had occurred shortly before sampling started in late June 1977 (see last year's report) was still apparent in the 26 May 1978 samples in the greatly reduced numbers of Elminthid beetle adults and larvae, from 436 above, to 22 individuals below the flood-water entry point. There also persisted a corresponding reduction of stone-fly larvae of Amphinemura sulcicollis from 106 to 6, but numbers of other stone-fly larvae (notably Leuctra mosleyi) have recovered to become similar above and below.

3. Silver Band Mine Hush. The faunal position on 26 May 1978 was as described in the previous report, with there being a restricted fauna whose composition suggests no acute toxic effects from the entry of some brown silt-rich water into the hush. However, the silt continued to accumulate along the hush as mentioned above. This constitutes a threat to the fauna of Knock Ore Gill if there is an accident leading to a large volume of water being discharged down the hush.

(p) Adaptation of plant growth to upland conditions.
(J.D. Graves, University College London)

In the past year a project has been started to look at the adaptation of plant growth to upland conditions. Two closely related species are being studied, Geum rivale and Geum urbanum. The former occurs naturally on the Reserve. Field work includes summer and winter growth experiments at four sites in the north Pennines, two of which are on the Reserve, one at Moor House itself (1800 ft OD) and the other in the Knock Fell enclosure (2400 ft). The two other sites, at lower altitudes, are at Helbeck, near Brough. Gas analysis and growth chamber studies are being carried out in the laboratory to back these studies.

Climatological data are being collected at several of the sites, using a variety of equipment, but principally based upon the automatic weather stations at Moor House and Helbeck.

Appendix 1.

Publications.

CHAMBERS, C. 1978. A radio carbon dated pollen diagram from Valley bog, on the Moor House National Nature Reserve. New Phytol., 80, 276 - 280.

CLAPHAM, A.R. (ed.) 1978. Upper Teesdale: the area and its natural history. London, Collins. 238 pp.

Chapters particularly relevant, or using data from Moor House, are these:-

Phytogeography, Variation and Evolution T.T. Elkington
Plant Communities D.A. Ratcliffe
History of Vegetation and Flora J. Turner
Climate and Vegetation C.D. Pigott
Terrestrial Animals J.C. Coulson

CLYMO, R.S. 1978. A model of peat bog growth. Production - Ecology of British Moors and Mountain Grasslands (Ed. by O.W. Heal and D.F. Perkins) pp. 187 - 223. Springer-Verlag, Berlin.

COLLINS, V.G., D'SYLVA, B.T. & LATTER, P.M. 1978. Microbial populations in peat. Production - Ecology of British Moors and Mountain Grasslands (Ed. by O.W. Heal and D.F. Perkins), pp. 94 - 112. Springer-Verlag, Berlin.

COULSON, J.C. & BUTTERFIELD, J. 1978. An investigation of the biotic factors determining the rates of plant decomposition on blanket bog. J. Ecol. 66, 631 - 650.

COULSON, J.C. & WHITTAKER, J.B. 1978. Ecology of moorland animals. Production - Ecology of British Moors and Mountain Grasslands (Ed. by O.W. Heal and D.F. Perkins), pp. 52 - 93. Springer-Verlag, Berlin.

CRISP, D.T. & MANN, R.H.K. 1978. Fish populations. In: Aspects of the Ecology of the Northern Pennines, Moor House Occasional Paper no. 11, 15pp and figures.

CRISP, D.T. & CUBBY, P.R. 1978. The populations of fish in tributaries of the River Eden on the Moor House National Nature Reserve, Northern England. Hydrobiologia 57, 85 - 93.

GRACE, J. & MARKS, T.C. 1978. Physiological aspects of bog production at Moor House. Production - Ecology of British Moors and Mountain Grasslands (Ed. by O.W. Heal and D.F. Perkins), pp. 38 - 51. Springer-Verlag, Berlin.

JONES, H.E. & GORE, A.J.P. 1978. A simulation of production and decay in blanket bog. Production - Ecology of British Moors and Mountain Grasslands (Ed. by O.W. Heal and D.F. Perkins), pp. 160 - 186. Springer-Verlag, Berlin.

HEAL, O.W., LATTER, P.M. & ROBSON, G. 1978. A study of the rates of decomposition of organic matter. Production - Ecology of British Moors and Mountain Grasslands (Ed. by O.W. Heal and D.F. Perkins), pp. 136 - 159. Springer-Verlag, Berlin.

HEAL, O.W. & SMITH, R.A.N. 1978. Introduction and site description. Production - Ecology of British Moors and Mountain Grasslands, (Ed. by O.W. Heal and D.F. Perkins), pp. 3 - 16. Springer-Verlag, Berlin.

LATTER, P.M. 1977. Decomposition of Moorland litter, in relation to Marasmius androsaceus and soil fauna. Pedobiologia 17, 418 - 427.

LATTER, P.M. & HOWSON, G. 1978. Studies on the microfauna of blanket bog with particular reference to euchytracidae II Growth and Survival of Cognettia sphagnetorum on various substrates. J. Anim. Ecol. 47, 125 - 148.

MARTIN, N.J. & HOLDING, A.J. 1978. Nutrient availability and other factors limiting microbial activity in blanket peat. Production - Ecology of British Moors and Mountain Grasslands. (Ed. by O.W. Heal and D.F. Perkins), pp. 113 - 134. Springer-Verlag, Berlin.

RAWES, M. & HEAL, O.W. 1978. The blanket bog as part of the Pennine moorland. Production - Ecology of British Moors and Mountain Grasslands. (Ed. by O.W. Heal and D.F. Perkins), pp. 224 - 243. Springer-Verlag, Berlin.

STANDEN, V. 1978. The influence of soil fauna on decomposition by micro-organisms in blanket bog litter. J. Anim. Ecol. 47, 25 - 38.

WHITTAKER, J.B. 1978. Homoptera (Insecta) from the Cow Green (Teesdale) plant communities with reference to the effects of fertiliser treatments. Entomologist's Mon. Mag. 113, 159 - 163.

WOTTON, R.S. 1977. The size of particles ingested by moorland stream Blackfly larvae (Simulidae). Oikos, 29, 332 - 335.

STAFF LIST

(as at 30 September 1978)

Officer-in-Charge	M. Rawes
Scientific Staff	R.B. Marsh
	Vacant
Warden	P. Burnham
Estate Worker	P.J. Holms
Housekeeper	Mrs. G. Dunn (April-September)
Part-time Warden	J. Rose (November-March)
Honorary Wardens	J. Hollington
	O.W. Harrison
	F. Birkbeck

Meteorological Summary for Moor House 1977 (Met Office Station No 7188)
c 558 m OD (Main Instrument Site) Lat 54° 41' N. Long 2° 23' W Nat Grid Ref NY/758328

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean max temp °C	0.7	1.7	4.9	5.1	10.4	12.7	15.6	14.5	11.3	10.6	4.0	4.1	8.0
Mean min temp °C	-3.9	-2.6	-0.2	-0.7	0.5	3.8	6.9	6.7	5.8	5.3	-1.0	0.2	1.7
½ (max + min) °C	-1.6	-0.5	2.3	2.2	5.5	8.3	11.3	10.6	8.5	7.9	1.5	2.1	4.8
Highest max temp °C	5.2	5.0	11.5	9.6	19.5	20.4	23.4	20.6	15.4	15.5	11.2	9.6	23.4
Lowest min temp °C	-16.4	-12.1	-7.5	-7.4	-7.0	-4.2	0.6	-2.0	0.6	-0.6	-6.7	-5.0	-16.4
Lowest max temp °C	-6.3	-1.7	-1.5	0.3	4.9	5.3	10.8	10.6	6.1	6.6	-0.7	-0.2	- 6.3
Highest min temp °C	1.2	0.6	3.9	5.9	4.7	8.2	12.2	11.8	10.5	10.7	7.4	5.0	12.2
Lowest grass min temp °C	-19.0	-14.4	-11.0	-11.0	-12.0	-10.7	-5.0	-6.7	-4.4	-4.5	-11.3	-8.0	-19.0
Earth temp 30cm 0900 hr	1.5	1.4	2.7	3.1	5.8	8.6	11.1	11.1	9.3	8.3	5.0	3.1	5.9
Rainfall (mm)	520.9	198.5	179.4	185.7	80.5	144.6	86.2	103.8	181.6	159.4	251.8	194.1	2286.5
Rain days (0.2mm)	24	24	25	26	12	17	12	16	19	24	26	22	247
Wet days (1.0mm)	22	20	24	22	10	14	9	13	17	19	23	16	209
Days snow/sleet	17	18	17	19	4	0	0	1	0	1	15	2	94
Days snow lying	29	17	8	5	0	0	0	0	0	0	11	6	76
Days hail	0	2	4	12	4	1	0	0	0	1	2	2	28
Days snow/ice pellets	0	2	2	2	0	0	0	0	0	0	2	2	10
Thunder	0	0	0	0	1	0	0	1	0	0	1	0	3
Fog	12	12	6	2	1	1	2	1	4	6	3	7	57
Air frost	25	23	15	15	12	4	0	1	0	1	18	16	130
Ground frost	29	27	20	21	21	7	4	8	5	7	23	21	193
Av Daily bright sun (hr)	1.01	1.49	1.78	3.39	7.35	6.22	6.05	4.93	2.61	2.77	1.60	0.77	3.33
Total bright sun (hr)	31.3	41.7	55.3	101.6	227.8	186.7	187.6	152.7	78.2	86.0	48.1	23.8	1220.8
Total snow (cm)	310	42	18	8	0	0	0	0	0	0	21	8	407
Greatest depth snow (cm)	41	21	8	4	0	0	0	0	0	0	9	5	41
Days with gales	5	3	4	5	1	0	0	1	3	6	7	5	40
Solar radiation gm cals/cm^2	1648	2432	4489	7244	12870	12015	11806	8861	4671*	3597	1687	872	72192

*data up to 26 September, 4 days missing

Averages for 25 years 1953-77

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean Max temp °C	2.3	1.9	4.0	7.0	10.7	13.9	14.9	14.7	12.4	9.5	5.0	3.5	8.3
Mean min temp °C	-2.4	-3.2	-1.6	-0.1	2.5	5.4	7.2	7.3	5.9	3.8	0.1	-1.7	1.9
Mean °C	0.0	-0.7	1.2	3.4	6.6	9.6	11.1	11.0	9.1	6.6	2.5	0.9	35.1
Highest max temp °C	10.2	11.7	18.9	17.2	23.3	25.6	25.5	25.5	23.9	21.1	12.1	10.6	25.6
Lowest min temp °C	-18.5	-18.3	-16.1	-9.6	-7.0	-4.8	-1.1	-2.0	-4.4	-5.6	-11.7	-15.0	-18.5
Lowest max temp °C	-6.3	-7.2	-6.1	-2.2	1.7	2.8	7.8	7.6	5.1	0.7	-4.0	-5.6	-7.2
Highest min temp °C	6.4	5.6	8.9	8.3	12.2	13.3	16.1	14.4	12.8	11.7	8.4	7.8	16.1
Lowest grass min temp °C	-20.0	-21.1	-17.8	-15.0	-12.1	-12.4	-6.6	-6.7	-10.0	-12.2	-15.8	-18.1	-21.1
Earth temp 30cm 0900 hr	1.8	1.6	2.0	3.8	6.8	9.9	11.6	11.7	10.2	7.9	4.7	2.8	6.2
Rainfall (mm)	208.8	149.1	132.2	122.7	122.7	108.3	139.3	155.2	165.0	182.7	201.0	216.6	1903.6
Greatest rainfall	104.6	57.9	54.6	64.3	42.2	64.0	62.2	55.1	72.9	68.3	68.8	74.4	104.6
Rain days (0.2mm)	23	21	21	20	19	18	19	20	19	21	23	24	248
Wet days (1.0mm)	20	17	17	15	15	14	16	16	16	17	19	19	201
Days snow/sleet	12	12	10	7	2	*	*	*	*	1	7	9	60
Days snow lying	16	16	12	5	*	*	0	0	0	*	5	11	65
Fog	7	7	7	4	3	2	3	3	2	4	5	7	54
Air frost	22	21	21	15	7	1	0	0	2	4	14	20	127
Ground frost	25	24	24	20	13	7	4	4	6	10	19	22	178
Av Daily bright sun (hr)	0.95	1.74	2.72	4.01	5.28	5.97	4.78	4.57	3.34	2.51	1.42	0.91	3.18
Days with gales	5	2	3	2	1	1	1	1	3	3	4	5	31
Solar radiation gm cals/cm^2 (since 1972).	1105	2480	5356	7709	10500	12054	11238	9827	5506	3260	1689	953	71677