MOOR HOUSE

20th ANNUAL REPORT, 1979.

The Nature Conservancy,
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With the Compliments of

Michael.

At Last?

THE NATURE CONSERVANCY COUNCIL

MOOR HOUSE

1979

20th ANNUAL PROGRESS REPORT

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C O N T E N T S

A.J.P. Gore.

The sudden death of Tony on 2 November 1979, was not only desperately sad for those of us who knew him, but a severe loss to Moor House. It was here that his research was done over 20 years. Apart from the work aspect, I know he had a great personal feeling for the place, blanket bog made him "tick", he used to say.

Tony first came to Moor House as a student, whilst at University College, in 1954, and, under Professor Pearsall's tutelage, he developed an interest in peat. After graduating from London he joined the Nature Conservancy and was based at Merlewood, but his work was to study the blanket bog at Moor House. He started his field work in 1956 and from then until 1973, when the old Nature Conservancy was split, he was a frequent visitor. But even after the change in organisation he continued his annual sampling and one sensed a reluctance to make a final parting.

I. GENERAL.

The Report covers the period 1 October 1978 to 30 September 1979. A time of utmost difficulty for Moor House and, in 1979, for the Nature Conservancy Council.

In August, Brian Marsh, who came to Moor House in 1964, left to become assistant to the N.C.C. Safety Officer at Huntingdon. His post has not been filled. The shortage of staff is now serious and it has been necessary to reduce the services we have been able to give in the past.

Brian had been responsible for the Climatological Station, and all equipment and instrument recording, since Michael Nelson left Moor House in 1968. He carried out his duties with care as to detail and over many years proved himself a dependable member of staff.

Judith Scott joined the staff in October 1978, and, surviving a testing first winter, has taken on Linda Teasdale's work with enthusiasm.

Alan Stewart also started work last October. Alan accepted a year's contract to review knowledge on the biological effects of moor gripping (draining) and its conservation impact. This is a Chief Scientist's Team project. A summary report is given later.

The weather, poor by any standard, is discussed briefly in this report. The winter was one of the worst in living memory and compared in severity with 1947 and 1963. In February, the path of an avalanche, which crossed the Reserve boundary wall below Silverband, could be clearly seen from the M6 motorway at Penrith. In the latter part of the winter access to the Field Station was helped by the use of a Sno-tric, otherwise the road was blocked to Land Rovers from 23rd December 1978 to 20th April 1979, when the remaining drifts were finally cleared after 3 days work by contractors using a tracked digger.

The snow had lain longer than previously recorded. A drift by Nether Hearth ruin finally melted on 7 June, but large drifts were still present on 20 June on Knock Fell and as far down the west scarp as 550m OD in Knock Ore Gill. A large drift persisted well into July in Crowdundle.

Although the effects of the winter were devastating, fencing was shattered, many trees cut to the ground and river banks undermined, it was followed by a summer (there was no spring), in which sunshine was absent for long periods, adding to the difficulties of the economic climate. For the cut back in public expenditure led to a fall in every activity that affects the Field Station. Nevertheless, every effort has been made to keep the options open and maintain a presence. The investment of ecological knowledge is the capital of Moor House and it is reassuring to know that organisations and persons outside N.C.C. appreciate this.

It is however, a fact that this store of information would be much greater, and more available, if all who had worked at Moor House had made their data available to be stored in the Reserve Records. It amazes me how strong the demand for information is and the amount of interest that is still taken in work done many years ago.

I would therefore like to ask everyone to search their records and make their data available to me. It will be our responsibility to catalogue these data, make our site index more comprehensive, and be in a position to improve on the information we provide. The Occasional Paper series is a means by which data can be made available. It is particularly suitable for species lists, which require periodic revision. For example, we were fortunate in having the British Lichenological Society hold 2 days of their summer field meeting on the Reserve. Their report will undoubtedly extend the lichen list published this year in Occasional Paper No. 12.

Interest by the Game Conservancy in our earlier work on sheep grazing and moorland management, with details of yearly grouse population numbers, is encouraging. Dr. G.R. Potts, Director of Research, visited Moor House and expounded the Game Conservancy North of England Grouse Project, which has been launched to enable grouse moor owners in northern England to manage their grouse more efficiently. We have made data available to the Project and look forward to future co-operation. A report from Dr. Potts appears later.

University interest has been maintained, in particular by Leeds, Durham and University College, London, who held a field course here in September. A residential course was also held for 6th formers from Leeds High School. This was a new and successful venture.

The following natural history account has been compiled from P. Burnham's report. It is intended to give a general picture of events; for more detailed information, the Warden's Quarterly Reports, held in the Reserve Record, should be consulted.

The most important single influence on the wildlife of the Reserve this year has been the weather. As reported in more detail in other sections of the Report, the winter was not only exceptionally long with frequent and heavy snow falls from late November to mid-May, but low temperatures and repeated blizzards with much drifting made conditions very harsh. When spring came it was cold and wet, as, with few exceptional days, were summer and autumn.

During the dead of winter from November to March, the Reserve had little to offer birds. Packs of grouse began to build up from 20 birds to 60 but none were seen for 8 days after a 4-day blizzard at the beginning of February. However, by March the packs had built up again and before the birds dispersed towards the end of the month, 2 packs of 150 and 40 birds were present. In recent years snow buntings have only been seen occasionally, usually as lone individuals. However, small flocks of 4 - 12 birds were seen regularly near Moor House during the first 3 months of 1979 and a flock of 35 was observed near Garrigill. These snow buntings survive on the high fells during periods of complete snow cover by feeding on the seeds falling from hay fed to sheep. Apart from 3 sitings in December, dippers were absent from the Reserve from late October until mid-April.

Among mammals, foxes occasionally ranging the fell, and stoats both managed to sustain themselves throughout the winter, but at least 2 rabbits escaped their attentions and survived at Moor House during the severest weather by feeding on the hay stored for the sheep!

The late onset of spring delayed the return of breeding birds. Isolated pairs of lapwings and golden plovers seen displaying in March were driven down dale again by further snow. However, a few golden plovers took up territory on snow free strips of ground in early April, despite continuing snow showers. There was some movement of wheatears, meadow pipits, and skylarks on the west side of the Reserve at the end of March, but these birds were thought to be in transit across the high fells on their way to the kinder conditions of the Eden Valley. It was not until the third week of April that passerines began to build up on the Reserve with meadow pipits not reaching a peak until late June. Continuing poor weather once the nesting season was under way no doubt accounted for generally low bird numbers and reduced breeding. An exception was noted in an unusually early brood of grouse seen on 31 May. The toll taken by the winter was also apparent in the numbers of grouse picked up dead in subsequent months (see Grouse Report). It is noteworthy that this year only 3 dipper territories were established as against 7 last year. The continuing lack of sunshine and warmth made the summer a poor one for Lepidoptera with small numbers only of green-veined white, large white, small tortoiseshell, and orange-tip butterflies, and northern eggar moths being observed.

Unusually late broods of golden plover chicks were noted in July, their presence overlapping with the flocking of full-grown birds, very few of which were young of the year. As the waders began to leave and groups of meadow pipits were passing through the Reserve in August, other late breeding meadow pipits on the high fells were still feeding young. Also passing through the Reserve in August was a good range of raptorial bird species including buzzard, hen harrier, peregrine falcon, merlin, and kestrel. Only one short-eared owl was noted.

Autumn once more showed the value of the plantations to birds. However stunted they may be, if regarded as "woods", they do provide shelter and no doubt food for many birds. On a few warm days at the end of September the pasture plantations were alive with birds, mostly meadow pipits, on their way to lower ground.

II. SCIENTIFIC (Moor House Staff).

a) The Programme

Lack of staff and of money to employ students have precluded any attempt at field work this year, apart from a brief survey of the tree enclosures. As far as one can tell, it seems unlikely that the situation will improve in the future and it may not be possible to continue the extensive ecological studies that have formed the programme of the Moor House staff at more than a minimum sampling level. This is very much to be regretted.

The programme, which was essentially to find out the effect of different treatments (management) of upland habitats that have been grazed by sheep for centuries, has been described in previous Annual Reports and publications. It has the aim of showing the effects (deleterious or otherwise) of certain managements, such as the removal of sheep grazing, excessive grazing, and burning. Whereas most of the measurements are botanical, it was originally envisaged that the effects on fauna and soil would receive as much attention, and certain base line studies were made, in particular of a survey nature, for the approach was at two levels, Reserve-wide surveys and detailed studies of small sites.

The surveys have included those of the composition of the vegetation and its productivity (see Eddy, Welch and Rawes, 1969 and Rawes and Welch, 1969, and others) and of sheep distribution and ecology (Rawes and Welch, 1969), and incorporated the findings of soil surveys by Johnson and Dunham (1963) and Hornung (1968), and the numerous faunal surveys of other research workers. Climatological records, maintained by the Moor House staff, have been utilised throughout.

The studies based on sites are grouped according to habitat, and over the past 25 years the most important and regular measurements have been those of the changes in botanical composition that accompanied the removal of sheep grazing. Exclosures representative of vegetation types were erected as far back as 1953. The main method of analysis has been the measurement of species cover, and more recently of sward height and density, by using a vertically stratified point quadrat, usually 1000 points per site. Charting of the vegetation and close-up photography have also been employed. There are 12 of these sites and they include _Agrostis-Festuca_, _Festuca_ and _Nardus_ grasslands, _Juncus squarrosus_ dominated vegetation, blanket bog of differing aspects and a species-rich flush. Nearby each of these sites and on similar vegetation, are plots of a similar lay-out, and the botanical composition of these, under the existing free range sheep grazing, has been recorded. Additionally, there are 5 other grazed sites and 21 plots to follow change in _Nardus_ and _Juncus squarrosus_.

On the blanket bog there have been trials of different sheep grazing pressures and heather burning regimes, and the botanical effect of moor gripping (draining) has been looked at on Burnt Hill. The grazing trials include a plot that was heavily grazed to the extent of eliminating heather. Sheep were removed from this plot for the rate of return to the previous composition to be recorded. Heather burning studies have included 2 regimes, burning every 10 years and every 20 years, whilst a start has been made on investigating the effects on grouse productivity of burning two 80 ha areas with small narrow strips. Annual counts of grouse numbers and breeding success, have been part of the programme.

The establishment of natural grasslands by exclosure and by the introduction of arctic-alpine and montane plants is a trial in which an attempt was made to hasten change by planting species expected or known, to have been present in the northern Pennines, before sheep grazing became common place. The species tried and the habitats in which they are being tested are far from being exhaustive. Early results were published by Hawes and Welch (1972).

Trials with trees started early in the history of the Reserve. The objectives were; to see whether tree cover could be established and how different species performed; to find the altitudinal tree limit; and to assess the effect of trees on soil and wildlife. The aim of producing woodland would be to create habitats that improved the natural wildlife, that provided shelter and had an amenity value. Nether Hearth is an example of the latter, whereby the old mine waste would be screened. Whereas a number of trees have been tested (and largely failed), the scope for research in this field is enormous and failure to capitalise on earlier findings ranks as a serious failure.

The policy at present is to maintain these sites, carry out minimal maintenance, observations and measurements. A brief report on the results of some of this year's survey findings follow later.

b) Climatology.

Whilst it is intended to maintain records from the Climatological Station as far as possible, the routine provision of data for Water Authorities and similar organisations can no longer be given. Likewise we are no longer able to attend to the Northumbrian Water Authority Trout Beck Gauging Station.

Reference has been made before in the Report to aspects of the year's weather. Snow lie, defined as days when snow covers more than half the ground representative of the Station, was nearly double the annual average for the preceding 25 years with 121 days compared to 66. Other winters of heavy snow have been 1962-3 98 days, 1968-9 94, and 1977-78 84. The most noteworthy factor however, was the lateness of the snow lie in 1979. All temperature recordings have been lower than average for the months December, January, February and March, but they were not the lowest recorded: for example, the average minimum daily temperature for January was 1.2°C lower (-8.1°C) in 1963. Precipitation has been much heavier than average, 2800.0mm. compared with 1921.0, and nearly 1/5 of this total fell as snow and rain in March. Sunshine in March, April, May and July was 80% of average. It has been an average windy year with gales recorded on 35 occasions.

The importance of the Climatological Station is highlighted by the installation of a new anemometer by the Meteorological Office who set great store by the continuance of good data from this long standing Station at high altitude.

c) The Tree Enclosures.

There are 4 enclosure sites at which observations and measurements are made.

1. Green Hole, the earliest enclosure, planted mainly with Scots Pine, Rowan and Birch and started in 1954.

2. Force Burn, a group of 5 small enclosures of Scots, Lodgepole and Mountain Pine.

3. Nether Hearth, with Lodgepole and Mountain Pine, Swedish Whitebeam, Larch and Sitka.

4. Pasture, originally a wide ranging species trial, but now largely Lodgepole, Mountain and Scots Pine, Swedish Whitebeam and Rowan.

   Other species, such as Bird Cherry, Ash and Willow have been planted, especially in Green Hole, and some survive.

Information on tree performance at an early stage in the project is available but not relatable to marked trees prior to 1970. We also have information on the number of trees planted. In 1974, 50 of each of the Pine species were selected in each enclosure and measurements taken of height and annual incremental growth. These measurements are to be repeated at 5 yearly intervals, and, where trees have failed to survive, further sample trees are marked to retain the sample number. The second occasion of this sampling regime is due this Autumn. However, the severity of last winter was so great that it was decided to make a general survey of damage. This was an opportunity to look for and attempt to trace every surviving tree. The results of this survey are shown in Table 1 (overleaf).

Many losses occurred in 1979 and surviving trees were often badly damaged, especially in the Pasture enclosure. A record of damage was taken, and it was noted that trees of all sizes and ages were equally affected. 9% of the Lodgepole Pine seedlings planted in 1978 died and 8% of the Mountain Pine.

However, annual death rate is not solely governed by winter damage. Table 2 shows how trees have fared in the Pasture enclosure, probably the most inhospitable of all the tree plantings, in the past 5 years. The deaths of Pines in 1976 and 1977 are thought to be closely related to drought conditions of 1975 and 1976.

Table 2. The decrease in the number of live trees in the Pasture enclosure (1975 - 9).

	1975	1976	1977	1978	1979
Scots Pine	200	178	111	111	42
Lodgepole Pine	207	181	152	152	151
Swedish Whitebeam	158	158	158	158	131
Rowan	163	163	163	163	144
Larch	14	13	13	13	12
Sitka	24	23	23	23	23

These figures, together with observational ratings on performance and appearance, suggest that the most suitable species tested to date might be provenances of Swedish Whitebeam, Rowan and Sitka, whilst where willow cuttings and Bird Cherry suckers have taken, as in Green Hole, their success has been very encouraging. Many of the Pines, including the Lodgepole, are showing signs of severe damage and are unlikely to remain alive many more years. Death of needles due to desiccation in spring frosts and physical damage in snow storms, when the pine offers much greater resistance to wind than the Rowan, Willow, and Bird Cherry, are serious shortcomings.

Table 1. Tree survival rates in 3 enclosures.

	Scots Pine	Lodgepole Pine	Mountain Pine^{x3}	Swedish Whitebeam	Rowan	Birch	Bird Cherry	Ash	Alder, Common	Willow^{x1}	Larch	Sitka
Green Hole.												
No. trees planted to 1962	2447	3^{x}	-	-	2018	1081	41	200	175	190	-	-
No. trees alive July 1979	456	3	-	-	184	31	10	3	0	10	-	-
% Survival	18.6	100	-	-	9.1	2.9	24.4	1.5	0	5.3	-	-
Nether Hearth.												
No. trees planted to 1962	200	600	775	425	150	625	4	-	97	70	100	200
No. trees alive July 1979	7	sampled	not counted	116	7	0	0	-	0	2	8	72
% Survival	3.5	81.2^{x2}		27.3	4.7	0	0	-	0	2.9	8	36
Pasture.												
No. trees planted to 1961	297	249	1151	232	284	233	-	-	43	9	57	135
No. trees alive July 1979	42	151	not counted	131	144	1	-	-	0	0	12	23
% Survival	14.1	60.6		56.5	50.7	0.4	-	-	0	0	21.1	17
Total of 3 enclosures.												
No. trees planted	2944	852	1926	657	2452	1939	45	200	315	269	157	335
No. trees alive 1979	505	not counted	not counted	247	335	32	10	3	0	12	20	95
% Survival	17.2	c. 75		37.6	13.7	1.7	22.2	1.5	0	4.5	12.7	28.4

x planted in error

x^1 cutting, chiefly Salix atrocinerea

x^2 estimate from sample of 80 trees

x^3 difficulties of counting "individuals" too great, majority survive.

However, as an example of the poor performance of these trees, it was found that the mean height of Rowan (0.78m.) and Swedish Whitebeam (0.74m.) was accompanied by 28 and 22% respectively of the trees having severely bent trunks, 55 and 52% heeling over from the vertical by 10 - 70°, and 32% having most of their branches stripped by the winter storm damage. There can be little doubt that at 560m. O.D. trees are under severe stress.

The vegetation of Green Hole was surveyed and mapped in 1957. This survey is being repeated this year and it is hoped to use the results in a paper to be prepared for publication.

d) A population study of the Red Grouse.

Weather conditions and the pressure of other work has much affected the amount of time available for P. Holms to carry out the field work of this important project.

In common with most grouse moors it has been a very poor year, due primarily to the severe winter and late spring, and wet weather during nesting time. It was estimated that the spring population was 0.5 birds/ha (0.74 in 1978) and the clutch size 5.5 eggs (7.5 in 1978). Mortality during May was exceptionally high, compared with recent years, and dead birds continued to be found throughout the summer. Nevertheless, hatching success was assessed at 90%, though the broods were small. Surviving chicks grew well, due to the weather and feed available in mid-summer being good. The young to old bird ratio of 1.46:1 was the lowest for 12 years, 1.1:1 being recorded in 1967.

At the end of the summer the moor was fully recovered and in good condition. It will be of particular interest to see the state of the grouse population next season.

e) Ecology and reproduction of the Common Frog, (Rana temporaria temporaria)(Lin.) in an upland and a lowland area.
(P. Holms)

This study forms a substantial part of a 2 year ecology course, the Certificate in Field Biology, run by the Extra-Mural Department of London University.

Common frog breeding ponds at an altitude of 500m. on the Reserve were compared with a lowland site at 80m. near the village of Belsay in Northumberland.

An ecological characterisation of each body of water was carried out, together with comparative climatological data. The times of emergence from hibernation, spawning and tadpole development were recorded at both sites.

Spawn was kept in tanks in the laboratory under identical light and heat regimes in order to compare development times with ~~natural~~ populations. Control experiments were done by transferring lowland spawn ~~to~~ upland water in an attempt to suggest factors controlling development rate, growth rate and mortality.

It is hoped to summarise the results obtained from this study in the next annual report.

f, The environmental impact of moor-gripping.
(A.J.A. Stewart, N.C.C. Contract Moor House).

Moor gripping is the practice of cutting open contour ditches on blanket-bog moorland using the conventional Cuthbertson plough. Drains are 50cm. deep and spaced at 15 - 30m. intervals. They are intended to intercept seepage water, remove standing water and wet *Sphagnum* areas and lower the water-table within the peat. Better drainage is expected to improve heather cover and quality for grouse and upgrade the grazing potential for sheep. Gripping costs around 4p per metre, but 70% subsidies are available from the Ministry of Agriculture. Gripping enjoyed a wide popularity in the 1950's and 1960's in northern England, western Scotland and parts of upland Wales, and is still very much in evidence around the Moor House N.N.R..

N.C.C. concern was aroused because of the potential danger to the species-rich, wet, *Sphagnum* dominated type of blanket-bog, a peatland type virtually unique to the British Isles. Furthermore, gripping under certain environmental conditions appeared to have no obvious beneficial effect at all. A review of literature and published information was undertaken in order to clarify the situation.

Blanket-peat has a characteristically low hydraulic conductivity which renders deep drainage ineffectual. Water-table drawdown around open ditches on Burnt Hill does not extend more than 1 - 2m. 90% of the ground between ditches remains unaffected by drainage. The cover and performance of *Calluna* is marginally improved in a 1 - 2m. strip on the lower sides of drains, but remains unaffected elsewhere. This very local drying decreases cover and species diversity of bryophytes and frequently eliminates Sphagna. Locally, lichen cover increases correspondingly.

The effect of gripping on flat blanket-bog is therefore very marginal. Drains cut through soligenous mires (flushes) however have a more extensive effect. Sphagna may be removed over a large area, thus jeopardising the survival of many rare hydrophilous vascular and lower plant species.

The minimal improvement in heather growth, effected by moor-gripping, would not be expected to affect the grazing potential of moorland for sheep. Gripping is however often a cue to increasing stocking densities, with the associated adverse effects due to overgrazing. Grouse population densities on blanket-bog rarely increase following open drainage, if at all; the improvement does not last beyond 2 - 3 years. Burning, grazing and fertilising are regarded as much more powerful agents of change on the blanket-bog ecosystem than moor-gripping.

Early experiments at Moor House showed that gripping induced earlier, sharper and higher flood peaks following individual rainstorms. Erosion of badly-placed grips, with excessive channel gradients, has frequently produced treacherous ravines several metres deep. Concern in recent years has been voiced about the adverse effects of such drainage on watercourses downstream. Increased flood peaks and suspended sediment loads have caused declines in fish stocks and problems of flood and water purification downstream.

In summary, moor-gripping is considered to be a slow, costly and usually ineffective method of removing water and increasing heather and other plant growth on wet blanket-bog. It does however, pose a threat to the conservation of rare species that are dependant upon a high water-table, and may have undesirable side effects on other upland management interests.

The results of 2 student projects on the subject of moor gripping are summarised in the following reports.

f(1) An investigation into the effects of drainage ditches on the distribution of invertebrates.
(I.W. Jardine, Department of Zoology, Durham University).

This 3 week study (May/June) used 2 sites on Burnt Hill (level top and side slope) where drainage ditches were approximately 25 years old. Samples were collected by pitfall trapping and wet extraction of soil cores.

The distribution of 3 groups of invertebrates appeared to be affected by ditches on the top of Burnt Hill. The abundance of Mycetophilidae (Diptera), which require a damp larval habitat, was 5 - 20 times greater away from the marginally drier conditions close to open ditches. A large species of enchytraeid worm (probably *Cognettia sphagnetorum*) showed a 100% increase in numbers closer to the ditches. Most spider species remained unaffected by drainage, although the ditches themselves did provide suitable habitats for large numbers of Argiopidae (orbweb spinning spiders). One species however, *Antistea elegans* (Agelenidae) was only trapped at a distance from, and never close to, drainage channels.

None of these differences were apparent on a side slope of Burnt Hill, except the preference of Argiopidae for web-spinning between branches of heather overhanging ditches. The only significant difference in soil fauna abundance between wet and dry zones there, was observed for a small, unidentified species of enchytraeid worm, that was twice as abundant in damp areas between ditches.

f(2) A study of the effect of drainage on moorland vegetation.
(R.H. Jackson and C.A. Wright, Department of Botany, Durham University).

Two areas of different slope were studied on Burnt Hill, during 3 weeks in May/June. Studies of water-table and vegetation cover were made along transects across 25 year-old drainage channels.

Water-table levels were found to be lowered only locally around drainage ditches (less than 1m. from the drain edge). The rate of drying, following rainfall, was found to be greater close to, rather than at a mid-point between ditches. This was measured as the fall-rate of water levels in bore-holes.

Point-quadrat and Domin scale vegetation analysis showed that plant cover, biomass and vegetation height were unrelated to ditch positions. The performance of *Calluna* in particular was unaffected at either of the sites.

Soil core samples, also taken from a transect across a drainage ditch, were used for measurements of peat moisture content and *Calluna* root density (using Newman's grid method). Neither moisture content of the peat nor root density was related to distance from open drains. Root density (cm/cm^3) was however correlated ($r = -0.68$, $n = 32$) with moisture content (%) at the steeply sloping site on the side of Burnt Hill.

III. RESEARCH BY GAME CONSERVANCY.

a) Grouse: Game Conservancy North of England Grouse Project.
(G.R. Potts, Director of Research at the Game Conservancy).

This 7 year project was started during the 1979 season. A study of 14 moors in April included Moor House, which was visited again in July, this time accompanied by the Earl Peel (Chairman of the NEGP) and Peter Hudson (newly appointed to the project).

Samples of caecal droppings were collected on 17 April, mostly from territorial birds. The samples contained an average of 36,000 eggs of *Trichostrongylus tenuis* and 4,000 *Eimeria* oocysts per gram wet weight. New research suggests that these levels are sufficient to adversely influence breeding success.

It is hoped that other NEGP work will involve Moor House in future especially as the project moves into the field (March 1980). At present most of the work concentrates on improving a computer model of grouse population dynamics based on data already available.

IV. RESEARCH BY THE INSTITUTE OF TERRESTRIAL ECOLOGY.

a) Plant ecological studies on peat.
(A.J.P. Gore, Monks Wood Experimental Station).

Erosion reclamation.

Photographs of the trials at Moor House and at Longdendale (Gore, 1976) were taken in August 1979. The fencing at Moor House is still effective against sheep but the wire and some posts will shortly need replacing. The fence has now been in position for 13 years. The revegetated parts now have some 35 species present including higher plants, mosses and lichens.

At Longdendale, the fences have been breached in several places, at least since 1976 on 2 of the 3 plots, and on the third the fences have more recently been removed altogether. Notwithstanding this lack of protection from sheep grazing, the successful plots show no deleterious effects of grazing. These plots received fertilizer in 1966 and still consist almost solely of *Deschampsia flexuosa* although *Calluna vulgaris* and *Vaccinium myrtillus* are steadily increasing and there are a few patches of *Dicranella heteromalla* and *Cladonia* spp. present. In some places grazing is very intense but the ground cover is still good. This is very encouraging since it was not known whether revegetated eroded peat could support grazing. The North West Water Authority, Eastern Division (one time Manchester Corporation Water Works) have complete records of the sheep population on Arnfield Moor for the period of the experiment and these show a marked reduction in sheep numbers, a consequence of deliberate policy, since 1969. The importance to catchment management of grazing in relation to the vegetative cover on vulnerable and inherently infertile soils has thus been increasingly recognized by the managers of this catchment area.

Reference.

Gore, A.J.P. 1976. Erosion reclamation. 17th Annual Progress Report of Moor House, p. 17.

b) <u>Competition between grass species.</u>
(Helen E. Jones, Merlewood Research Station).

The project is concerned with the growth of *Agrostis tenuis* and *Festuca ovina* under various cutting regimes both in competition (in 1:1 mixed cultures) and in monoculture. Tillers of the 2 species derived clonally from material obtained from Moor House have been grown in pots in the greenhouse in John Innes compost. Earlier experiments showed that in uncut treatments, *Agrostis* was more vigorous than *Festuca*, though after an initial fairly rapid decline in the percentage of *Festuca*, it did not die completely. In monoculture it appeared to produce less biomass, but more tillers than *Agrostis*.

The present experiment is designed to investigate the effects of differential cutting on the 2 species when grown in a 1:1 mixture. Six tillers of each, planted alternately in pots, were left to grow undisturbed from November to April when the following treatments were applied at 2 week intervals:-

1. Both species uncut
2. Both species cut to 10cm.
3. Both species cut to 5cm.
4. One species uncut, the other cut to 10cm.
5. One species uncut, the other cut to 5cm.
6. One species cut to 10cm., the other cut to 5cm.

giving a total of 9 combinations, arranged in a randomised block layout of 3 replicates. The experiment has 3 harvests, 2 of which have already been taken and the third for early summer 1980. The cuttings removed during the 2-weekly clippings have been oven dried and weighed. Preliminary observations confirm the better growth of *Agrostis* in uncut mixtures, but *Festuca* appears to do well in cut treatments. As expected, in the differentially cut treatments, the less severely cut species is much more successful, and in some instances, the other species has not survived.

c) <u>Risk of frost damage at bud burst on Sitka spruce.</u>
(M.G.R. Cannell, Bush Estate, Penicuik).

Observations were taken to determine the date of bud-burst of Sitka spruce at Moor House. It occurred about 4 June in 1979. The timing of this event was then related to winter and spring temperatures. The number of "growing day-degrees" (heat-sum) greater than 5°C prior to bud-burst was 72 at Moor House, the same as at Eskdalemuir (in 1979), but less than at Bush, Midlothian (105 day-degrees) and very much less than at Bush in 1961 (153 day-degrees). That is, bud-burst occurred at the upland sites without prolonged warming temperatures. Two possible reasons for this are that:-

a. trees at the upland sites had their winter dormancy more completely broken by prolonged "chilling", and

b. bud-burst occurred in late May or early June even in cool upland conditions in response to long photoperiods.

These 2 notions are being tested and will form part of a model to predict dates of bud-burst from daily temperature data. These predicted dates of bud-burst will then be used to assess the risk of spring frost damage at various sites.

d) Microbial characteristics of soils. Their relationships to plant growth and soil properties.
(Pam Latter, Merlewood Research Station).

Pot experiments are being set up at Merlewood with the aim of defining the relationships between microbial processes and,

a. soil chemical and physical properties

b. plant growth, and

c. litter decomposition.

Five soils are being tested, blanket bog peat from Moor House being included as the example of an organic soil. Other soils are from Merlewood, Banchory, Gisburn Forest, and Ravenstonedale.

Microbial tests include the weight loss of specific substrates (chitin, pectin, protein, lignin, cellulose), and the test plant is Radish. Early dead *Eriophorum* leaves from Moor House are being used for the test of litter decomposition.

Prior to testing, the soils will be stored under various conditions of moisture content, nutrients, temperature or litter type etc..

In a preliminary experiment plant growth and microbial tests were made on 76 soils from 8 major soil groups. A range of peats, peaty gleys, and peaty podsols were among the soils collected from all over Britain, which also included brown earths, podsols and gleys. The results will give information on the decomposition of *Eriophorum* litter under varying soil conditions. The occurrence of microfauna is being noted.

e) Ecology of vegetation change in uplands.
(Kathy Dickson, Merlewood Research Station).

I.T.E. is at present engaged on a study of vegetation change in the uplands of England and Wales on behalf of the Department of the Environment. This is as a follow up of a review on upland land use (I.T.E. 1978) which included hypotheses of vegetation change in relation to management. The work is centred on 12 upland parishes which were selected as a sample of the main upland areas and although the studies are localised in this way, the results will be related to Regional and National conditions. The 2 parishes nearest to Moor House were Lunedale and Shap. Approximately 80 points per parish, arranged in a regular grid, were examined and this information was used to classify the vegetation. During the interpretive stage, probable courses and rates of change between vegetation classes in relation to gradual changes in management practices will be investigated. A source of interpretive material is sites where known management modifications have been applied and these are particularly valuable where the vegetation at the start of a change is well documented, as is the case at Moor House.

To this end the following sites at Moor House were examined during the summer of 1979:-

The burning/grazing experiment at Hard Hill.

The grazing experiment at House Hill - although this experiment was completed in 1976, it is hoped that some indication of the recovery of blanket bog from heavy or light grazing pressures can be gleaned by comparing results at the cessation of the experiment with those obtained in 1979.

The meadow in front of Moor House - the management of this has been well documented and it should provide an end point to the change in upland limestone grassland subjected to fairly intensive management.

Areas dominated by Juncus squarrosus (GR 758 337) and Nardus stricta (GR 762 329) - the grazing pressure on the different vegetation types at Moor House has been recorded and by incorporating these types into our vegetation classes, the grazing pressures on those vegetation classes can be inferred.

To ensure consistency of approach over the whole project the standard methods used in the parish surveys were applied at Moor House, but modified as required to accommodate the size of the experimental sites. The well documented experiments at Moor House may also provide us with a check on how analysis of our recorded list of species places the sites in the vegetation classes compared to their placing from independent species lists in the Reserve Records. The experimental sites at Moor House also allow us to compare cover measured by different methods; and to determine the extent to which analysis of data of adjacent controls compares with the original record of the situation on the actual experimental sites.

Methods.

At each sample site a list of vascular plant species was recorded. Species were recorded in concentric quadrats $1m^2$, $4m^2$, $25m^2$, $100m^2$, $200m^2$ and where possible $5000m^2$. Four small soil samples were taken from each site. Cover estimates were made in 5 $1m^2$ quadrats at the centre and the corners of the $200m^2$ quadrat. Cover values were recorded to the nearest 5%.

Results.

The data from Moor House will be combined with those from other areas, including the 12 parishes, and presented in a report to D.O.E. in Spring 1980. Further information can be obtained from Miss K.E. Dickson (I.T.E., Merlewood Research Station, Grange-over-Sands, Cumbria), or from the project leader, Dr. D.F. Ball (I.T.E., Bangor Research Station, Penrhos Road, Bangor, Gwynedd).

Reference.

I.T.E. 1978. Upland Land Use in England and Wales. Countryside Commission Publication III, 140 pp.

V. RESEARCH BY FRESHWATER BIOLOGICAL ASSOCIATION.

a) Fish populations.
(D.T. Crisp).

Sampling of fish populations in some of the freshwaters of the Reserve, especially of trout from Cow Green Reservoir spawning in the Tees and its tributaries within the Reserve, has continued.

VI. RESEARCH BY UNIVERSITIES.

a) The geographical characterisation of moorland using invertebrates.
(J.C. Coulson and J.E.L. Butterfield, Department of Zoology, Durham University).

Between autumn 1976 and autumn 1978 we carried out an invertebrate survey of uplands and peat bogs in northern England on a contract from the Nature Conservancy Council. The survey was based on pitfall catches and the sites used ranged from near sea level mosses on the Lancashire coast to upland limestone outcrops and blanket-bog on the Pennines, and to the dry heaths of the North York Moors. As a basis for comparison with other sites in the North of England we used 9 sites on the Moor House Reserve. These were of various soil types and had been sampled in previous years.

Cluster analysis (average linkage), based on the similarities of the invertebrate faunas of each site, were used to identify 6 types of site. Type I (lowland oligotrophic mire), Type II (upland blanket-bog), Type IV (dry heath) and Type VI (upland grassland) each have characteristic invertebrate communities. Types III and V form gradients between Types II and IV and between Types II and VI respectively.

We found that the 2 blanket-bog sites (set up at Bog End adjacent to areas where much of the work for the I.B.P. was carried out) at Moor House were typical of the Type II upland blanket-bog group. Not only did this confirm the wider application of the detailed work that has been carried out on the blanket-bog at Moor House, but it also allowed us to relate the pitfall trap catches to population densities and biomass of invertebrates on an area basis. Five sites (4 on peat and one on a mineral soil) on the west scarp slope of Dun Fell were interesting in that they formed a group (Type V) in which one other site only (in Dentdale) was included. The fauna on these sites included components from both mineral and peat soil invertebrate communities and, in addition, a number of rare species such as the staphylinids, Olophrum assimile and Lathrobium zetterstedti, the mycetophylids, Mycomya clavigera and Brevicornu boreale and the tipulid, Tipula gimmerthali, all of which occurred at one or more sites on the west of Dun Fell.

b) Aspects of the ecology of Coleophora alticolella Zell. (Lep.).
(M. Randall, Department of Zoology, Durham University).

The ecology of the moor rush moth Coleophora alticolella, has been studied in relation to its main food plant Juncus squarrosus L. over a large altitudinal range in northern England.

Much of the work was carried out on the Middle Tongue region of the Moor House Reserve, from 215m. to the summit of Little Dun Fell, with sample stations at the lower altitudes being on adjacent farm land. A comparative site at Drigg (Grid ref. SD 049987) on the Cumbrian coast was also used.

Samples of Juncus squarrosus inflorescences were collected every week from the end of May until the beginning of November. These were examined in the laboratory to assess seed production by the plant, and the numbers of eggs and larvae of the moth.

Analyses of the data collected in 1978 show similar results to those obtained for 1977 (see 19th annual report) especially with respect to floret and seed capsule production by the _Juncus_ inflorescences. For 1978 the reduction in the proportion of florets developing into ripe seed capsules, with increasing altitude, can be described by a logistic equation, with the formula

$$y = \frac{0.9722}{1 + \exp(0.0164x - 6.1218)}$$

where y is the proportion ripe at each altitude x (in metres).

In June the female moth lays her eggs on the developing inflorescences, the majority are laid between adjacent florets. The newly hatched larvae have limited mobility and burrow into the nearest floret or capsule; if this has produced seed there is a food supply for the larva, if not starvation ensues. Consequently, the survival rate of the first instar larvae, between hatching and becoming established inside seed capsules, is determined by the proportion of capsules ripening at each altitude and so greater mortality occurs at higher altitudes during this stage of larval development.

At the lower altitudes sampled the third and fourth instar _Coleophora_ larvae are attacked by hymenopterous parasitoids. As in 1977, the rate of parasitization, and the number of species of _Hymenoptera_ reared from parasitized _Coleophora_ larvae, decreased with an increase in altitude. However, parasitized larvae were only found from samples up to 335m. in this season, compared with 395m. in 1977. This parasitization has a significant effect upon the population dynamics of the _Coleophora_ below 260m.

These 2 mortality factors, high mortality of the first instar larvae towards the upper limit of their distribution, and a high rate of parasitization at the lowest sites, result in an optimal area for the _Coleophora_ around the 300m. part of the transect. In this region larval density is at its highest, resulting in much greater destruction of the _Juncus_ seed capsules than at the other altitudes.

c) _Studies on the Common Sandpiper (Actitis hypoleucos)._
(Shirley Jones, Department of Zoology, Durham University).

As part of a study of habitat selection of breeding waders in Upper Teesdale work at Moor House has been concentrated on the Common Sandpiper (_Actitis hypoleucos_).

To try to explain the distribution of Common Sandpiper breeding within the Reserve, further measurements of habitat variables have been taken for computer analysis.

There was a decrease in the number of pairs of Common Sandpiper breeding on the eastern part of the Reserve from 30 pairs in 1978 to 22 pairs in 1979.

Table 1 shows the numbers of colour-ringed Common Sandpipers returning to the Reserve since 1977 when 20 adults were ringed.

Table 1.

		Returned in 1978	Returned in 1979.
Number of adult Common Sandpipers ringed in 1977	20	9	5
Number of adult Common Sandpipers ringed in 1978	1	-	1

In considering the mortality of the colour ringed population the site tenacity of the birds must also be taken into account. Those birds which returned showed good site tenacity, defending territories in the same areas held previously. A nest at Nether Hearth was found in the same grassy tussock for the fourth consecutive year, (one bird ringed in 1977 returned in 1978 and 1979, having definitely changed mates in 1978). This would suggest that there is a maximum average annual mortality of about 48%.

d) An investigation of the different forms of the harvestmen (Mitopus morio)(Fabr.) in north-east England.
(Amanda Jennings, Department of Zoology, Durham University).

In upland regions of north-east England, Mitopus morio exists in 2 forms, distinguishable as separate size classes: the larger, longer-legged M. m. alpinus; and the smaller M. m. cinerascens. In the lowlands around Durham city only one form is found, designated M. m. morio. Around Bog End, and at other Pennine sites, alpinus and cinerascens occur together. The aim of the project is to establish whether or not alpinus and cinerascens interbreed, and how their relative numbers abundance and sizes vary over a range of altitudes.

For this purpose, a series of pitfall traps were laid down at Bog End in early May on the Calluna moor. The traps have been emptied at weekly intervals (fortnightly after 29 August) to parallel pitfall collections made at other lower altitude sites (Muggleswick Common, grid references NZ 029499, NZ 014447, NZ 003449, and elsewhere). The harvestmen have been separated out and the other species caught in the traps also listed.

Numbers of animals caught are given in tables 1 and 2.

No harvestmen were captured until June. This is probably because early instars are relatively inactive. As they get older, their activity increases. Hence the numbers falling into pitfalls increased as the summer progressed. Fifth instar individuals and also the pre-adult stage are very active at the surface. Hence the large numbers trapped at the end of July and beginning of August.

Very few alpinus were trapped compared with cinerascens. This may be because alpinus are more active on top of the heather rather than at ground level: or it may be a real difference in the relative abundance of the 2 forms. Bearing in mind the fact that only one alpinus was caught by hand, then the latter is probably true.

Some adults have been paired in the lab in an attempt to breed them. Results are not yet available.

Table 1. Pitfall trap frequencies.

Date	Number of Trap Days	Numbers trapped alpinus	cinerascens	Other Harvestmen
Jun. 06		0	1	
15	9	1	10	
21	15	0	15	
28	22	0	12	
Jul. 05	29	1	22	
11	35	3	50	
22	46	0	32	1 (*Nemastoma bimaculatum*)
30	54	2	96	2 " "
Aug. 06	61	0	53	
14	68	3	61	
21	75	0	15	
29	83	0	25	3 " "
Sept. 11	98			

Table 2. Hand collections.

Date	Numbers caught alpinus	cinerascens
Jul. 05	1	5
11	0	3
17	0	1
22	0	1
30	0	3
Aug. 06	0	1
21	0	8
29	0	5

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

No report has been received.

f) Spiders at Moor House.
(Julie Ladds, Department of Zoology, Durham University).

The study had 3 aims:-

1. to examine species appearing at different altitudes to see if there was any difference in body size
2. to examine distribution of some species over an altitude range
3. to compare briefly the faunas of limestone grass and peat bog, as represented by pitfall traps.

Seven sites were chosen on limestone grassland. These were Rough Sike (1800ft), Green Hole (1800ft), Moss Burn (2050ft), Currick Hill (2109ft), Hard Hill (2200ft) and Knock Fell enclosure (2450ft) and grazed area (2499ft). Six pitfalls were set in each and left for an average of 15 days.

Two peat sites were used, (spiders taken in the course of another study). These were on Burnt Hill and Nether Hearth flats. Ten pitfalls were set in each and left for approximately 19 days.

Results.

1. Of species found in large numbers over an altitude range, only Erigone dentipalpis (family Linyphiidae) showed a change in size; for all 4 measurements made (carapace width, sternum length, femur I length, tibia I length), the animal seems to increase in size with altitude (see graphs). Using a χ^2 test it was shown that the animals' body size in the highest site was significantly different from size at lower sites at the 20% level, although the increase was not a smooth rise.

   Possible reasons for this increase are not known, but it has been reported in other spider species, for example, Alopecosa pulverulenta (Locket and Millidge).

2. Within limitations of a small altitude range for any one species and small sample sizes due to lack of time, some animals were shown to favour either the lower or higher sites used. Monocephalus fuscipes was found in the lower sites (up to 2109ft), Erigone dentipalpis in the higher sites (above 2050ft) and 2 closely related animals, Dicymbium nigrum and Dycymbium tibiale were found not to overlap in their occurrence, the former being found up to 2109ft and the latter found only above 2200ft.

3. χ^2 values were calculated for species found in larger numbers in one or both sites. At a level of p = $<$0.001, Dicymbium nigrum, Tiso vagans, Monocephalus fuscipes and Erigone dentipalpis were found to be limestone species, Dicymbium tibiale was also a limestone species (p = 0.01 - 0.001). Lepthyphantes zimmermanni and Lepthyphantes angulatus (p = $<$0.001) were found to be peat species, as was Bathyphantes gracilis (p = 0.01 - 0.001).

Many other species were recorded, but in numbers too low for analysis.

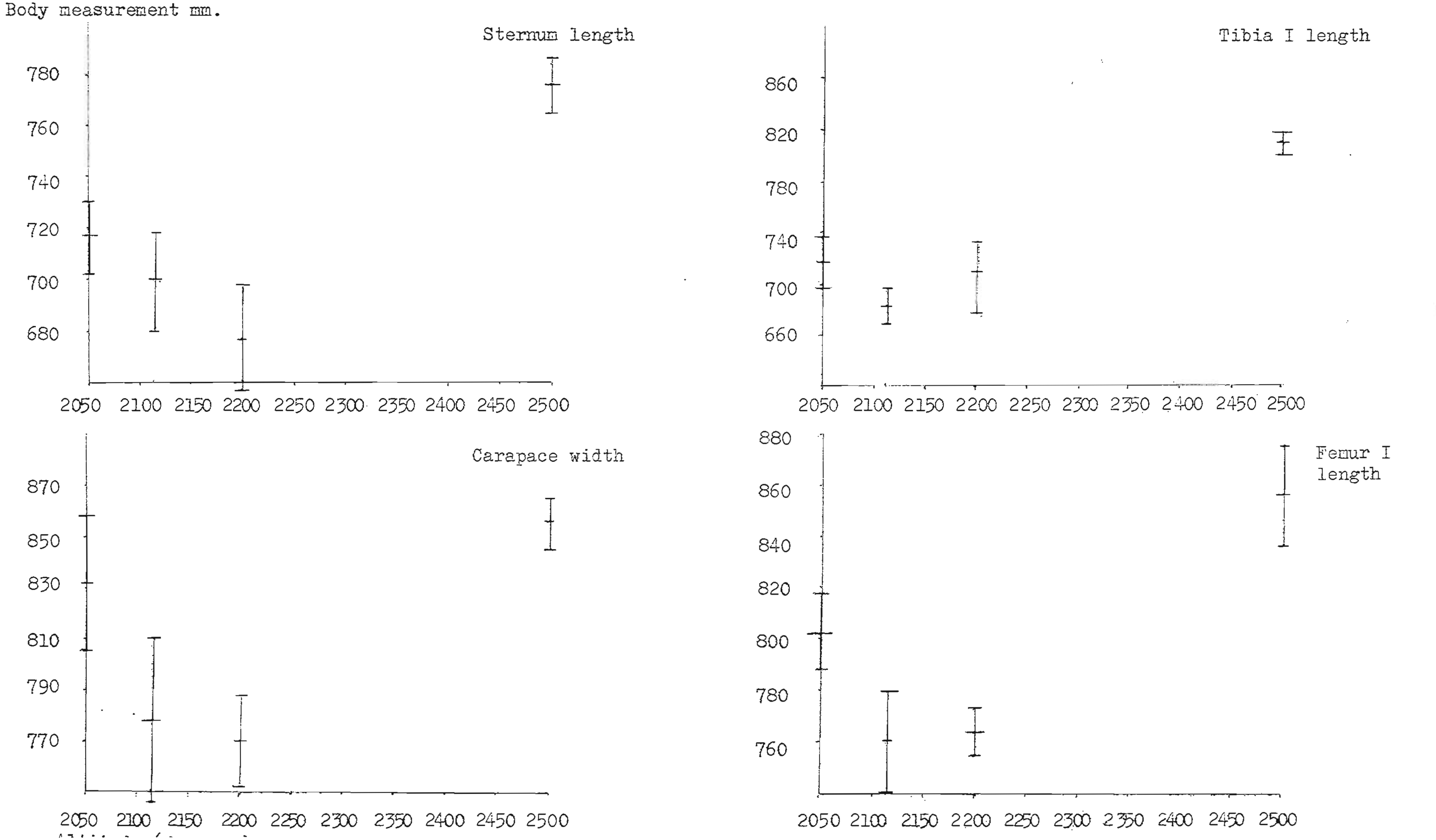
References.

"British Spiders", vol. I - III, Locket and Millidge.

"The Spiders of Moor House", J.M. Cherrett (Ph.D. Thesis, 1961, Durham University).

"The World of Spiders", Bristowe.

Erigone dentipalpis - body measurement with relation to altitude.



g) The Distribution of Carabids at Moor House.
(Susan Wilson, Department of Zoology, Durham University).

Work was carried out on the distribution of the Carabidae (Coleoptera) on the Moor House Nature Reserve between 15 May and 5 June 1979 as part of a second year undergraduate project.

Pitfall traps were laid in a range of sites, as the main sampling method. The sites were divided into mineral areas, Great Dun Fell, Troutbeck river-bank, and the limestone grassland areas of Knock Fell, Currick Hill and Green Hole, and peat areas such as Burnt Hill, Rough Sike and Bog End sites.

The pitfall catches on both the mineral and peat areas were compared and showed marked differences. Carabids, such as Pterostichus strenuus, Carabus problematicus, Clivina fossor, and Loricera pilicornis were frequently taken on mineral areas, though never on peat areas. Patrobus atrorufus, Pterostichus adstrictus and Notiophilus biguttatus were usually found on mineral areas and only very occasionally found on the peat sites. A total of 32 Patrobus atrorufus were caught, of which only 2 were found on the peat sites (at Currick Hill), possibly due to a spill-over effect, from a nearby limestone area. The common species found on the peat areas included, Pterostichus diligens, P. nigrita, Agonum fuliginosum and Trichocellus cognatus, all being predominantly damp preferring species.

There was greater diversity of species on the mineral areas, with a total of 23 species giving an index of diversity of 10.9 (after Margalef), while on the peat areas only 11 species were found, giving a lower index of diversity of 4.2.

h) Long term studies on upland Homoptera.
(J.B. Whittaker, University of Lancaster).

Sampling has continued by there is nothing to add to the conclusions reported in the 19th Annual Report (1978). The population of S. ericae on a 10m. x 10m. plot on Sike Hill has been reduced to one half of its previous density (and that of the control) by spraying. The response of the population to this treatment is being monitored.

i) A comparison of the fauna of grazed and ungrazed areas at Knock Fell.
(M. Hayward and J.B. Whittaker University of Lancaster).

In the summer of 1978 samples of the fauna found inside the enclosure set up at Knock Fell in 1955 were taken for comparison with samples taken on the grazed area outside the enclosure.

Methods.

1. Quadrat samples of vole runs.
2. Suction sampling - 20 samples on each of 2 sample dates, inside and outside the enclosure.
3. Pitfall traps.
4. Soil cores 6cm. in diameter.
5. Sweep netting.

Results.

Quantitative data from the suction samples, pitfall traps and soil cores are listed in Table 1.

In general, the herb layer of the ungrazed site supports more animals, especially Homoptera (Aphididae and Cicadellidae) than does the grazed sites. The soil cores also reveal densities (mainly Acarina and Collembola) which are approximately twice as high on the ungrazed as on the grazed site.

Only in the pitfall traps were numbers higher on the grazed site. These measure activity and trappability which for the main group making up the catch, the Carabidae, may be expected to be higher in less dense vegetation.

Discussion.

In general the results of this study agree with those of Morris (1968) who found that ungrazed chalk grasslands supported 3 to 4 times as many invertebrates as did grazed. Only the pitfall trap results agree with those of Morton-Boyd (1960) who, using the same method reported higher numbers on grazed rather than ungrazed grassland in Argyll.

The fauna of the ungrazed plot in the present study was rather more diverse than was that of the grazed site. For example, whilst 16 families of Diptera were recorded on the grazed site, 20 were found on the ungrazed. Similarly, 12 common species of Coleoptera were taken on the grazed site but 17 were taken in the enclosure. *Microtus agrestis*, although quite abundant in the enclosure was ~~not trapped~~ on the grazed site.

References.

Morton-Boyd, J. 1960. Studies on the differences between the fauna of grazed and ungrazed grasslands in Tiree, Argyll. Proc. Zool. Soc. Lond., 135, 33-54.

Morris, M.G. 1968. Differences between the invertebrate faunas of grazed and ungrazed chalk grassland. II. The faunas of sample turves. J. Appl. Ecol., 5, 601-11.

Table 1. A summary of the fauna in quantitative samples of grazed and ungrazed grassland at Knock Fell.

A. Suction samples of herb layer fauna - mean number/m^2 $\pm$ S.E.

	Grazed		Ungrazed	
	10th Aug.	1st Sept.	10th Aug.	1st Sept.
Aphididae	9 $\pm$ 3	2 $\pm$ 1	113 $\pm$ 23	25 $\pm$ 8
Cicadellidae	6 $\pm$ 2	0	35 $\pm$ 5	1 $\pm$ 1
Thysanoptera	14 $\pm$ 5	9 $\pm$ 3	1 $\pm$ 1	6 $\pm$ 2
Diptera	12 $\pm$ 3	30 $\pm$ 7	18 $\pm$ 7	49 $\pm$ 15
Hymenoptera	5 $\pm$ 2	1 $\pm$ 1	6 $\pm$ 2	8 $\pm$ 3
Coleoptera	18 $\pm$ 4	13 $\pm$ 5	2 $\pm$ 1	6 $\pm$ 1
Total	64 $\pm$ 11	55 $\pm$ 14	176 $\pm$ 27	94 $\pm$ 18

B. Pitfall traps - mean number of animals/trap/day.

	Grazed	Ungrazed
8th Aug.	9.8 $\pm$ 2.4	4.4 $\pm$ 1.2
10th Aug.	8.8 $\pm$ 2.1	4.5 $\pm$ 0.1
14th Aug.	10.7 $\pm$ 3.3	5.1 $\pm$ 2.2
26th Aug.	11.5 $\pm$ 3.1	5.0 $\pm$ 3.2

C. Soil cores - mean number per m^2 $\pm$ S.E.

	Grazed	Ungrazed
27th June	12,969 $\pm$ 2,645	29,575 $\pm$ 9,775
21st Aug.	10,800 $\pm$ 3,452	18,469 $\pm$ 3,032

j) *Physiological studies of root growth in moorland species.*
(Celia Jones, Department of Plant Sciences, University of Leeds).

Has started research into the growth, aeration, respiration and protein turn over in the root systems of *Calluna* and *Eriophorum* throughout the year on the blanket bog. A report will be given next year.

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

This investigation continues.

l) *Seasonal dynamics of foliage in Eriophorum vaginatum.*
(K. Robertson, Department of Plant Sciences, University of Leeds).

This study of leaf demography, photosynthesis and the partitioning of assimilates has continued and a full report is promised for next year.

m) *Adaptation to the upland environment in two closely related species.*
(J.D. Graves, University College London).

Work is continuing on a project started in 1977 to look at the adaptations made to the upland environment by 2 closely related species, *Geum urbanum* and *Geum rivale*. These 2 species have strikingly different altitudinal and latitudinal distributions, *G. rivale* being found at the higher altitudes and more northerly latitudes.

In the summers of 1978 and 1979 growth experiments were completed at 3 sites, Helbeck Wood (800 ft), Moor House (1800 ft) and Knock Fell (2400 ft). The experiments have shown the *G. urbanum* grows more vigorously than *G. rivale* at all 3 altitudes. This is despite the fact that *G. urbanum's* natural altitudinal limit is at about 1300 ft in the northern Pennines. Similar results have been found in growth studies completed in the laboratory.

Presently work is continuing on photosynthesis, assimulate partitioning and frost resistance in the 2 species.

Climatological data are still being collected from several sites, principally from the Moor House and Helbeck Wood automatic weather stations.

n) *Post-fire succession in Calluna-dominated communities.*
(R.J. Hobbs, Department of Botany, University of Aberdeen).

Regeneration of vegetation after management fires in relation to age of stand before burning is being studied at Dinnet N.N.R. and Glensaugh Experimental Farm (H.F.R.O.) in Scotland, and at Moor House. These provide examples of species-rich and species-poor dry heath, with Moor House being used as a wet blanket bog site.

Sites were set up last year at Green Burn in the hope that experimental burning might be carried out there this spring. Unfortunately the exceptionally bad weather conditions prevented any burning, as was the case in 1978. Since next year is the last year of the project, monitoring of regeneration from experimental burns at Moor House is now ruled out. It is still hoped, however, that some experimental burning might be done in 1980 to provide temperature data for fires on blanket bog for comparison with those on dry heath.

Monitoring of plots in the Hard Hill long-term experiment was continued. The plots, burned in 1975, provide examples of slightly later stages in the succession, and the Short and Long rotation plots have been studied. The results obtained this year show the same overall relationships as found last year, but some important changes have occurred. *Calluna vulgaris* and *Rubus chamaemorus* have increased in abundance, while *Eriophorum vaginatum* has decreased slightly. *Dicranum scoparium* has increased in abundance, while most liverworts and lichens have decreased. These results are largely in accordance with the expected trends, with *Calluna* increasing towards co-dominance with *E. vaginatum*, and the canopy becoming more closed thus reducing the abundance of liverworts and lichens. There does not appear to be any simple relationship between these trends and the treatment applied, but more detailed analyses of the data are in progress.

Terminal shoot length of *Calluna* was again measured in all treatments (100 shoots per treatment). The results meaned over 4 blocks are:-

	cm.
Short rotation grazed	3.85
Short rotation non-grazed	4.39
Long rotation grazed	3.91
Long rotation non-grazed	4.43
Unburnt grazed	2.89
Unburnt non-grazed	3.39

These results are similar to those from last year, with no significant differences between Long and Short rotation treatments (only the unburnt controls were significantly different from the other treatments, at 5% level). This year, however, there was a significant difference between blocks, terminal shoot growth apparently increasing with elevation.

These plots will be studied again next year and the data included in a Markovian model of post-fire succession.

o) Carbon balance of *Sphagnum capillifolium* (Ehrh.) Hedw.
(S. Daggitt, Department of Plant Sciences, University of Leeds).

During the 1979 field season, measurements of the photosynthetic rate of *S. capillifolium* were made using $^{14}CO_2$ incorporation techniques. The equipment used was a 2 gas system as described by Incoll (1978) and previously used at Moor House by Ashmore (1975) and Robertson (1978) with *Calluna vulgaris* and *Eriophorum vaginatum* respectively.

In conjunction with each measurement of photosynthesis a number of other variables were monitored. Among these were photon flux density, moss temperature, air temperature and moss water content. An attempt will be made to explain the variation in measured photosynthetic rates using these and other variables.

The results from this study will be compared with measurements of net CO_2 exchange obtained in the laboratory using an infra-red gas analyser. In the laboratory photon flux density, moss temperature and, as far as possible, moss water content were controlled during the observations. Any lack of agreement between field and laboratory results may indicate the role of environmental factors not considered during the laboratory work, (e.g. temperature prehistory, time from the start of the growing season) in determining the photosynthetic rate.

References.

Ashmore, M.R. 1975. Ecophysiological studies of Calluna vulgaris in a moorland habitat. Ph.D. Thesis, University of Leeds.

Incoll, L.D. 1978. Field Studies of Photosynthesis: Monitoring with $^{14}CO_2$. In: Environmental Effects on Crop Physiology, Landsberg, J.J. and Cutting, C.V. (Eds.). Academic Press.

Robertson, K.P. 1978. 19th Moor House Annual Report.

p) The effects of grazing pressure on Trifolium repens L.
(Jill H. Collison, University of Newcastle upon Tyne).

Introduction.

A detailed study of Trifolium repens L. (white clover) was carried out at Moor House Nature Reserve during July and August 1978. This survey was initiated after work at Newcastle University on the low temperature growth potential of a small collection of plants from Moor House suggested that agriculturally useful genetic variation is present in T. repens on the Reserve (Ollerenshaw, 1975; Ollerenshaw and Baker, 1976).

Method.

Eleven sites of T. repens occurrence were chosen for their diversity in soil type, altitude and aspect. A random sample of 50 plants was taken from each site and measurements of leaflet length and stolon internode length were made. In an attempt to identify the factors affecting the distribution and morphology of T. repens, observations and measurements of grazing pressure, sheep behaviour, flowering, associated species, soil type and soil fertility were recorded.

An additional experiment to investigate the effect of removing grazing pressure on morphology was also carried out. Wire cages to cover an area approximately $1m^2$ were placed on sites 1,2,4,5,6 and 9 for a period of 4 weeks.

Results.

Table 1 summarises the information on each site. Measurements of leaflet length and internode length are recorded in Table 2.

Table 1: Site Data.

Site	Grid Reference	Alt.	Aspect	Soil Description	pH	Phosphorus (p) (ppm)	Grazing pressure G.P*
1. Hard Hill Flush	732,330	670m	SE	Peaty gley, over 50cm. deep	5.6	10	high – very high
2. Trout Beck	747,329	565m	S	Shallow, (0-15cm) alluvial soil	6.3	5	high
3. Nine Wells Flush	733,307	730m	N	Peaty gley, over 50cm. deep	6.0	13	low
4. Moss Burn Currick	743,316	640m	NE	Shallow (0,45cm) calcareous soil	5.6	9	high
5. Moss Burn	746,317	615m	NE	Red-brown limestone soil	6.3	5	high
6. Moss Burn Flush	746,315	615m	NE	Peaty gley, over 50cm. deep	6.0	5	low
7. Trout Beck	737,323	595m	S	Shallow (20-30cm) alluvial soil	5.3	5	medium
8. Trout Beck Foot	760,338	535m		Alluvial, very silty soil			
(a) Enclosed area since April 1978					5.5	5	no grazing
(b) Unenclosed					5.4	7	medium
9. Hard Hill	732,330	670m	S	Shallow (0-30cm), red-brown limestone soil	5.4	8	medium – high
10. Old Moor House Flush	741,314	655m	N	Peaty ranker	5.1	12	medium
11. Swath Beck Flush	715,332	685m	ENE	Peaty gley, over 50cm. deep	6.5	3	medium

* Grades are based on observations in the Reserve.

Table 2. Measurements of leaflet length and internode length arranged to illustrate correlation with grazing pressure.

Site	95% Confidence Interval for the $\bar{x}$ of 50 plants (mm)		G.P.	pH	Altitude	Aspect.
	Leaflet length	Internode length				
3	9.7 ± 0.21	14.7 ± 0.50	low	6.0	730m	N
6	7.1 ± 0.25	11.2 ± 0.89	low	6.0	615m	NE
10	7.1 ± 0.27	9.0 ± 0.65	mod.	5.1	655m	E
11	6.9 ± 0.14	10.6 ± 0.59	mod.	6.5	665m	ENE
8a	6.7 ± 0.28	11.4 ± 1.09	low	5.5	535m	-
1	6.5 ± 0.16	7.0 ± 0.32	v.high	5.6	670m	SE
7	6.2 ± 0.14	7.3 ± 0.38	mod	5.3	595m	S
9	5.7 ± 0.17	7.0 ± 0.47	high -mod.	5.4	670m	S
2	5.7 ± 0.19	7.6 ± 0.55	high	6.3	565m	S
5	5.4 ± 0.15	7.0 ± 0.36	high	6.3	640m	NE
4	5.4 ± 0.19	7.7 ± 0.47	high	5.6	640m	NE
8b	5.0 ± 0.19	6.5 ± 0.55	mod.	5.4	535m	-

Except where grazing pressure was least the indigenous population is characterised by small leaved, prostrate plants with small internode lengths. Grazing pressure is the only factor with which plant size can be easily correlated.

The caging experiment was not completely successful. On sites 1,4 and 6 the wire cages were partially flattened and the sheep had evidently been able to graze through the mesh to a small extent. Plants sampled from inside the cage at the end of the 4 week experiment had significantly larger leaves and longer stolon internodes than plants sampled outside the cage at the same time. The magnitude of these differences was approximately correlated with the grazing pressure experienced at each site.

Detailed records of all measurements and observations are available (Collison, 1979) but will not be presented here. Only those items directly related to the discussion will be considered.

Discussion.

It is evident from the measurements of soil pH and phosphorus that *T. repens* is close to its edaphic limits (Snaydon, 1962) on the Reserve and that soil fertility is a major factor limiting its distribution. The data from both the main experiment and the caging experiment indicate however, that grazing pressure is possibly the factor with most effect on morphology.

Evidence from shading experiments with *T. repens* (Mitchell, 1956) suggests that grazing affects plant size through its effect on light intensity and spectral composition throughout the sward. Although actual measurements of these 2 parameters were not made, observation on sward height and site aspect suggest that in Table 2, the sites are arranged approximately in the order of irradiance experienced, with competition for light being greatest on site 3.

Plant size is associated with the balance of red/infra-red light throughout the sward as it is this balance which controls the rates of cell division and elongation (Livermann, Johnson and Starr, 1955). Infra-red light, which is stimulatory, penetrates the foliage to a greater extent than the inhibitory, shorter wavelength, red light (Holmes and McCartney, 1976). Thus cell division and elongation are greater where the sward is denser and taller. Hence the largest plants are found on sites which experience the lowest grazing pressure. Grazing pressure thus appears to mask any effect which soil fertility or exposure may have on plant size and growth habit.

General observations recorded during the course of the study indicate that sheep are an important factor, not only affecting morphology, but also in controlling the distribution by seed and genetic variation of *T. repens*. Notes on sheep behaviour and flowering patterns indicate that, by eating the majority of flower heads, sheep minimise the opportunity for genetic variation through seed set. Most flowering occurs on south facing slopes, a phenomenon which is probably also associated with sheep behaviour. In general, south facing slopes tend to be more heavily grazed than other aspects. Haggar (1962) found that close sheep grazing removes stolon apices and that this results in an increase in flowering. Sheep, however, are not the only factor involved in the question of flowering and seed set. The observations of 1978 are that *Bombus* spp. are but rare visitors to the Reserve so pollination is unlikely.

These observations tend to suggest that genetic diversity within the populations of *T. repens* on the Reserve could be limited. This idea is confirmed by notes made on a collection of plants from the Reserve. Ten plants, collected randomly from each site, have now been kept under the same environment for 6 months. Each "batch" of 10 plants is visibly different from the next but variation within batches is much less evident. Observations on leaf markings and cyanogenic tests on these plants tend to support the view of limited diversity within each site (K. Moore, University of Newcastle upon Tyne; pers. comm). In respect of these observations, further research on flower production and pollination under grazed and ungrazed situations at Moor House would be of interest.

q) Variation in low temperature growth and epicuticular wax production of *T. repens* plants.
(Jill M. Collison, University of Newcastle upon Tyne).

Trifolium repens L. (white clover) is widely considered to be the "ideal" plant for hill-land grazing (Newbould, 1974). The advantages to be gained from *T. repens* are firstly the provision of high quality herbage and secondly the promotion of an effective nitrogen cycle (Munro and Hughes, 1966). Currently available varieties of *T. repens* do however have certain disadvantages in the hill-land environment. Low frost tolerance and poor growth at low temperatures, particularly in the spring and autumn are serious problems. Previous work with a small collection of plants from Moor House has suggested that the T. repens populations on the Reserve contain ecotypes with good growth at low temperature, (Ollerenshaw, 1975; Ollerenshaw and Baker, 1976). It was therefore considered worthwhile to study a larger number of plants collected from the wide range of sites which have been studied and described in the preceding report.

Two plants from each site were included in an experiment to determine growth at low temperatures. Experimental details were as described in Ollerenshaw (1975) and are also recorded with the full results in Collison (1979). Several ecotypes with good growth at low temperature were identified and further field investigations will be made on these plants.

In addition to the study of the low temperature growth potential of these plants, a study of their potential for epicuticular wax production was also made as this has been considered to be an important physiological factor affecting frost hardiness (Hall and Jones, 1961; Banks and Whitecross, 1971). The ability to prevent excessive water loss when the soil is frozen but the transpiration demand high (clear, sunny mornings often follow severe frosts) would be a useful characteristic for upland plants.

The experiment (details in Collison, 1979, B.Sc. Thesis, copy held at Moor House) clearly showed that the potential for epicuticular wax production is related to the probability of experiencing drought stress as indicated by the exposure, aspect and soil conditions of the site of origin. For instance, of the plants tested, those from site 9 (see Table 1 in preceding report) an exposed, well drained, south facing site on limestone had a much greater potential for epicuticular wax production than plants from sites such as 6 and 1. Plants from these relatively unexposed, flush areas are much less likely to experience drought stress.

These experiments have shown that although genetic variation within populations of T. repens on the Moor House Reserve may be limited, there is relatively wide genetic variation between populations. Several ecotypes are of agricultural use and further work at Moor House would be of great value.

c) The effects of sheep exclusion on the cycling of Na, K, Ca and Mg ions of Rough Sike limestone grassland.
(G.A. Ulmanis, Department of Geography, University of Sheffield)

The experiment consisted of studying the cycling of the above ions inside and outside of a newly established exclosure and a long term exclosure, through the soil/plant/animal or soil/plant system. This entailed regular collections of grass, soil, faecal material, leachate and rainwater.

In 1979 the study continued with a series of daily visits at weekly intervals, to primarily collect water and faecal material (and snow in the early part of the year) during mid April to June and mid July to August when the field work was completed.

All samples have been chemically analysed and await statistical treatment.

All the results point to the importance of the grazing animal as a distributor and recycler of ntrients, with large amounts of ions being made available even with water extractions on oven dried material.

The soil cation exchange capacity is high and probably directly related to the high organic matter levels and so varies as organic matter varies, in depth and seasonally.

The input of ions in rainfall is small and variable (and especially small in snow) and the output in leachate, drips and "springs" seems to be relatively consistent, the ion ratio being Ca > Na > Mg > K.

The statistical significance of all the results has yet to be found.

s) <u>Studies of periglacial phenomena.</u>
(L. Tufnell, Huddersfield Polytechnic).

Five of the Reserve's ploughing blocks had their movement recorded for the fourteenth consecutive year. Despite the harshness of the winter, results were very similar to those obtained on previous visits. This reinforces the view expressed on p. 24 of the 1977 report that there is no simple correlation between severity of a winter and rate of block movement.

Table 1. <u>Movement of 5 ploughing blocks on the Reserve between August 1978 and August 1979. Block numbers correspond with those in the 1975 report.</u>

Block No.	Amount of movement recorded (cm.).
1	5.4
2	3.5
3	1.0
4	1.0
5	0.0

t) <u>The effect of barytes quarrying on the invertebrate fauna of streams near Silverband Mine.</u>
(Susan Haile (formerly Susan Dick), Department of Civil Engineering, University of Newcastle-upon-Tyne).

This account is a supplement to the reports made in 1978 and 1977. Further invertebrate fauna samples were taken in May - July 1979 and levels of suspended solids were measured in the streams around the Silverband Mine.

<u>Knock Ore Gill</u>:

Results here still showed no difference in numbers or composition of the fauna in samples taken above and below the entry of the Silverband Hush. This is not surprising since the water from Hush Stream has been entering Knock Ore Gill on very few occasions. Levels of suspended solids in the stream are low (see table 1).

Middle Tongue Beck:

The fauna of Middle Tongue beck now seems to have recovered from the effects of the flood that came down the Mine Stream into Middle Tongue beck following the bursting of the lagoon above the quarry in June 1977. Levels of suspended solids at sites above and below the entry of the Mine Stream were fairly low except on 2 August 1979 when levels of suspended solids at the site below the entry of the Mine Stream were 40 mg/l. This followed a storm and presumably the silt had been washed down the Mine Stream into Middle Tongue beck, from the barytes quarry area.

Silverband Hush Stream:

Levels of suspended solids were fairly high on every sampling date. The fauna of the Hush Stream is still rather restricted, namely chironomids, limnophilid caddis, and *Agabus* sp. beetles, although further down the Hush some stonefly (*Nemurella picteti*) have been found.

The heavy metal content of the silt in the Hush was measured and found to be quite high (table 2). The presence of water beetles and caddis within the first 150 yards of the stream suggests that these metals are not having a toxic effect or that these species are resistant to these levels.

The recent expansion of the lagoon system and the installation of a new pump to recycle water from the lagoon back to the mine has made the possibility of further overflows from the lagoon into the Hush Stream less likely to occur.

Table 1.

Suspended Solids.

Mg/l

		29.5.79	27.6.79	2.8.79	8.8.79
Middle Tongue beck	above	7	1.1	14	4
	below	8	2.7	40	4
Knock Ore Gill	above	2	1.9	6	4
	below	1	0.8	8	4
Mine Stream		-----	32.0	6	8
Hush Stream		106	-----	34	36
Effluent entering lagoon		-----	2187	20540	52

Table 2.

Heavy Metal Analysis.

Mg/g

	Cu	Pb	Zn
Hush Stream Silt	70	40	16.6.

Publication List.

Nelson, J.M. 1978. Observations on the biology of Chrysolina marginata (L.) (Coleoptera: Chrysomelidae). Entom. Gazette 29, 237-43.

Rawes, M. 1979. Botanical species lists for Moor House National Nature Reserve. In: Aspects of the Ecology of the Northern Pennines. Moor House Occasional Paper No. 12, 51 pp.

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Trudgill, S.T. 1979. Chemical polish of limestone and interactions between calcium and organic matter in peat drainage waters. Brit. Cave Res. Assoc. 6, 30-5.

Turner, J. and Hodgson, J. 1979. Studies in the vegetational history of the northern Pennines. 1. Variations in the composition of the early Flandrian forests. J. Ecol. 67, 629-46.

There have been a series of papers using Moor House climatological data and the following have been noted:-

Baldwin, H. and Smithson, P.A. 1979. Wind chill in upland Britain. Weather 34, 294-308.

Crisp, D.T. 1977. Some physical and chemical effects of the Cow Green (Upper Teesdale) impoundment. Freshwater Biol. 7, 107-20.

Green, F.H.W. and Harding, R.J. 1979. The effects of altitude on soil temperature. Met. Mag. 108, 81-91.

Harding, R.J. 1979. Altitudinal gradients of temperature in the northern Pennines. Weather 34, 190-202.

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Manley, G. 1971. The mountain snows of Britain. Weather 26, 192-200.

White, E.J. 1979. The prediction and selection of climatological data for ecological purposes in Great Britain. J. appl. Ecol. 16, 141-60.

Dissertations.

Haile, Susan. 1979. The effect of barytes mining upon the invertebrate fauna of moorland streams. Department of Civil Engineering, University of Newcastle-upon-Tyne.

Collison, Jill H. 1979. Ecological Adaptations of Trifolium repens L. to the upland environment. Department of Agricultural Biology, University of Newcastle upon Tyne.

Staff List.

Officer-in-Charge	M. Rawes
Scientific Staff	R.B. Marsh (until 3rd August, vacant since) Judith Scott
Warden	P. Burnham
Estate Worker	P. Holms
Housekeeper	Mrs. G. Dunn (April - September)
Part-time Warden	J. Rose (November - March)
Honorary Wardens	F. Birkbeck J. Hollington

Meteorological Summary for Moor House 1978 (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	1.2	-0.3	4.2	5.2	12.4	13.2	13.8	13.5	11.9	10.4	7.0	1.4	7.8
Mean min temp °C	-3.8	-4.7	-0.3	-1.1	2.2	5.1	6.2	7.8	7.2	5.5	1.9	-2.5	2.0
$\frac{1}{2}$ (max + min) °C	-1.3	-2.5	1.9	2.1	7.3	9.1	10.0	10.7	9.5	7.9	4.4	-0.5	4.9
Highest max tem °C	4.4	6.2	11.4	11.0	20.9	22.3	19.2	18.7	15.3	16.2	13.4	10.2	22.3
Lowest min temp °C	-12.0	-15.1	-7.5	-10.2	-3.6	-3.6	1.7	0.4	2.6	-1.9	-8.0	-11.0	-15.1
Lowest max temp °C	-3.1	-5.3	-0.6	-0.5	3.1	8.4	9.1	9.7	8.6	5.6	-2.4	-8.1	-8.1
Highest min temp °C	1.5	1.9	3.3	3.2	7.7	9.0	11.5	11.5	11.3	10.0	8.9	5.0	11.5
Lowest grass min temp °C	-17.5	-19.9	-11.4	-15.5	-8.5	-9.6	-3.3	-3.6	-2.9	-6.5	-11.8	-15.5	-19.9
Earth temp 30cm 0900 hr	1.8	1.3	2.4	3.3	6.9	9.7	10.7	11.3	10.3	8.5	6.9	2.7	6.3
Rainfall (mm)	500.0	334.9	297.8	51.9	45.4	54.1	93.9	116.5	264.0	103.0	222.0	263.8	2347.3
Rain days (0.2mm)	27	25	27	16	11	14	19	19	23	22	20	24	247
Wet days (1.0mm)	24	21	23	9	8	14	16	15	23	16	18	22	209
Days snow/sleet	17	15	16	9	0	0	0	0	0	1	5	13	76
Days snow lying	25	28	8	6	0	0	0	0	0	0	6	18	91
Days hail	3	1	6	2	1	0	1	0	0	1	0	0	15
Days snow/ice pellets	1	2	1	1	0	0	0	0	0	0	1	0	6
Thunder	1	0	0	0	0	1	0	1	0	0	0	0	3
Fog	10	9	4	2	2	0	1	1	4	3	3	14	53
Air frost	28	22	18	15	6	1	0	0	0	2	7	25	124
Ground frost	30	26	20	20	15	4	9	3	2	9	13	26	177
Av Daily bright sun (hr)	1.09	1.17	2.08	3.06	6.36	5.42	5.39	3.20	2.18	1.91	1.22	0.48	2.80
Total bright sun (hr)	33.7	32.8	64.5	91.9	197.2	162.7	167.2	99.1	65.4	59.1	36.6	14.9	1025.1
Total snow (cm)	375	352	54	21	0	0	0	0	0	0	4	88	894
Greatest depth snow (cm)	83	83	12	7	0	0	0	0	0	0	4	23	83
Days with gales	4	0	5	0	0	0	1	0	4	1	9	1	25
Solar radiation gm cals/cm²	1650	3082	4833	7343	12165	11424	11234	7243	7692	3029	1451	810*	71956*

* 3 days missed.