MOOR HOUSE

17th Annual Report, 1976

The Nature Conservancy,
Moor House Field Station,
Garrigill,
Alston,
Cumberland.
CA9 3HG.

Dr. K. Taylor
Tel: ALSTON 435

With the Compliments of

Linda

Can you please give the attached report to Jon Hodgson, Manchester

Nature Conservancy Council,
North West Regional Office,
Merlewood Research Station,
Grange-over-Sands,
Cumbria,
LA11 6JU.

Tel: Grange-over-Sands (044-84) 2266

Nature Conservancy Council,
Moor House Field Station,
Garrigill,
Alston,
Cumbria,
CA9 3HG.

Tel: Alston (049-83) 435

THE NATURE CONSERVANCY COUNCIL

MOOR HOUSE

1976

17TH ANNUAL PROGRESS REPORT

M. RAWES

C O N T E N T S

/...

I. GENERAL

a) Introduction

The Report covers the period 1 October, 1975 to 30 September 1976. Apart from the weather it has been a quiet year with less to report than usual.

In common with the remainder of the country a relatively mild winter was followed by the hottest and driest summer we have ever recorded. Weather records are given later in this Report, but the fact that it was possible to walk on the bog for more than 3 months in low shoes (rarely a sensible thing most years on any day) illustrates perhaps the dryness of the ground this summer better than average met. figures. Few bog pools had surface water by early September, but although the peat was dry to the drift level in a number of cases the normally high moisture content of the peat was usually apparent within 30 cm of the surface. Under these circumstances plant growth was either very good, as in the case of heather, or poor, as with some of the lower plants. Flowering was exceptional and so was the abundance of butterflies, ladybirds and greenfly.

b) Reserve Management

The object of providing facilities for ecological research has been under some strain this year due to lack of money for maintenance and repair and to the vacant Scientific Officer post remaining unfilled. This will, in course of time result in very high maintenance and repair costs. However, the danger to health and the need to prevent a complete breakdown resulted in action to remove accumulated silt from the dried up reservoir, the Field Station's water supply, in August. At long last a much needed sluice valve has been fitted, making the periodic cleaning of the reservoir possible in the future.

Repairs to tracks, fences, walls and the buildings generally, occupy much of the Warden's time, as do failure of worn out plant, such as electric generators and grass mower. Thus much work is delayed and some indefinitely postponed.

For the second year running, heather burning was satisfactory and the results were better than normal. A hay crop of good quality was harvested in July, the flowering and seed setting time for most species being particularly well advanced.

Despite constant attention, rabbit damage continues to cause much concern especially with regard to the recently planted trees. The denseness of both the Pasture and Nether Hearth enclosures provides shelter and protection for rabbits that are difficult to control in such circumstances. This year most of the planting of hardwoods has been in smaller enclosures of rabbit proof netting within the larger enclosures; the cost of replacing the original rabbit fencing would be prohibitive. The following trees were planted:- 100 each of Sorbus aucuparia, S. intermedia, and Alnus glutinosa, 180 Alnus incana, 300 Pinus montana and 400 P. contorta. Additionally a few Corylus avellana and nurseryman's "Scotch Elm" were planted and a number of willow cuttings struck. The greater part of the Pasture enclosure and Force Burn lower enclosure are now planted up.

Whilst there has been an increase in the number of visitors using the courtesy route by the River Tees, from Tees Bridge to Cross Fell, the number approaching the Reserve from the north remains small. However, the publication of the English Tourist Board's Northern Pennine booklet has increased inquiries. The advice of the Tourist Board Information Centres at Brough and Appleby has directed many visitors to the west side of the Reserve and the summits in particular. Removal of peat, collecting of plants, exercising of dogs and driving of 4 wheel drive vehicles onto the fell are among the offences committed. Something like half the visitors bring a dog on to the fell and it is usually not under control. Apart from disturbance to wildlife, this is causing concern to the shepherds. However, total prevention of misdemeanour would require large wardening resources.

Very few skiers used Great Dun Fell last winter despite there being snow in the popular gulley on most week-ends. Snow cover generally, however, was very poor and its absence from the west side of the Reserve undoubtedly played a major part in the drop in interest.

The operators of Silverband Mine obtained an extension of planning permission from Cumbria County Council to continue to extract barytes for a further 5 years. The licence is to a restricted area, with improved sedimentation reservoirs and re-cycling processes to prevent the recurrence of last year's pollution of water courses and to the open fell. Extraction of barytes is limited to 150 tons a week.

c) Natural History

The bird species list for the Reserve now stands at 103, with Turtle Dove, Black Redstart, Pied Flycatcher, Garden Warbler, Common Whitethroat and Sedge Warbler added this year.

The Yellow Wagtail has been added to the list of breeding birds, one pair rearing two broods close to the house.

All the regular breeding species had a good year, apart from the Wren, which was well down on breeding pairs, and the Goldcrest which did not breed.

During searches of the Reserve only one fox earth was found and this was at Green Burn Head. The cubs were killed by the shepherds.

Badgers have returned to a sett on the west side of the Reserve.

A Roe Deer was recorded in July among the Bog End trees and low down Green Burn. Willows have been browsed for the second year running, probably by Deer.

Two Butterflies new to the Reserve were recorded: the Peacock was seen on two dates in August and a Camberwell Beauty within a mile of the house, up Rough Sike, in August. The Red Admiral has been very common during August and early September.

d) Survey and Research

Over half the projects undertaken on the Reserve are of a botanical nature but the spread in University involvement remains wide. The main users of facilities are Durham, Edinburgh, Lancaster, Leeds, London, Manchester and Newcastle. Reports of projects are given later.

Dr. Coulson, with Dr. Butterfield, has continued the work by Durham zoologists on moorland invertebrates with the study of factors influencing abundance. The importance of nutrition remains the current theme. They are also making use of Moor House as a site in a wider invertebrate survey (NCC contract) of the northern Counties with comparisons of moorlands at varying altitudes and on differing soils. Robert Beattie (Durham) has finished his Ph.D. work on the ecology of the frog, whilst Dr. Susan Goddard and Martin Randall are starting studies, the former on the biology of Pseudoscorpions and the latter on parasitism in Coleophora alticolella, a moth, the larvae of which feed on Juncus squarrosus (moor rush).

Dr. Whittaker (Lancaster) has an unbroken record of 15 years recording the abundance of Cercopidae, studying frog-hoppers in Juncus squarrosus and Nardus stricta habitats.

Professor Woolhouse (Leeds) has now had a succession of students working on physiological aspects of growth in moorland plants. David Tattersfield has finished his Ph.D. investigation of Sphagnum rubellum, Adam Kwolek, following Michael Ashmore's study of Calluna, presents a seond year report on dormancy in the plant, whilst Ken Robertson has made an early start in looking at Eriophorum vaginatum (cotton grass), often the dominant plant of blanket bog. From London University, Dr. Taylor (University College) has continued with his study of Geum spp. He has retained the autographic weather station at Helbeck, Brough, used last year by Ross Hynes and is obtaining records of solar radiation at Great Dun Fell. Dr. Clymo (Westfield College) has a student, Duncan Mackay, working on Sphagnum, studying the movement of particulates in S. rubellum and S. papillosum. Interest in bog ecology is stimulated by Dr. Tallis's (Manchester) measurements of pool formation and erosion, whilst Patricia Ferguson, supervised by Dr. Lee, is collecting rainwater in a study on the effect of acid rain on Sphagnum, a project centred on the southern Pennines. From Newcastle University a survey by A. Mays, supervised by Dr. Blackburn, has been started on the incidence of disease in upland grasses and legumes, whilst Dr. Ollerenshaw has continued his investigation into aspects of growth in these two groups. The botanical survey of the Pennine scarp and plateau, from Hartside to Brough, nears completion. Dr. Richards has a further year's work. New locations for Alopecurus alpinus (alpine meadow foxtail), Saxifraga hirculus (yellow marsh saxifrage) and Lycopodium alpinum (alpine clubmoss) were found on the Reserve, this year. The rare fern Dryopteris assimilis was found in no less than four 1-Km squares, whilst outside the Reserve boundary Haplodon wormskjoldii and Dicranum starkei, both rare mosses, were located. A brief survey of the Tees above Cow Green Reservoir by Dr. N. Holmes (Durham) found species new to the Reserve and enables a more complete list of algae to be drawn up.

Lowland studies by J. Davies (Nottingham) and J. Waughman (Durham) of the genus Alopecurus were extended to looking at species at higher altitudes and specimens have been taken from Moor House for laboratory investigation.

The F.B.A. Cow Green Section continue to be based at the Field Station and studies on freshwater fauna are made by them on the Reserve.

A. J. P. Gore and Dr. Helen Jones represent I.T.E. in continuing projects on the Reserve. Interest in Moor House by I.T.E. (Merlewood) has not been lost and when the opportunity arises it is hoped that new projects will be put forward. The wealth of information about the Reserve is such that it will be used for many years as a control site.

e) Advice and Education

Residential field courses for undergraduates were run by Lancaster and Durham Universities and day visits continue to be made by Durham Zoology and M.Sc. Ecology parties. Students at all undergraduate and graduate levels use the facilities. An introductory course on bryophyte identification was run for North Region staff in September. Dr. J. Richards of Newcastle University was the tutor. Numbers were made up from other Regions and from ITE, Merlewood. It would appear that 2 day residential courses of this nature, which can be cheaply run at Moor House, meet a demand otherwise unsatisfied and will be encouraged. The facilities of Moor House with hostel, laboratory and field at hand are highly suitable for such enterprises.

II. SCIENTIFIC - Moor House Staff

The preparation and storage of data collected over 24 years has continued. The Reserve Record has been re-organised on a habitat basis and indexed. Together with the notched card system for site information and the respective files, it forms the basis of the data storage system. The completion of input charts for botanical data storage is far from finished, but many of the problems in devising a satisfactory method have been ironed out.

Shortage of staff with field experience has limited the summer programme to the re-examination of two monitoring sites, one measuring the effect of removing sheep grazing from Juncus squarrosus (moor rush) dominated vegetation and the other from Nardus (white bent). Preliminary results are discussed later. Attention continues to be paid to the problems of blanket bog management, the work being concentrated on the effect of burning and sheep removal.

The question of heather burning is of particular importance in the management of blanket bog where for some time there has been, in some quarters, doubt as to its value and the wisdom of the practice. This has recently received official acknowledgement in the recommendation of the Scottish Muirburn Working Party 'A Guide to Good Muirburn Practice' where it is stated that "there is generally little to be gained by burning vegetation types such as flow ground, blanket bog and moss".

Nevertheless, the working party have stressed the need for research, stating "there is a major area of ignorance about the influence of muirburn on the management and ecology of western blanket bog".

It is noted that the Game Conservancy has entered into the field of grouse moor management with a preliminary 18 month survey of heather burning and grazing in relation to the numbers and performance of grouse, other wildlife and hill farming livestock. The survey is being undertaken in Scotland, recognising that there are considerable variations in the environment, current standards of burning, and grazing practices. Blanket bog should therefore receive attention. This makes any small contribution that we at Moor House can make to the subject all the more worthwhile.

The employment of students on small projects within the general programme has proved helpful and the information gained will improve the scope of work now being written up.

To summarise, the Field Station programme covers the following:-

a) Climate - routine recording

b) Vegetation and sheep - mainly botanical recording of sites to measure:-

(i) effect of present day sheep grazing of the open fell

(ii) effect of removal of sheep grazing

(iii) effect of drainage

(iv) effect of burning

(v) effect of different sheep grazing regimes

(vi) numbers and distribution of sheep

c) Natural grassland communities - re-creation and establishment

d) Red grouse - recording of numbers and breeding performance

e) Tree growth and effect on habitats - growth measurements, botanical recording and bird counts

f) Ski-ing - recording numbers and botanical effect

g) Pennine Way - recording numbers and botanical effects

h) Meadow - sample cropping for yield and botanical analyses

Additionally records are taken for the Northumbrian Water Authority (climate and hydrology), Rothamsted Experimental Station (Moth Survey) and assistance given to a number of University research workers and others.

a) Climatology (R. B. Marsh)

The weather summary for 1975 is given in the appendices and observations covering the reporting year are shown below the 23 year mean:-

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Year
Maximum - Mean	9.5	5.1	3.5	2.3	1.9	4.0	7.1	10.7	13.8	14.7	14.6	12.5	8.3
1975-76	9.5	4.9	4.5	3.3	2.7	2.7	6.7	10.1	15.7	17.8	17.5	11.6	8.9
Minimum - Mean	3.7	0.1	-1.7	-2.4	-3.3	-1.7	-0.1	2.5	5.3	7.2	7.4	5.9	1.9
1975-76	3.0	-0.1	-0.5	-0.7	-1.3	-2.5	0.2	3.4	7.9	7.2	6.1	5.9	2.4
Mean - Mean	6.6	2.6	0.9	-0.1	-0.7	1.1	3.5	6.6	9.5	10.9	11.0	9.2	5.1
1975-76	6.3	2.4	2.0	1.3	0.7	0.1	3.5	6.7	11.8	12.5	11.5	8.1	5.5
Earth - Mean	7.8	4.6	2.7	1.8	1.6	2.0	3.8	6.9	9.9	11.5	11.7	10.3	6.2
1975-76	7.5	5.2	3.5	3.4	1.6	1.9	3.9	6.4	10.3	12.8	12.0	9.6	6.5
Rainfall - Mean	186.5	202.7	218.5	193.1	148.1	125.9	120.3	122.0	109.3	144.9	162.9	161.5	1895.7
1975-76	64.7	150.4	111.6	258.1	123.2	130.3	104.0	182.2	50.5	63.2	29.0	228.7	1495.9
Sunshine - Mean	2.54	1.37	0.90	0.96	1.78	2.76	4.07	5.28	5.89	4.57	4.41	3.42	3.16
1975-76	2.67	1.98	1.20	0.52	1.01	2.62	3.28	3.20	7.53	8.16	7.73	2.30	3.52
Air Frost - Mean	4	14	20	22	21	21	16	7	1	0	0	2	128
1975-76	6	18	17	17	20	27	13	3	0	0	0	1	122
Ground Frost-Mean	9	18	22	25	24	24	20	13	7	4	3	6	175
1975-76	15	24	25	20	25	29	18	8	2	9	16	9	200
Snow lying - Mean	0	5	11	16	16	12	5	1	0	0	0	0	66
1975-76	0	2	2	9	12	16	3	0	0	0	0	0	44

October and November had mean temperatures /½ (maximum + minimum)/ similar to the monthly average for the Climatological Station (1952-75), while December, January and February had temperatures at least 1°C above average. December, with only 2 days of snow lie, gave us the lowest record for this month. In February ice formed a thick covering on everything, including vegetation, for approximately 8 days of low temperature and fog.

March was cold with a mean temperature of 0.1°C which is 1.0°C below average. Temperatures and hours of sunshine were also below average, whilst air frost, ground frost and days of snow lying were all above average. April and May were average months.

June, July and August were in each case the driest we have recorded, and the total rainfall for the three months was only 142.7 mm (5.7 ins) compared with the average of 417.1 mm (16.7 ins). Earth temperatures in July averaged 12.8°C, the highest ever recorded. In contrast August, although dry, had the greatest number of ground frosts with 16 days compared with the average of 3 days. August was also the sunniest we have recorded with 7.73 hours of sunshine a day.

September brought further differences. The mean temperature was 1.1°C below average, 60 mm (2.4 ins) more rain fell than average and there were 3 days more ground frost than usual.

Although it has been a year of contrasts the 12 monthly records are not far short of normal. Temperatures were similar, but rainfall was 400 mm (16ins) below average and days with snow lying were only 44 days, one third less than average.

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

This project depends on the regular monitoring of the botanical composition of some 17 sites, representative of the more common vegetation types of the Reserve. Surveys supplement the site data.

Effect of present day sheep grazing of the open fell

The idea that the vegetation of hill land is static, in equilibrium with the environment and therefore unchanging, is a view widely held. However, evidence from our long-term plots suggests that this is far from being so. Vegetation is dynamic and although changes may only be detectable by careful analysis in the short term, clearer trends are becoming apparent on the Reserve within a period of 10 years. These changes, if continued, will be visually obvious in say 50 years time. Why they should occur is not fully understood. Factors of climate, soil impoverishment, changes in grazing management, and vegetational cyclic development, are all important, But, as in most ecological situations, the interaction of factors is likely to be more important than any single one. Nevertheless, we cannot afford to neglect the importance of the grazing animal and given the staff resources a resurvey of sheep grazing patterns should have priority in 1977.

This year two swards, Juncus squarrosus and Nardus stricta dominated grasslands, are being examined. The botanical composition of both were first recorded on permanent grids 9 years ago. In 1966, the average sheep grazing pressures on these swards were recorded as 0.5 and 1.4 sheep/ha respectively. It is suspected that overall sheep numbers have dropped since then, but a brief survey (see M. Randall) this summer did not confirm this. However, preliminary analysis of the botanical results shows that the swards have altered (see also J. Whittaker's report) in a manner suggesting a reduction in grazing pressure.

Effect of different sheep grazing regimes

Work on the trial to measure the effect on blanket bog of different grazing regimes has been reduced to maintaining the grazing regime on the most heavily grazed plot, where the stocking rate approximates to 4 sheep/1 ha/annum. No botanical monitoring has been done, but the same variety of plant invasion specified last year has been observed as well as an increase in young heather plants.

Effect of removal of sheep grazing

Detailed analyses of the botanical composition of Juncus squarrosus and Nardus stricta dominant grasslands enclosed 9 years ago are being made. A vertical stratified point quadrat method enables cover, structure and sward density to be described and comparisons to be made with the grazed situation. In the first sward the previously recorded trend of Juncus squarrosus itself diminishing has continued, but a corresponding increase in Eriophorum vaginatum cover is more marked than before. A move to vegetation akin to blanket bog can now be seen more clearly. The mat of plant material is inhabited by numerous voles whose tunnelling and grazing activities can be seen.

In contrast to the Juncus sward, the changes in Nardus are less, although the mat of litter is similar.

Continuing last year's studies of the blanket bog, Jon Graves (Westfield College, London) has been examining Sphagnum rubellum in enclosed and grazed vegetation for structural and growth differences, whilst Heather Mallory (Edinburgh) has been looking at lichens. Last year, although differences in bog composition were recorded, the results of lichen cover were contradictory. Jon Graves has found that although the mean capitulum density of Sphagnum rubellum was higher in the ungrazed bog, the difference was not significant. But there is likely to be a relationship between Calluna cover and structure, and the possible growth of Sphagnum under the canopy. This is being examined further. The lichen study supports previous measurements in showing how very variable lichen distribution is, and non-significant differences between treatments were found. Considerable difficulties were discovered in making comparable measurements of lichen performance. In the case of Cladonia impexa, the most common lichen, significant differences were found in the distances between branching, the greater distance in the enclosed lichen suggesting that growth was better in the absence of grazing.

Reports of both these investigations will appear in the Reserve Record.

From past observations there is evidence that sheep grazing prevents many plants and trees from becoming established on the Reserve. Therefore a survey of the potential for natural colonisation should indicate some of the possibilities. Jonathan Hodrien (University College, London) undertook this survey, searching likely sites, such as molehills, exposed river banks, shingle, made ground, limestone outcrops, bare peat and sheep-proof exclosures, and taking soil samples for seed germination trials.

The most promising feature of the survey, which was restricted to a 2 mile radius of the Field Station, has been the number of willow seedlings found. 15 seedlings of Salix cinerea ssp. atrocinerea were found by the Tees, and others found in Troutbeck and Force Burn. Over 40 willows are known to be growing in sheep proof enclosures, the largest shrub having attained a height of over 2 metres. Other tree/shrub seedlings that have been found include Betula spp., Fraxinus excelsior, Pinus sylvestris, Prunus padus and Crataegus monogyna. Thus the potential for shrub development below 2000 ft. O.D. looks good. A copy of Hodrien's report is in the Reserve Record.

Effect of burning

The Hard Hill burning trial was started in 1954, since when the burning regimes of short rotation (burning every 10 years) and long rotation (burning every 20 years) have been applied to grazed and protected plots. These plots present good opportunities to measure change. This year it was appropriate to have Richard Hobbs, who had surveyed a range of different aged burnt plots in 1975, make a number of measurements, two years after the last burn when both long and short rotation plots were burnt. He was able to record the effect different treatments were having in the recolonisation and subsequent performance of the major plant species. The following plants were studied:-

Calluna vulgaris	a) Seedling establishment b) Amount and performance of vegetative regrowth
Eriophorum vaginatum	Numbers of tussocks, basal area and flowering performance
Eriophorum angustifolium	Numbers of shoots and flowering performance
Rubus chamaemorus	Numbers of shoots and fruiting
Empetrum nigrum	Numbers of shoots

Significant differences were found in many of these measurements and the results will be used in an account on botanical changes in blanket bog. A copy of the report on the study will appear in the Reserve Record.

Number and distribution of sheep

Martin Randall (Durham University) undertook a project to record the total number of sheep on the Reserve in July - August, the location of flock territories (heafs), number of flocks, and the different breeds and crosses involved.

28 census areas were selected, covering in total 370 ha of the Reserve, from the western boundary to the Tees. The variation in sheep density over the Reserve is great, but as previously shown, is related to habitat. Thus no sheep were recorded on a 30 ha blanket bog area, whilst small Agrostis dominant grasslands averaged 22 - 54 sheep/ha.

The census areas were used as representative of the different vegetation types present and by applying the data of Rawes and Welch (1969) on the extent of these, it was estimated that 9800 sheep (ewes, shearlings and lambs) were on the fell during the 3 week period of the census.

20 different flock markings were identified, but the period of survey coincided with a time of disturbance when sheep were gathered for clipping and drafting. The chances of error or omission during these occasions were high.

Except for one flock of Rough Fells, the ewes were all Swaledales, but many of the lambs were found to be crosses. In four flocks grey-faced lambs accounted for up to 5% of the lamb crop, whilst 20, 60 and 80 - 90% grey-faced lambs respectively were recorded in three other flocks.

c) Natural grassland communities (M. Rawes and Linda Teasdale)

Flowering in the Rough Sike enclosure was again prolific, but the drought in late summer has killed a number of introductions.

The general impression is one of plants such as Alchemilla alpina, Silene acaulis, Saxifraga oppositifolia, Hypericum pulchrum, Pinguicula vulgaris, Sedum roseum and the native Primula farinosa being crowded out by the dense growth of grasses and other species, such as Alchemilla glabra. Polygonum viviparum is not competing in some of the stations, but has spread rapidly elsewhere in the enclosure.

Plants which have seeded successfully and have spread elsewhere are Potentilla crantzii, on the grassy ledges, Saxifraga aizoides in the rock crevices and streamsides, and Angelica sylvestris, which has more than 30 seedlings from a plant that flowered 6 years ago, established in the enclosure. Angelica may well increase further in the future as another plant has flowered this year. Sesleria caerulea has spread through much of the enclosure.

Thalictrum alpinum, Saxifraga oppositifolia, Luzula sylvatica and Parnassia palustris were affected by the drought, the latter seeming to have disappeared altogether after producing one flower bud.

In spite of these conditions, flowering was exceptionally good, one plant of Saxifraga oppositifolia flowered twice, once in March and again in July.

The trees introduced in 1974 and 1975 have done well, the Rowans producing flowers and fruit. Myrica gale has grown well in flush and wet ledge habitats; all plants produced catkins in the Spring. Andromeda polifolia and Vaccinium oxycoccus both disappeared in the drought. Salix phylicifolia cuttings introduced in 1975 have all become established.

On Little Dun Fell only one introduction, Salix herbacea, is left alive, but it seems to be doing well. Alchemilla alpina remains successful on Knock Fell where the Salix bush produced catkins in the Spring. On Hard Hill one plant of Solidago virgaurea is left alive.

d) Red Grouse - Moorland Management
(M. Rawes, R. B. Marsh and P. Holms)

Overwinter and until a series of unique weather combinations occurred in late February, the heather was in excellent condition following the good growing season of 1975. Severe ice glazing, due to high humidity, zero temperatures and wind, almost totally destroyed the heather green leaf over the whole Reserve. Although this provided an excellent medium for the heather burning programme later, the Spring food for the breeding grouse population was severely curtailed and a poor season was at that time forecast. In the event this was incorrect as the report below shows.

In the management project, now in its third year, narrow burns, of good result, were obtained on the Green Burn and Hard Hill census areas. In the 3 years of this project over 100 burns have been marked accurately on the ground and recorded on a map.

Grouse counts were repeated by Phil Holms and a number of chicks were marked. His report follows:-

The study of the Red Grouse population has continued with counts of the adult breeding birds in Spring, numbers of nests, clutch size, hatching success and a count of birds in August to establish breeding success. The effect, if any, of a programme of heather burning is in its third year, but the results from this management will not be known for several more years.

The weather during the breeding season was very good this year. Frosts during May and June were well below average and only half the normal rainfall occurred during June.

This season follows a year of moderate Spring numbers with a fair young to old ratio in the Autumn.

The Study Areas

The four main study plots were monitored this year and also the more recent Hard Hill and Green Burn areas, the latter covering approximately 70 hectares in total. Study of the grouse population was limited to these eight diverse areas of 141 hectares. The study areas vary in elevation between 500 and 600 metres.

Results

Good conditions during the 1975 breeding season led to a slightly higher Spring population of 0.69 birds per hectare this year as shown in Table 1. There was considerable movement during the early part of the year. Some areas carrying relatively large numbers of birds, while others were almost deserted. Though the overall picture was one of normality, the distribution was most unusual. The heather on some areas was slow in its early growth and this may have been a contributing factor.

Table 1 Spring density of grouse per study area at Moor House 1976

Site	Area	No. of adults	Birds/hectare
Bog End	10.2 ha	8	0.78
Burnt Hill	20.3 ha	14	0.69
The Drive	20.2 ha	13	0.64
Hard Hill 2	14.0 ha	7	0.50
Hard Hill A	21.2 ha	14	0.66
Hard Hill B	24.5 ha	16	0.65
Green Burn A	15.6 ha	12	0.77
Green Burn B	14.7 ha	12	0.81
		Average	0.69

Nesting

This year a total of twenty nests were located on the main study areas. One nest was predated by black headed gulls on the Hard Hill 2 census area, but all others hatched successfully (95%).

The earliest hatching date was 16 May, though most birds hatched around the 22 May, rather earlier than usual.

Clutch size was high this season, an overall average of 8.8, as shown in Table 2, compared with 6.7 in 1975 and only 5.4 in 1974. All nests studied showed the same high hatching success.

Table 2 Estimation of clutch size

Area	No. in clutch	Total	Average/site
Bog End	8	8	8.0
Burnt Hill	8,10,7	25	8.3
The Drive	9,10	19	9.5
Hard Hill 2	11	11	11.0
Hard Hill A	8,8,8	24	8.0
Hard Hill B	7,9,7	23	7.7
Green Burn A	7,10,10	27	9.0
Green Burn B	8,9,8,7	32	8.0
	Total number of eggs	169	
	Overall clutch average		8.8

Chicks

Heavy rainfall occurred during the latter part of May when the majority of the chicks were less than a week old. This did not prove to be too harmful, as most of the broods were of a good size at fledging time and numbers were high. The major predator of grouse chicks, the black headed gull, was less numerous this year, probably due to control activity at their breeding grounds.

Chick ringing

In order to gain more information on the movement of grouse, a number of chicks was ringed this year. The chicks were found by the pointer and flushed into nets. Plastic expandable pigeon rings were used from this stage when the chicks were ten days old until they were about six weeks old and could not be caught easily. All chicks were aged accurately using the primary moult and development method (Raymond Parr, 1975).

Table 3 Replicated counts to estimate breeding success

Area	Adults	Young	Young/Old	Av./Area
Bog End	3	9	3.0/1	3.2/1
	3	10	3.3/1	
The Drive	8	20	2.5/1	2.5/1
	6	15	2.5/1	
Burnt Hill	4	12	3.0/1	2.8/1
	7	18	2.6/1	
Hard Hill 2	2	7	2.3/1	2.5/1
	4	11	2.8/1	
Hard Hill A	3	10	3.3/1	3.3/1
	5	16	3.2/1	
Hard Hill B	4	11	2.8/1	2.9/1
	4	12	3.0/1	
Green Burn A	5	13	2.6/1	2.6/1
	5	13	2.6/1	
Green Burn B	5	15	3.0/1	2.8/1
	8	21	2.6/1	
			Overall average	2.8/1

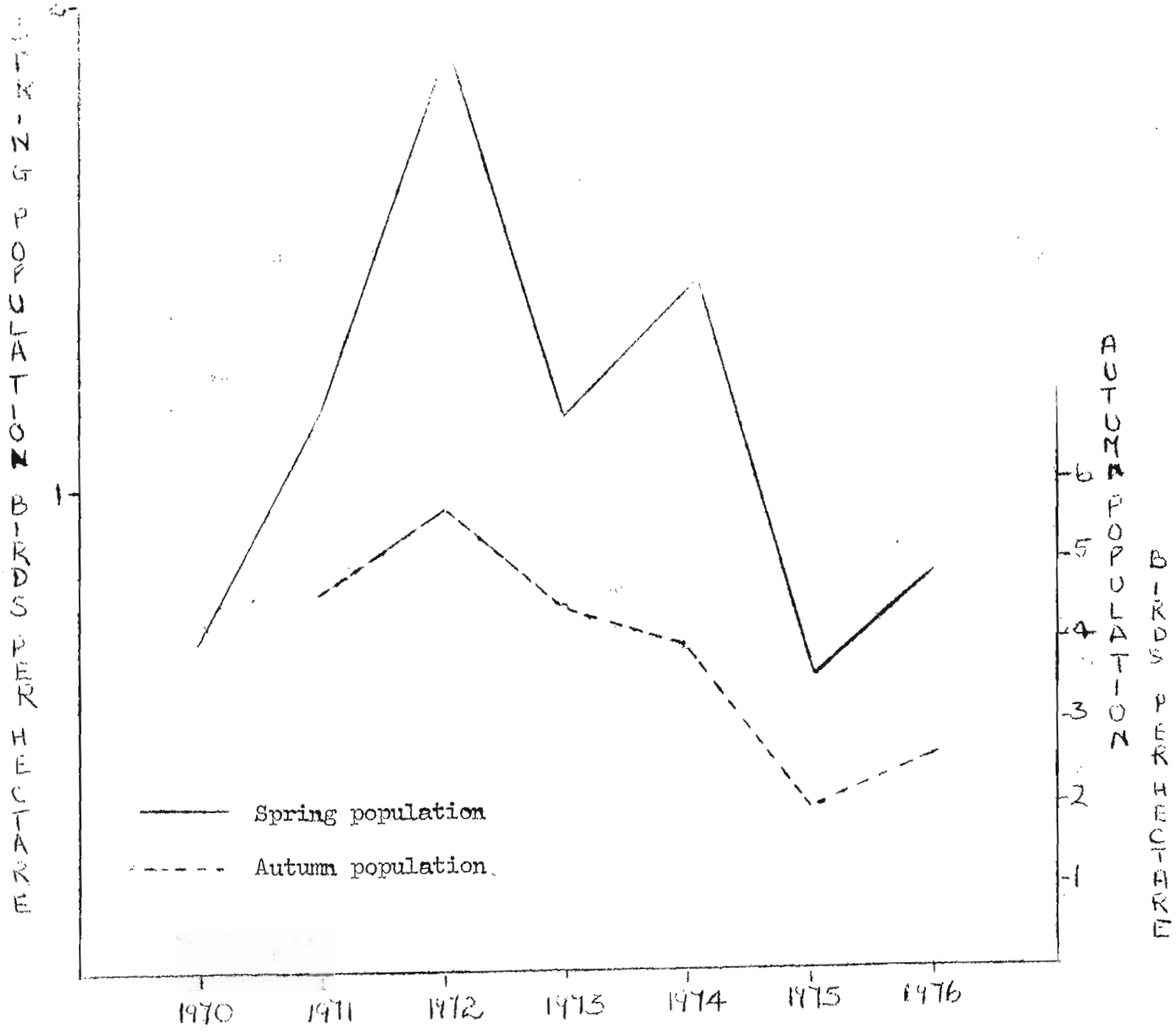
Breeding Success

Results of the August counts are shown in Table 3. The young birds were well grown and in good condition. On each of the eight study areas two counts were made to assess the ratio of young to old birds. The overall ratio of 2.8 to 1 is high and compares well with last year (2.2 to 1).

Conclusion

The weather this year has been excellent and the grouse have reflected this in their breeding performance. Though the number of breeding birds in the Spring was low, nesting went well and the large broods led to a high August population. Large numbers of hatching insects formed adequate food supplies for the young chicks this season. The heather was in good condition by late Spring when young growth is so essential for the breeding birds.

Density of Grouse
Moor House National Nature Reserve



e) Tree growth and effects on habitats
(M. Rawes, R. B. Marsh and Linda Teasdale)

The weight of ice and force of wind (see reference to heather above) caused considerable damage to trees in February, especially to the Lodgepole Pines (Pinus contorta) in Nether Hearth enclosure. A number of trees were bent over so that their leaders touched the ground and the main stems of 19 broke at a mid-way point. Apart from this it has been a good year with excellent growth: increments of over 60 cm have been noted.

A preliminary trial of 11 Sitka spruce provenances was started near Bog Hill in conjunction with the Cumbria Agricultural and Forestry College. The provenances originate from Alaska, Washington, British Columbia and Oregon. By Autumn 50% of the trees had lost their leading shoot, grazed by the larvae of the moth, the Northern Eggar.

Partricia Holmes (Edinburgh) undertook a study on measuring the performance of Scots Pine in relation to habitat. The work was carried out in Green Hole enclosure and a copy of her report is in the Reserve Record.

Site measurements were of vegetation, soil type, peat depth, aspect and exposure and measurements of performance were of top height, annual increment (1969-76), needle dry weight, % dead branches in last 15 years, needle retention, presence of original leader, growth form and frost damage.

The results (see Table 3) showed that the best increment was obtained from the mineral soils and shallower peats and that needle weight was greatest from trees on limestone soils where the vegetation is predominantly Agrostis spp.

Table 3

Vegetation	% typical growth form	% presence of original leader	% Dead branches	100 $\bar{x}$ needle dry wt.	Increment last 7 years	Height
Calluna, sheltered	13	6	19	1.4g	39 cm	1.8 m
Calluna, exposed site	21	28	20	1.3g	93 cm	1.8 m
Deschampsia flexuosa	47	65	16	1.5g	129 cm	2.2 m
Other grassland (Agrostis)	48	43	14	1.7g	152 cm	2.3 m

Miss Holmes showed (see Table 4 below) that the steady increase in increment with age was checked in 1975, a year of late frosts and drought in June.

Table 4

	1969	1970	1971	1972	1973	1974	1975	1976
Annual mean increment (cms)	10.3	11.4	12.8	13.9	14.1	16.3	13.0	16.8
Days of frost, May & June	10	4	9	2	9	8	16	3

III RESEARCH BY THE INSTITUTE OF TERRESTRIAL ECOLOGY

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

1. Factors limiting plant growth on peat

Although final work on the Molinia caerulea transplant experiment has been held up owing to new duties, modifcations and improvements to the draft, suggested by colleagues, have been incorporated.

2. Erosion reclamation

A second set of measurements, the 10 year stage, were made at Moor House (Troutbeck site) and at Longdendale in the Southern Pennines in August. Point quadrat records were taken at points corresponding to those taken in 1972. There are nine higher plant species colonising the previously eroded peat at Moor House, but none apart from the original Deschampsia flexuosa at Longdendale. The mosses and liverworts collected from both sites await confirmation. The Salix caprea bushes continue to thrive and in some cases are getting excessively subject to wind effects. Bushes which failed to attain a certain height quickly initially, are subject to grazing, presumably by grouse or hares, as sheep are excluded. Some bushes have assumed a prostrate form of growth.

3. Water balance studies

At the completion of their calibration period one of the pair of automatic weather stations was removed from Moor House in November, 1975, and installed at Holme Moss in the southern Pennines. By arrangement with the N.C.C., the B.B.C. and with Manchester University, records have been obtained from both Moor House and Holme Moss since that date. Difficulty with solar records has been experienced, however, due to R.F. interference from the television transmitter itself. It is hoped that these difficulties have now been overcome.

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

The project is an experimental attempt to compare the growth of Festuca ovina and Agrostis tenuis in pure stands and in competition with each other.

A preliminary experiment in which the two species were grown together in a 1:1 mixture and as monocultures indicated that, under greenhouse conditions, Agrostis tenuis is more vigorous and will exclude Festuca ovina in mixtures. Festuca is able to produce a greater number of tillers than Agrostis when grown in monoculture. Two populations of Agrostis were compared, one from Moor House and the other from Windermere. The latter was more vigorous, both in monoculture and with Festuca.

In a current experiment the two species are being cut at two weekly intervals, and the growth of the cut plants in mono and mixed culture compared with their behaviour when uncut. Several harvests are being made to study the dynamics of the species interactions over two growing seasons.

IV. RESEARCH BY THE FRESHWATER BIOLOGICAL ASSOCIATION

a) Studies on freshwater fauna - fish (D. T. Crisp)

The routine fish surveys in Force Burn, Crook Burn and Greenhurth Sike have now been completed. Most of our fieldwork is now concentrated at Cow Green, though visits to the Tees and its tributaries within the National Nature Reserve will be necessary each autumn in order to examine the distribution of spawning trout from the reservoir.

The thermograph at Tees Bridge has now been removed and the results have been used in a paper (in press) on physical and chemical changes caused by the Cow Green impoundment. We are grateful to the Moor House staff for their invaluable help in obtaining these data.

Preliminary studies of fish populations in Knock Ore Gill and Swindale Beck during 1973 (see Annual Report for 1973) were followed by more intensive work in Knock Ore Gill during 1975. The data have been processed and the results are now being written-up for publication.

V. RESEARCH BY UNIVERSITIES

a) A study of the factors influencing the abundance of invertebrates on blanket bog

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

The investigation of the effects of enriching blanket bog with ammonium nitrate (1 gN m^{-2}) and 'super phosphate' (0.5g P m^{-2}) on the invertebrate fauna has continued.

The numbers of the two commonest enchytraied worms, Cognettia sphagnetorum and Cernosvitoviella briganta, increased appreciably on the nitrogen fertilised areas. The changes in numbers of larvae of the cranefly, Tipula subnodicornis, were small and not significant but there were marked changes in the average weight of larvae and in the mean fecundity of the adult females. The numbers of eggs rose from 190 to over 270 per female on the nitrogen treated areas. In addition, significant increases in the numbers of Diptera other than T. subnodicornis, beetles and springtails were recorded.

In general, the effects of phosphorus on the fauna were small and not significant. However, on one occasion, a significant decrease in enchytraeid numbers was recorded.

The fertilised areas have also been used as a source of fertilised litter in the continuation of the litter bag experiments described in the 1975 Moor House Report. Control plant material showed no significant change in decomposition rate when placed on the different fertilised areas of the blanket bog. However, plant material that had been enriched with nitrogen showed a higher percentage decomposition than the control material when placed on unfertilised areas of blanket bog. The addition of phosphorus had the effect of enhancing the decomposition of Eriophorum vaginatum but of depressing that of Sphagnum. These differences are summarised in Table 5.

In addition, experiments comparing the percentage decomposition of selected plant material on alluvial and peat soils are being carried out.

Table 5 Percentage weight loss of fertilised litter on control sites (n = 15).

Vegetation in litter bag	Fertiliser enrichment	Percentage loss (dry weight)	Difference from control	't'(based on paired samples)
Eriophorum vaginatum	Control	26.4 ± 0.9	-	-
	N	30.5 ± 1.5	+4.1	2.63*
	P	29.1 ± 1.1	+2.7	2.44*
Calluna vulgaris	Control	35.6 ± 1.1	-	-
	N	38.0 ± 2.2	+2.4	0.97
	P	34.1 ± 1.3	-1.5	1.24
Sphagnum	Control	18.4 ± 2.7	-	-
	N	26.1 ± 3.6	+7.7	2.07
	P	4.2 ± 3.6	-14.2	3.68*

* $P < 0.05$

Fluctuations in the density of Tipula subnodicornis

In the study outlined above the population densities of fourth instar Tipula subnodicornis larvae were monitored at Bog End. In autumn 1973 the numbers ranged from 88 m^{-2} on Juncus squarrosus sward to 160 m^{-2} on the blanket bog while in 1974 they ranged between 111 and 205 m^{-2}. These exceptionally high densities (from 1969 to 1972 the autumn larval densities on the same areas never rose above 60 m^{-2}) were followed by a drastic decline in numbers in 1975. Autumn sampling indicated densities of less than 5 m^{-2} and very few adults emerged in the spring of 1976.

The decrease in numbers coincided with an exceptionally dry summer and it is suggested that, as in the 1955 population crash observed by Coulson, the first instar larvae hatching in late June and early July failed to survive.

b) The effect of altitude on the ecology of the frog(Rana temporaria)

(R. C. Beattie, University of Durham)

A study was made of the adaptations in the breeding biology of frogs inhabiting high altitude moorland regions.

In the three years of study, spawning was always later at higher altitudes. In 15 ponds ranging in altitude from 61 to 838 m, the date of spawning in days after 1 January (y) was related to altitude in metres (x) by the following relationships;

1974 Spawn date, $y = 0.051x \pm 59.5$ $(r = +0.8512)$

1975 Spawn date, $y = 0.076x \pm 55.3$ $(r = +0.8635)$

1976 Spawn date, $y = 0.06x \pm 65.2$ $(r = +0.8769)$

By delaying spawning the eggs of moorland frogs are less likely to encounter lethally low temperatures.

The eggs from highland frogs (those inhabiting areas above 400 m) were found to develop significantly faster at a given constant temperature than the eggs from lowland frogs (Table 6).

Table 6 The Mean time $\pm$ IS.E. taken by the eggs from frogs caught in lowland and highland ponds, to develop from the appearance of the furrow of the first division to the initiation of gill circulation. A batch of 20 eggs was taken from 15 lowland frogs and 14 highland frogs, and cultured at 6°C.

	Eggs from lowland frogs	Eggs from highland frogs
Mean time $\pm$ IS.E. (hours)	606.0 $\pm$ 3.07	579.4 $\pm$ 0.97
(n)	(15)	(14)

The difference in mean time $\pm$ IS.E. is 26.6 $\pm$ 3.32, $t = 8.02$, with 27 degrees of freedom, $P < 0.001$.

A fast rate of development will reduce the time frail immobile embryos are exposed to the risk of desiccation and extreme temperatures. The increase in the rate of development in highland embryos, however, is only about four percent.

Highland frog embryos were able to tolerate lower developmental temperatures than lowland embryos (Table 7). This may increase the chances of frog embryos surviving in highland ponds.

Table 7 The mean temperature ± IS.E. at which 50 per cent of the eggs from lowland and highland frogs developed normally to the initiation of gill circulation. A batch of 20 eggs was taken from four lowland frogs and five highland frogs.

	Lowland eggs	Highland eggs
Mean temperature ±	3.8 ± 0.29	2.8 ± 0.28
(n)	(4)	(5)

The difference in mean temperature ± IS.E is 1.0 ± 0.41, $t = 2.42$, with seven degrees of freedom, $P < 0.05$.

The swelling of the gelatinous capsule surrounding the embryo, was found to be inhibited more in some pond waters than in others. The larger the capsule the better it will insulate the embryo from fluctuating environmental temperatures. The main factors affecting the swelling of frog egg jelly were found to be the nature, concentration and valency of the ions in the pond water. There was some evidence to suggest that highland frogs chose to spawn in ponds which favoured the swelling of the gelatinous egg capsule.

Observations suggest that, compared with lowland frogs, those frogs from higher altitudes tend to spawn in the shallow regions of a pond. This may be a further adaptation, allowing the maximum use of solar radiation to hasten development.

c) Studies on upland Homoptera
(J. B. Whittaker, University of Lancaster)

In this long-term study of several Homoptera species, populations have been sampled on 12 occasions since the last report (September, 1975).

Strophingia ericae (Psyllid on Calluna)

Direct comparisons of population density are now possible for almost all the years 1968 to 1976 inclusive.

It is convenient to summarise densities of S. ericae in winter when recruitment has ceased and the overwintering population of 2 overlapping generations is suffering very little mortality and moulting is not taking place. Comparable figures are as follows:-

Year	No./100 g Calluna ± S.E.
1969	4090 ± 137
1970	383 ± 39
1971	243 ± 16
1972	..

1973	119 ± ?
1974	237 ± 24
1975	277 ± 52
1976	578 ± ?

The two overlapping generations can be separated by our study of instar composition and a k-factor analysis will be made.

Cercopidae

Neophilaenus lineatus has now been monitored since 1961 on the Juncus squarrosus site at Bog End. Of particular interest this year was the extremely high mortality between 5th instar and adult stages.

Philaenus spumarius

An isolated population of this polymorphic species was studied in 1962 and 1963 when it was not very abundant. High densities this year have provided an opportunity for more detailed consideration of morph frequencies.

Cicadellidae

A vegetation analysis of the J. squarrosus site conducted in July 1976 showed a considerable change from one conducted in 1962. The most significant change was a marked increase in the percentage cover of Deschampsia flexuosa from a Domin scale of < 1 to 6.

The effects of this on the Cicadellidae are under investigation.

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

A field experiment was set up on 1 July 1976 to assess the response of potted seedlings to climatic conditions during the growing season. Seedlings were raised in a standard potting compost from seed collected in 1973 at Green Hole (Geum rivale) and near Helbeck Hall, Brough (Geum urbanum). Groups of twenty plants of each species were placed in the rabbit proof exclosures described in previous reports (1974-75) within an altitudinal range from 800 -2,450 ft.

The plants will be sampled in October, 1976, but examination of the plants during the past few months suggest that growth of the two species has been good at all altitudes during the exceptional weather conditions.

The results of germination experiments show that for seed of Geum rivale the Moor House Meadow and Green Hole populations respond to temperature over the range 13-35°C whereas Geum urbanum (Helbeck Hall) responds over the range 13-29°C.

e) A physiological study of Sphagnum rubellum in relation to microclimate (D.M. Tattersfield, University of Leeds)

Field work this season has involved measurement of photosynthesis using a similar technique to that described by Ashmore in the 13th Annual Report. The terminal capitula of a number of plants are arranged on a copper tray and kept moist by a layer of wet cotton wool. The plants are enclosed in a chamber and exposed to a mixture of ^{14} - carbon dioxide in air for 3 minutes after which they are rapidly frozen to present subsequent respiration of fixed $^{14}CO_2$. On return to the laboratory the samples are dried, weighed and combusted using a tissue oxidiser, the resultant $^{14}CO_2$ being absorbed and mixed with a suitable scintillant. The amount of $^{14}CO_2$ fixed by the samples is then determined by counting the solutions in a scintillation counter.

Data collection was hampered during the summer drought, as almost all the Sphagnum in the vicinity of the study site was completely dry and incorporation of $^{14}CO_2$ extremely low. Plant surface temperatures during this period were consistently above $40^{o}C$ during the greater part of the day. However visual recovery of Sphagnum was very rapid after rain and it is hoped to continue measurements into October.

Parallel with field measurements, photosynthesis was measured in the laboratory using an infra red gas analyser over the range of conditions experienced in the field.

It is hoped to summarise the results obtained from the work described above in the next Annual Report.

f) Dormancy and overwintering in Calluna vulgaris (A. Kwolek, University of Leeds)

The object of the study is to investigate overwintering and the onset of dormancy in Calluna vulgaris on a blanket bog at Moor House.

In autumn, there is a rise in the sugar content of the shoots, concurrent with a decline in photosynthesis, and the buds become dormant. The winter bud of Calluna is open ie. special bud scales are absent. A primary objective is to investigate whether the increase in sugar content of the shoots, and the state of winter rest with the onset of autumn is induced by low temperatures or short day length, or a combination of the two. This is being investigated using controlled environment rooms.

While these experiments are in progress the nature of dormancy in Calluna is being followed with particular reference to influence of endogenous inhibitors of growth such as abscisic acid.

Experiments have so far shown that the "depth" of dormancy, as judged by time taken to bud burst on bringing into a warm growth room decreases from November till April (although data are incomplete before November). It has also been shown that dormancy can be induced by low temperature alone, under a long photoperiod, and also that heavy pigmentation takes place under low temperatures, although this is a temperature/light interaction since the light facing surface of the shoots shows greater leaf pigmentation.

The experiments on induction of dormancy by short photoperiod are incomplete although it appears that opening of flower buds is inhibited by short day length.

Given a long photoperiod (18 hour) and an adequate temperature for growth, Calluna will grow throughout the normal winter rest period, suggesting that dormancy is induced by external environmental factors.

Experiments on abscisic acid are incomplete at this stage, and work is also progressing to investigate whether dormancy can be induced by exogenous application of abscisic acid.

Conclusions

The controlled environment experiments should eventually show the inter-relations between short days and low temperature in inducing a dormant state, and secondly we should soon know whether abscisic acid is present in Calluna vulgaris, and whether it exerts a role in dormancy, as it does in many deciduous species.

g) Pool systems in blanket peat (J.H. Tallis, University of Manchester)

A permanent quadrat 30 x 20 m was set up on Shaft Hill in August 1975 to cover two large permanent pools and the heads of three gully systems, to monitor possible long-term changes towards erosion of the pools by extension of the gully heads. The quadrat has been mapped and levelled, and a series of 33 water-table pits is under periodic observation. Water-table levels in different parts of the quadrat differ considerably and it is probable that the surface peat layers are very heterogenous in their ability to conduct water laterally. It is hoped from the water level changes in the pits to be able to recognise lines of preferential water flow laterally in the surface peat layers, which might influence future development of the pools and gullies. Little progress has been made on this aspect because of the exceptionally dry summer. It is hoped also to study the development in the past of the present-day pool system through examination of a series of peat stratigraphic profiles.

h) A study of the movement of solutes and particles through the surface layers of peat bogs (D.J. MacKay, Westfield College)

These experiments, which have been started on Burnt Hill, are being performed in conjunction with others at Cranes Moor in the New Forest. Tracer substances have been placed at known depth, in plots with a predominant cover of Sphagnum. The movement of the tracers will be measured in cores, retrieved 1 year after the start of the experiment.

The tracer substances include a range of particles, dyes and ions of different valency, introduced at concentrations, which, though significantly above their background levels, will not saturate the profile. These tracers have been introduced into sites with different environmental characteristics.

In order to compare movement at Moor House with that at Cranes Moor, measurements are being made of evaporation and rainfall. Simple lysimeters and rain gauges have therefore been installed, and measurements are taken monthly.

i) Low temperature growth of grasses and clovers
(J. H. Ollerenshaw and R.H. Baker, University of Newcastle-upon-Tyne)

Introduction and background

Much of the research on the ecotypes of grasses and clovers collected from the Moor House Reserve in 1974 has been concentrated on the species, Trifolium repens during the past year. However the ecotypes of Lolium perenne collected from the meadow, were subjected again to low temperatures and light intensities in the cold cabinets; the results were similar to those recorded in the last Report, and are not presented here.

We have concentrated on white clover (T. repens) because this species is regarded as being the corner-stone to the improvement of hill pastures (Watkin Williams, 1970). White clover is an essential constituent of upland seeds mixtures since nitrogenous fertilizer is seldom justified in low output systems such as hill and marginal farming. Fertilizer nitrogen has more than doubled in price and usage over the past 10 years (Aldrich, 1974) and requires large quantities of fuel energy for its production and distribution. Besides being capable of fixing atmospheric nitrogen, white clover has several other important characteristics. It provides a high quality feed (Armstrong and Eadie, 1973), improves the voluntary intake and efficiency of utilisation of the diet of grazing animals and increases the rate of nitrogen cycling in the soil (Munro, 1970).

Existing varieties of white clover start growth 2 or 3 weeks later and finish about 2 weeks earlier than the present varieties of grasses in Britain (Newbould, 1974). Little clover growth appears to occur below a soil temperature of 9°C (Munro, 1970). Hence with such a short growing season, current varieties of white clover are at a competitive disadvantage, and are also poor in supplying organic nitrogen to associated grasses during the spring and autumn. Consequently, the selection of white clover strains which can grow during these periods of the year, i.e. at low temperatures, would be a distinct advantage in hill and marginal, and also possibly in lowland areas. Some of the ecotypes of T. repens collected at Moor House have already shown promise in this respect (Ollerenshaw, Stewart, Gallimore and Baker, 1976). This report describes the further testing of some of these promising ecotypes and also of other ecotypes from the Moor House Reserve which have not been screened previously for low temperature growth.

Methods

The measurement of the growth of T. repens at low temperatures in cold cabinets has already been described (Ollerenshaw, 1975). A duplicate set of white clover plants in 7.5 cm pots were placed out of doors at Wylam in the Tyne Valley (50m above sea level) for comparison with the growth of the ecotypes in the cabinets. A record was made of the final dry weights and the number of stolons and leaves which developed on the plants in both the cold cabinet and outside. Stolons of each ecotype were also planted as mini-plots (60m x 60m) at the Redesdale Experimental Farm in the Cheviot hills (230 m above sea level). Records show that winters are long, with soil temperatures below 6°C for most of the period from November to April, at this site. The lengths of stolons on 8 plants per ecotype were measured at 4 weekly intervals during the autumn, winter and spring of 1975/6 at Redesdale and the number of new leaves and stolons were recorded.

Results

One of the ecotypes, Trout Beck 1, produced more growth than the commercial variety S184 under controlled cabinet, lowland and upland conditions during the winter period (Tables 8, 9 and 10). The growth of this ecotype, in terms of the rate of stolon extension and new leaf and stolon production, was particularly encouraging in early spring compared with S184 (Table 11). This is precisely the time of the year when high quality herbage is required for improving hill and marginal land output (Ollerenshaw et al) 1976). Ecotypes with low temperature characteristics similar to Trout Beck 1 would provide a very useful basis for breeding improved varieties of T. repens. Hence the Moor House Reserve can be regarded as being a very valuable source of genetic plant material for improving agricultural production in temperate and possibly other climatic zones of the world. A more intensive collection of grasses and clovers from the Reserve is needed as soon as possible.

It is very encouraging to obtain repeatable results in the cold cabinet over a period of two years with some of the ecotypes of both grasses and clovers, including Trout Beck 1. Similarly, it is rewarding to find that screening for spring growth under upland conditions can be accomplished in cold cabinets. However, there are indications that this screening method is not completely effective in view of the relatively good growth of the ecotype, Knock Fell 6 during the spring at Redesdale (Table 11). Although low light intensities, short photoperiods and low day temperatures can be simulated in the cold cabinet, there are many other parameters common to upland environments which are not simulated. One of these factors is the effect of sub-zero temperatures on growth and survival in the uplands. We hope soon to be able to test for cold hardiness under controlled conditions as well as in the field.

Work on finding grasses which can grow at low temperatures and which are also cold hardy, will continue over the next three years with the aid of a research grant from the Agricultural Research Council.

References

ALDRICH, D. T. A. 1974 The legume - a reappraisal of its place in today's farming. J. Brit. Grassld. Soc., 29, 247-251.

ARMSTRONG, R. H. & EADIE, J. 1973. Lamb growth on grass and clover diets. Proc. Brit. Soc. Anim. Prod., 2, 60.

MUNRO, J.M.M. 1970. The role of white clover in hill areas. In J. Lowe (Ed.) White clover research. Occ. Symp. No. 6 Brit. Grassld. Soc., 259-266.

NEWBOULD, P. 1974. The improvement of hill pastures for agriculture, a review. J. Brit. Grassld. Soc., 29, 241-7.

OLLERENSHAW, J. H. 1975. Low temperature growth of grasses and clovers. Moor House Field Station 16th Annual Report.

OLLERENSHAW, J.H., STEWART, W. S., GALLIMORE, J. F. & BAKER, R. H. 1976. Low temperature growth in grasses from northern latitudes. J. agric. Sci., Camb. 87, 237-9.

WILLIAMS, Watkin. 1970. White clover in British agriculture. In J. Lowe (Ed.) White clover research. Occ. Symp. No. 6, Brit Grassld. Soc., 1-10.

Table 8 Rates of stolon growth (mm stolon/week), dry weights (mg) and the number of new leaves and stolons of *T. repens* ecotypes grown in cold cabinets at 5°C (means of 8 plants).

Growth period : 10th November 1975 to 5th January 1976

Ecotype	Stolon growth	Shoot Weight	Root Weight	No. of new leaves	No. of new stolons
Trout Beck 1	2.41	28.7	45.1	9.0	2.5
Meadow 1	2.39	28.0	38.2	8.5	2.8
Meadow 2	0.88	7.1	23.2	3.8	1.3
Meadow 3	0.76	6.3	20.5	3.0	1.1
Knock Fell 6	0.79	6.7	14.2	4.1	1.4
Knock Fell 7	0.45	4.4	13.6	2.5	0.5
S184*	2.14	29.2	39.9	9.0	2.5

* commercial variety

Table 9 Rates of stolon growth (mm stolon/week), dry weights (mg) and the number of new leaves and stolons of T. repens ecotypes grown outside at Wylam, Tyne Valley (means of 8 plants).

Growth period : 11th November 1975 to 7th January 1976

Ecotype	Stolon growth	Shoot Weight	Root Weight	No. of new leaves	No. of new stolons
Trout Beck 1	3.08	34.2	56.9	12.4	4.3
Meadow 1	2.61	30.8	43.6	11.8	3.1
Meadow 2	1.35	12.5	29.3	8.6	2.2
Meadow 3	1.23	10.9	21.6	6.8	2.5
Knock Fell 6	1.73	11.6	23.3	10.4	3.1
Knock Fell 7	1.15	7.3	16.4	3.0	1.0
S184*	2.30	28.1	47.2	12.0	3.5

* commercial variety

Table 10 Rates of stolon growth (mm stolon/week) and the number of new leaves and stolons on T. repens ecotypes grown at Redesdale E.H.F. (means of 8 plants).

Growth period : 3rd November 1975 to 20th February 1976

Ecotype	Stolon growth	No. of new leaves	No. of new stolons
Trout Beck 1	1.31	8.5	4.0
Meadow 1	0.84	4.8	3.3
Meadow 2	0.51	4.5	1.9
Meadow 3	0.27	3.6	2.3
Knock Fell 6	0.62	4.5	2.5
Knock Fell 7	0.20	2.3	1.5
S184*	1.05	7.3	4.0

* commercial variety

Table 11 Rates of stolon growth (mm stolon/week) and the number of new leaves and stolons on T. repens ecotypes grown at Redesdale E.H.F. (means of 8 plants).

Growth period : 20th February 1976 to 21st April 1976

Ecotype	Stolon growth	No. of new leaves	No. of new stolons
Trout Beck 1	3.28	12.5	3.9
Meadow 1	1.05	6.0	2.8
Meadow 2	1.27	5.2	1.5
Meadow 3	0.29	3.3	1.8
Knock Fell 6	1.52	7.8	2.6
Knock Fell 7	0.12	1.2	0.5
S184*	1.36	7.3	2.9

* commercial variety

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

The movement of five ploughing blocks was recorded for the eleventh consecutive year. It was found that displacements were less than on most previous occasions (cf. the figures in the table below with those on page 42 of the 1975 report).

Table 12 Movement of five ploughing blocks on the Reserve between August 1975 and August 1976. Block numbers correspond with those in the 1975 Report.

Block Number	Amount of movement recorded (cm)
1	5.7
2	3.2
3	0.0
4	0.0
5	0.0

Appendix 1

Publications

BUTTERFIELD, JENNIFER E. L. 1976. The response of development rate to temperature in the univoltine Cranefly Tipula subnodicornis Zetterstedt. Oecologia, 25, 89-100.

BIRKETT, N. L. 1976. Chironomidae (Diptera) trapped in a Pennine stream, including two species new to Britain. Ent. Gaz., 27, 161-170.

COULSON, J. C. & DUNN, T. C. 1976. Invertebrates : In 'The Natural History of Upper Teesdale', Durham County Conservation Trust Booklet, 75 pages.

COULSON, J. C., HOROBIN, J. B., BUTTERFIELD, JENNIFER E. L. & SMITH, G. R. J. 1976. The maintenance of annual life-cycles in two species of Tipulidae (Diptera): a field study relating development, temperature and altitude. J. Anim. Ecol., 45, 215-233.

HEAL, O. W., JONES, HELEN E. & WHITTAKER, J. B. 1975. Moor House UK In: Structure and functions of tundra ecosystems. Ecol. Bull. (Stockholm), 20, 295-320.

OLLERENSHAW, J. H., STEWART, W. S., GALLIMORE, J & BAKER, R. H. 1976. Low temperature growth in grasses from northern latitudes. J. agric. Sci., Camb., 87, 237-239.

ROMANS, J. C. C. & ROBERTSON, L. 1973. Some aspects of the genesis of alpine and upland soils in the British Isles. Proc. IV. Working Meeting on Soil Micromorphology, Kingston, Ontario, Canada.

WHITE, E. J. & LINDLEY, D. K. 1976. The reduction of climatological data for ecological purposes: a preliminary analysis. J. Environ. Mgmt., 4, 161-182.

WOTTON, R. S. 1976. Evidence that blackfly larvae can feed on particles of colloidal size. Nature, 261, 697.

Theses

ASHMORE, M. R. 1975. The Eco-physiology of Calluna vulgaris (L.) Hull in a moorland habitat. Ph.D. Thesis, University of Leeds.

HESLOP, L. 1975. Recreational use of the northern Pennines (Pennine Way). M.Sc. Dissertation, University of Salford.

Occasional Papers

BAILEY, A. D. 1975. Solar radiation recording at Moor House. Merlewood Research and Development Paper, No. 65.

HORNUNG, M. 1976. Soils of Moor House. In: Aspects of the Ecology of the Northern Pennines. Moor House Occasional Paper No. 9. 12 pages.

HOWARD, P. J. A. & HOWARD, D. M. 1976. Respiration, litter nutrients, and soil organic matter in grazed and ungrazed upland limestone grassland. Merlewood Research and Development Paper, No. 67.

STAFF LIST

Officer in charge	M. Rawes
Scientific Staff	R. B. Marsh
	Mrs. L. M. Robinson (nee Miss L. M. Teasdale)
Warden	J. Parkin
Estate Worker	P. J. Holms
Housekeeper	Mrs. G. G. Dunn (April - October)
Part-time Warden	J. Rose (November - March)
Honorary Wardens	B. J. McArthur
	J. Hollington
	O. W. Harrison
F.B.A. Staff	Dr. D. T. Crisp
	Dr. P. D. Armitage
	P. Cubby
	Miss S. Ebden

Meteorological Summary for Moor House 1975 (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	4.9	4.3	3.2	7.1	9.2	15.0	15.8	18.9	11.5	9.5	4.9	4.5	9.1
Mean min temp °C	0.0	-1.7	-2.1	0.5	0.2	4.6	8.7	9.5	5.2	3.0	-0.1	-0.5	2.3
½ (max + min) °C	2.4	1.3	0.6	3.8	4.7	9.8	12.2	14.2	8.3	6.3	2.4	2.0	5.7
Highest max temp °C	7.8	11.5	8.4	16.0	15.5	22.5	20.8	25.5	16.9	15.1	9.0	8.8	25.5
Lowest min temp °C	-5.5	-6.6	-7.2	-7.1	-3.6	-1.7	2.3	4.7	-1.3	-5.3	-4.8	-9.1	-9.1
Lowest max temp °C	-0.1	-0.8	-1.2	-1.1	4.4	2.8	10.2	11.4	7.0	5.4	0.4	-0.9	-1.2
Highest min temp °C	5.0	2.6	3.0	8.3	4.8	13.3	13.7	14.0	10.0	8.9	5.7	4.2	14.0
Lowest grass min temp °C	-11.2	-11.5	-9.7	-9.9	-11.0	-6.6	-3.8	-1.9	-6.5	-9.1	-9.1	-12.6	-12.6
Earth temp 30cm 0900 hr	3.4	2.2	2.1	3.8	6.4	9.3	11.8	13.4	10.3	7.5	5.2	3.5	6.6
Rainfall (mm)	341.0	31.6	96.6	141.2	43.0	68.9	179.4	119.9	235.8	64.7	150.4	111.6	1584.1
Rain days (0.2mm)	29	11	25	26	11	11	17	17	21	16	22	24	230
Wet days (1.0mm)	29	6	16	22	9	7	16	13	20	12	20	14	184
Days snow/sleet	15	2	19	10	1	2	1	0	1	0	8	8	67
Days snow lying	8	1	13	8	0	2	0	0	0	0	2	2	36
Days hail	5	0	4	6	2	2	0	0	1	0	0	0	20
Days snow/ice pellets	1	2	3	1	1	0	0	0	0	0	1	1	10
Thunder	0	0	0	0	0	0	1	6	1	0	0	0	8
Fog	2	7	0	2	2	1	2	0	1	2	1	3	23
Air frost	17	22	26	13	12	4	0	0	2	6	18	17	137
Ground frost	20	25	29	18	25	17	5	3	14	15	24	25	220
Av Daily bright sun (hr)	0.29	2.79	3.28	3.45	7.20	7.91	4.70	7.09	4.08	2.67	1.98	1.20	3.89
Total bright sun (hr)	9.1	78.0	101.6	103.4	223.2	237.2	145.8	219.8	122.5	82.8	59.4	37.3	1420.1
Total snow (cm)	34	2	20	14	0	14	0	0	0	0	4	5	93
Greatest depth snow (cm)	12	2	8	6	0	12	0	0	0	0	3	4	12
Days with gales	13	0	0	2	0	1	0	0	3	2	3	6	30
Solar radiation gm cals/cm²	840	2,771	5,285	7,424	12,060	13,499	10,067	10,971	5,897	3,665	1,771	939	75189