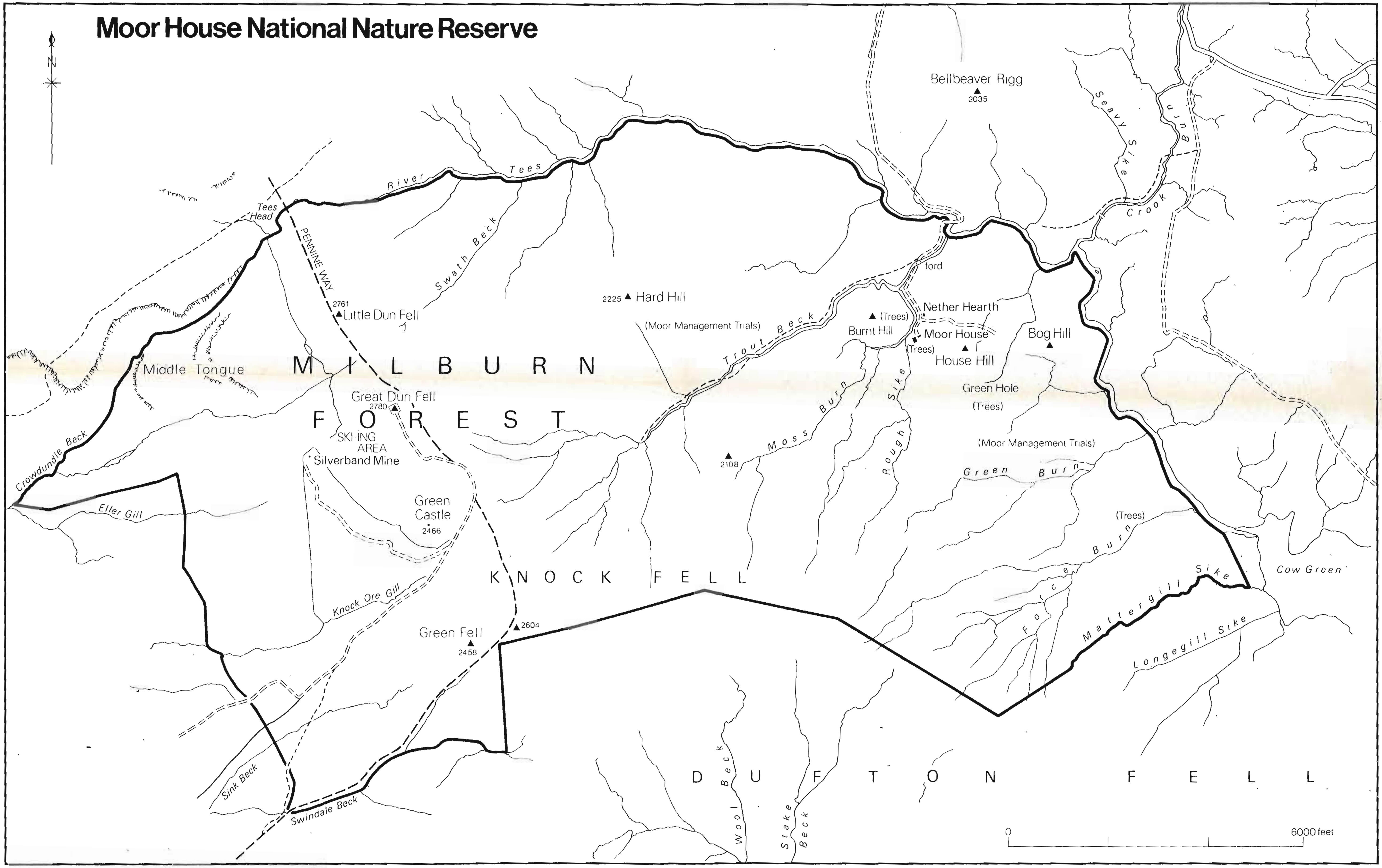
MOOR HOUSE

16th Annual Report, 1975

Moor House National Nature Reserve



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THE NATURE CONSERVANCY COUNCIL

MOOR HOUSE

1975

16th Annual Progress Report

M. Rawes

CONTENTS

I. GENERAL

a) Introduction

The Report covers the year 1 October, 1974 to 30 September, 1975, a year of exceptional weather records.

The Report follows previous style, but the decline in research is reflected in its size. At the time of writing it is uncertain whether this form of publication will continue. Annual Reports are written to record and inform, it would seem that the present format does not inform, at least it does not reach those people one wishes it to. This may be because the lay-out is unattractive or there may be other reasons. Come what may a record of occurrences at Moor House will always be maintained, and it is hoped that efforts will continue to be made to hold as much background information as possible. Thus a knowledge of the history of Moor House, and the area surrounding, is important ecologically and socially. Up to the present day this information has been used in publications by D. Welch in Occasional Paper No. 7, "A history of the Moor House area", and in an account of Elizabethan documents concerning Milburn Forest for the Transactions of the Cumberland and Westmorland Archaeological and Antiquarian Society, whilst Mrs. Alys Forrest produced an unpublished thesis on Garrigill "A study of a northern Pennine Village". Occasional Paper No. 6, on the ecology of the Red Grouse, also used historical data. In the latter account a list of Moor House gamekeepers was drawn up, so it was interesting to receive from Australia a letter which told us of another keeper until now unrecorded. The grandfather of our correspondent, now 77 years of age, had been head-keeper at Moor House in the last century.

b) Reserve Management

As the first stage to preparing a revised Management Plan a Brief and a Working Plan for 1975 were produced.

The objectives of management are broadly those of a Biosphere Reserve into which category Moor House falls. They are:-

1. To conserve and enhance the moorland habitats and their wildlife.

2. To establish by research the optimal management for wildlife, especially where it can be integrated with farming and grouse shooting.

3. To provide facilities, in the field and laboratory, for ecological research, particularly in those studies that bear an immediate relationship to management.

4. To provide facilities for education and training.

The existence of common grazing rights is to some extent a restriction to achieving some of the objectives, but common land is ubiquitous in Cumbria and there are some advantages in working in a normal situation even though it may present considerable problems from time to time.

Much of course, needs to be done, particularly to achieve the second objective. The maintenance of a viable permanent staff is as much an essential in executing management prescriptions as in providing facilities. Staff undertake numerous jobs outside their normal duties and it is only because of this and their willingness to work beyond normal hours that a place such as Moor House can be maintained. Adverse weather conditions often result in repairs being required more frequently than elsewhere, whilst remoteness increases the cost of contract labour. Nevertheless, improvements continue to be made. Laboratory alterations involving the replacement of a timber structure gable end with a brick wall is one, and the tarmacadaming of the access track within the Reserve, from the River Tees to the Field Station, is another. Time is spent by the Warden and Estate Worker on the access track, the greater part of which does not belong to the Nature Conservancy, but this road is the only means of vehicular access and would have to be maintained irrespective of the amount of use made of Moor House. A new tractor and equipment should improve our efforts in this direction and the supply of an improved half-track assembly allows the tractor to reach sites otherwise only accessible by foot or at one time by horse. In this field a major programme of fence renewal has been started. One of the earliest exclosures, Bog Hill, fenced in 1953, was replaced last winter. Repair of tracks and fences is a major commitment of the estate staff. Other routine aspects of day to day management are the provision of services, such as water and electricity, the maintenance of tree enclosures, planting and rehabilitation work, carrying out the heather burning programmes, which are linked to moor management projects, and the treatment of the meadow and movement of experimental sheep. The use of the Reserve for mining, walking and ski-ing has its management problems.

Through membership of the Department of Trade and Industry Interlab Co-operation Scheme contact was made with Professor G.R. Bainbridge, Director of the Energy Centre, Newcastle upon Tyne University, to review the feasibility of wind as the main source of heat at Moor House. The cost of heating and lighting by fossil fuels is such that the use of resources such as wind, water and radiation need to be considered more seriously than of late. In anticipation of a trial starting in 1976 provisional planning approval has been obtained to erect a 50 foot tower and propellor blade.

Little tree planting has been done since 1960, but this year some 300 Pinus mugo and 100 P. contorta were planted in the pasture, mainly on eroded or degraded peat areas, from which sheep are excluded, and on which drainage and grass seeding is to be undertaken preparatory to further tree planting. 100 Alnus incana are being grown in the nursery, which has an assortment of native hard-wood seedlings and cuttings for future planting out.

Heather burning in the grouse management study areas and in the long-term experiment to measure effects of different burning rotations took place by the end of March in ideal conditions. The long-term study of heather burning started in 1954 and this was the first occasion on which the 20 year regime plots had been re-burnt.

The meadow was cut for hay, part in July and the remainder in August. A light crop was harvested. Previously $7\frac{1}{2}$ tonnes of ground magnesium limestone were spread on the field and adjoining pasture. The Moor House sheep grazed the meadow over-winter.

The west side of the Reserve continues to receive more attention from the public, although ski-ing conditions were again very poor. The use of the Pennine Way has been noticeably heavier this year. More cars have been using the Dun Fell road during the holiday months, and, combined with traffic to and from Silverband Mine, the Civil Aviation Radio Station, and farmers vehicles, there is increasing likelihood of an accident occurring with possible damage to habitats. Crushing and washing plants have now been erected at the Silverband Mine and a planning application has been lodged for an extension to the mining licence. It is understood that the Eden District Council have raised no objection. The Nature Conservancy Council has sought an assurance that there will be no further pollution of water courses and the open fell. Analysis of Eller Gill, which rises just south-west of the mine, showed that suspended solids (172 mg/l) were exceptionally high for a fell stream. The estimate for Crowdundle for instance was 4 mg/l. Improvements in the treatment of waste water from the cleaning process should involve much of it being re-cycled and passed through a sedimentation reservoir.

c) Natural History

How atypical the year has been remains to be decided, but after an exceptionally late start to summer - there was little growth of heather until June - flowering of plants, especially noticeable in heather, has been of record proportions. The Warden reports as follows:-

Three new bird species were recorded for the Reserve this year, Collared Dove, Corn Bunting, and Blackcap, bringing the total to ninety. Of these only nineteen species breed regularly, a further eleven occasionally and nine are believed to have bred during the last few years but have not been proved to do so.

Three Linnet nests were found in the Pasture tree enclosure and one in Nether Hearth. One Redpoll nest was found in the Pasture tree enclosure, and one female Goosander was seen with young at Tees Bridge. This is the first recorded breeding for Goosander on the Reserve.

Only two species, Red Grouse and Dipper, are resident throughout the year, and one species, the Snow Bunting, is recorded as a winter visitor. Remaining species are either visitors or passage migrants.

A Roe Deer was recorded during July at Green Hole and one was reported on the summit of Cross Fell, which is off the Reserve, around the same time.

A Pipistrelle Bat was seen flying in day light at Moor House on April 17th, it was later caught, then released.

Other species recorded include Fox, Rabbit, Hedgehog, Stoat, Mole, Rat, House Mouse, Common Shrew, Pigmy Shrew, Water Shrew and Field Vole.

It has been a very good year for the Green Veined White and Small Tortoishell butterflies. Caterpillars of the latter were seen on nettles at Moor House in June. The Red Admiral was recorded on several occasions during August. Also recorded were the Small White, Orange Tip and Small Heath. Results from the moth lamp are given in the report on page 43.

Frogs which are common all over the Reserve had a bad year when many pools dried up during June killing thousands of tadpoles. No other amphibians were recorded and the Common Lizard was the only reptile.

d) Survey and Research

Most of the projects detailed in last year's Report have continued. The Freshwater Biological Association's Cow Green team re-surveyed the Tees within the Reserve and looked at the trout population in the fast-flowing Knock Ore Gill and Swindale Beck, on the western escarpment. Durham University workers (p. 24) have continued their studies of the Cranefly. Botanists from Leeds (p.38) are looking at the physiology of some moorland plants, whilst the value of the Reserve as a source of genetic material is acknowledged by others including Dr. Taylor (London) who has followed up laboratory work on *Geum* spp (p.35) with field trials. Studies on *Lolium* and *Trifolium* ecotypes have been reported on (p.38) by Dr. Ollerenshaw of Newcastle. Ross Hynes (London) is completing his final year in assessing ecological factors of importance in woodland on the northern Pennines (p.36). Dr. J. Richards' (Newcastle) botanical survey continued this year with a search of the area between Knock Fell and Murton Pike. Fifteen 1 Km squares were visited and a number of new localities of rare species and confirmation of old, were found. The Pennine scarp from Melmerby Fell to Warcop has now been covered, leaving only a small part of the total survey to be completed in 1976.

It was pleasing to see Dr. N. Martin (West of Scotland Agricultural College) return to re-sample peat for bacteria, whilst interest in bog ecology will be stimulated by the registration of a long-term study on bog pool development by Dr. J. Tallis (Manchester). A.J.P. Gore (ITE) has retained his interest in Moor House by undertaking a further year of productivity measurements on blanket bog, and moves to retain experimental and sampling sites have been made by ITE research workers. Reports are given of four Ph.D. students (M. Ashmore, D. Tattersfield, R.C. Beattie and R. Hynes) undertaking studies at Moor House. The study of fox behaviour (D.W. Macdonald, Oxford) has been centred mainly on the west scarp of the Pennines, but faecal samples have been taken from the Reserve and await analysis. Two undergraduate projects by Durham zoologists, Martin Randall and Jon Reynolds, involving the nesting and hatching of meadow pipits, were completed, and studies of blanket bog managements by undergraduates Elizabeth Telford and Richard Hobbs (both of Edinburgh) and Rory Post (University College, London) helped the survey programme of the Station.

e) Advice and Education

The Field Station and Reserve continue to be used by a variety of people, mainly from Universities, for education, whilst advice has been sought by a number of organisations. Parties of students have come for the day from Durham University, London University and Cumbria College of Agriculture and Forestry, while residential courses have been held for up to a week by the Forestry and Natural Resources Department, Edinburgh University and the Zoology Department, Durham University.

A seminar on trees at high altitude was held in June. Some thirty people attended. Two papers "Commercial tree planting close to the upper altitudinal limit for timber production" and "Ecology of, and potential for woodland in the northern Pennines" were given by M. Williams (Cumbria College of Agriculture and Forestry) and Ross Hynes (University College, London University) respectively.

The discussion was chaired by Mr. J.S.R. Chard, at one time Forestry Commission Conservator, North West England, who in 1954 had given the Nature Conservancy valuable advice on tree planting at Moor House. It was also helpful to have two previous members of Moor House staff, A. Millar and E.J. White, attending the meeting. Both had been responsible for putting into effect the programme of planting between 1954 and 1961. During the afternoon the sites were visited and the many comments were not only of great interest to the invited audience, but helpful to the staff. Mr. Chard was particularly impressed with the development of Green Hole.

In the spring, R. Williams lectured to the Conservation Corps' leaders course at Leeds on "The ecology and management of mountains and moorlands".

Among parties visiting the Reserve was one from the Northumberland Environmental Studies Association. They were shown around by J. Parkin. R. Williams attended the Nature Conservancy Council's mobile exhibition at Carlisle Show and was recorded for Radio Carlisle. M. Rawes spoke about Moor House in a BBC 1 (North-East) production.

f) Visitors

The Freshwater Biological Association Council visited Moor House on 10 April during their inspection of the work of their Cow Green Unit. Some twenty members of the Council attended.

The Chairman of the Nature Conservancy Council, Sir David Serpell, and the Director of England, Dr. M. Gane, visited the Reserve and Field Station in early June. D. Wells, Chief Scientist's Team, called during his review of northern meadows.

Apart from visits by parties the following have been to the Field Station: Dr. J. Hodgson, Dr. J.A. Milne and A.J. McDonald of the Hill Farming Research Organisation, Messrs. Crawley and I. Brotherton of the Yorkshire Dales National Park, Graham Dunbar of the Tussock Grasslands and Mountain Lands Institute, Lincoln College, New Zealand and L. Rapp of the Experimental Station at Tromsö, Norway.

g) Staff

There were no changes in staff until 30 September, when R. Williams left to become an Assistant Regional Officer in south-west England.

Mr. J. Rose undertook the part-time wardening of the ski-ing scheme again last winter.

R.B. Marsh attended a course at Malham Tarn Field Studies Centre on "Bog and Fen Ecology".

M. Rawes and R. Williams joined the Hill Land Use and Ecology Discussion Group Meeting in Perthshire, after which M. Rawes visited the Lephinmore Research Farm of H.F.R.O.

II. SCIENTIFIC - Moor House Staff

Emphasis this year has been given to preparing data for satisfactory storage that will allow simple retrieval, and on preparing results for publication. In view of the impending departure of R. Williams the field programme was severely pruned. It has on the whole concentrated on blanket bog studies and in these we have received help from students, whose work will be mentioned later in the Report.

To summarise, the following studies/projects are undertaken by staff:-

a. Climate - routine recording

b. Vegetation and sheep - mainly botanical recording of sites to measure:
   1. effect of present day sheep grazing of the open fell
   2. effect of removal of sheep grazing
   3. effect of drainage
   4. effect of burning
   5. effect of different sheep grazing regimes
   6. number and distribution of sheep

c. Natural grassland communities - recreation and establishment

d. Red Grouse - recording of numbers and performance

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

f. Ski-ing - recording numbers and botanical effect

g. Pennine Way - recording numbers and botanical effect

h. Meadow - sample cropping for yield and botanical analysis

Where recording is not done on a routine daily or annual basis a programme for repeat analysis is maintained. Records are made also for the Northumberland Water Authority (Troutbeck Weir), the Freshwater Biological Association (water thermograph), and Rothamsted Experimental Station (moth survey). Research site use is recorded on cards, using a grid system to identify location.

a) Climatology (R.B. Marsh)

The weather summary for 1974 is given in the appendices and observations covering the reporting year are shown below. No summary appears for Great Dun Fell as records from this station are no longer published.

The year has had many extremes recorded, beginning with October which was very cold with maximum, minimum, mean and earth temperatures, all being lower than recorded previously. Snow was recorded on two days; the last time this was recorded was in 1967.

November and December appeared almost mild by comparison, with November only recording seven air frosts; the lowest record for this month. December was very wet (449.4 mm (17.7") of rainfall, the wettest month ever recorded at Moor House) and windy (23 days recording gales (that is wind speeds of 34 kt - 40 mph for 10 minutes)).

January also was exceptional. It was very mild, having the highest figures recorded for maximum, minimum, mean and earth, whilst rainfall was very high (341 mm, 14 ") making the combined precipitation for the two months (790 mm, 31"). Gales reached another record with thirteen days being recorded.

By contrast, February was the driest ever recorded with only 31.6 mm, 1.2" of rain. This enabled heather burning to be completed by the end of the month; a very rare occurrence. May was also extreme, it was cold but sunny and dry. Minimum temperatures (0.2°C) and mean (4.7°C) were records, while sunshine hours/day were the highest at 7.20 hours/day. The month also gave us the most ground frosts (25 days) ever, and the lowest rainfall (43 mm, 1.7") since 1959.

With a year proceeding in such an odd way there was little surprise when two days of snow were recorded in June.

August proved to be another extreme month with the highest temperature (25.5°C) ever recorded on any day at Moor House. Otherwise records were exceeded for monthly maximum, minimum, mean and earth temperatures and for sunshine hours/day (7.09 hours).

September finished off this strange year by being the wettest September since 1968 and equalling the record of most ground frosts (14 days).

The table summarises the records and gives the 23 year mean values for comparison.

	YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.
Maximum °C	8.9	5.7	4.9	5.7	4.9	4.3	3.2	7.1	9.2	15.0	15.8	19.9	11.5
Mean °C	8.3	9.6	5.1	3.4	2.2	1.8	4.1	7.1	10.8	13.8	14.7	14.4	12.5
Minimum °C	2.3	1.0	0.6	1.0	0.1	-1.7	-2.1	0.5	0.2	4.6	8.7	9.5	5.2
Mean °C	1.9	3.8	0.1	-1.8	-2.5	-3.4	-1.6	-0.1	2.6	5.4	7.1	7.3	5.9
Earth °C	6.4	5.8	4.1	3.8	3.4	2.2	2.1	3.8	6.4	9.3	11.8	13.4	10.3
Mean °C	6.2	7.9	4.7	2.7	1.7	1.5	2.0	3.8	6.9	9.9	11.5	11.6	10.3
Rainfall mm	2111.9	133.1	272.0	449.4	341.0	31.6	96.6	141.2	43.0	68.9	179.4	119.9	235.8
Mean mm	1885.3	189.1	199.4	207.5	186.4	153.4	127.3	119.3	125.5	111.1	143.3	164.9	158.1
Sunshine hrs	3.61	1.25	0.82	0.47	0.29	2.79	3.28	3.45	7.20	7.91	4.70	7.09	4.08
Mean hrs	3.14	2.60	1.39	0.92	0.99	1.73	2.74	4.10	5.19	5.80	4.57	4.28	3.39
Air frosts	124	9	7	12	17	22	26	13	12	4	0	0	2
Mean (days)	129	4	14	21	22	21	21	16	7	1	0	0	2
Ground frosts	207	15	18	18	20	25	29	18	25	17	5	3	14
Mean (days)	171	9	18	22	25	23	24	20	12	6	4	3	5
Snow lying (days)	47	2	3	10	8	1	13	8	0	2	0	0	0
Mean	68	0	6	11	16	17	12	5	1	0	0	0	0

Regular requests for Meteorological data are received from both Universities and private individuals. This year with the emphasis of fuel conservation we have even dealt with a request for wind records by an individual installing a wind generator at his house.

The two automatic weather stations installed for A.J.P. Gore last July continue to give good results. Copies of the results are held at Moor House.

Moor House Solar Radiation - A.D. Bailey (Merlewood)

The recording of solar radiation, using a Kipp solarimeter linked to a Lintronic integrator/recorder, has continued. The monthly and annual totals for 1974 are summarised in the table opposite:

January	927	gm cals/cm^2
February	2,252	"
March	5,532	"
April	9,869	"
May	11,532	"
June	12,497	"
July	9,111	"
August	7,999	"
September	5,202	"
October	2,634	"
November	1,276	"
December	651	"
Annual total	69,482	"

A continuous run of reliable data is now available from October 1971 to present. An internal paper is in preparation describing the equipment and its maintenance, documenting the results obtained up to the end of 1974, and briefly comparing these results with those obtained from other recording stations. The relationship between solar radiation input and the standard meteorological recording of sunshine hours is being examined, using the equation:-

$$Q = Q_A \left(a + b \frac{n}{N} \right)$$

where Q = radiation received on the ground in gm cals/cm^2/day
Q_A = radiation received at the top of the atmosphere in gm cals/cm^2/day
n = daily hours of bright sunshine
N = day length in hours
a = regression constant
b = regression coefficient

The relationship will allow estimation of values missing through instrument failure and could be used to estimate radiation in years when it was not measured.

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

Some studies in this general field were started twenty one years ago. They are all relevant to management, seventeen major reference sites (these exclude isolated marked quadrats) ensure that the six most important (in area) vegetation types of the Reserve are investigated. Beyond the reference sites it is desirable to undertake more extensive trials or surveys, but at present lack of resources rarely makes this possible.

Effect of present day sheep grazing of the open fell

This year there has been little monitoring of untreated sites open to normal range of grazing of the fell but some twenty permanent quadrats to follow pattern of Juncus squarrosus, Nardus stricta, Calluna vulgaris and Trichophorum cespitosum were re-surveyed. The quadrats were laid down in 1967 at five places, on Agrostis-Festuca and Festuca grasslands, Juncus squarrosus vegetation, and on a neighbouring fell blanket bog subject to year-round grazing. Nardus stricta seems variable in the yearly extent of its tussocks, but in nine cases out of ten it has increased considerably over eight years. Juncus squarrosus has decreased in the Agrostis-Festuca limestone and alluvial grassland sites, but as expected, increased on neighbouring blanket bog, which has been heavily grazed in recent snow-free winters.

Effect of different sheep grazing regimes

We have concentrated this year on the effects of different grazing regimes, removal of grazing, draining and burning of blanket bog and re-surveyed a trial started in 1968 to measure the effect on botanical composition of heavy grazing (1 sheep/0.24 ha/annum), light grazing (1 sheep/2 ha/annum) and combinations of burning, draining and heavy grazing (1 sheep/0.24 ha/annum). Grazing takes place on four to five occasions in a year and records of botanical composition are made in early June with observations later in the summer.

The treatments continue to show that disturbed bog surface is a good medium for invasion by grass and other plant species. Juncus squarrosus is now found in all heavily grazed plots and the following angiosperms have been observed - Juncus effusus, Carex nigra, Luzula spp. Festuca ovina, F. rubra, Agrostis tenuis, Poa spp., Cerastium holosteoides Nardus stricta, Anthoxanthum odoratum and Galium saxatile. Calluna was recorded in the heavy grazed plot for the first time since 1970, with two hits, less than one per 100 points, whereas the control registers about 50 hits. Cover of Eriophorum vaginatum has varied little, but the amount of dead plant leaf is steadily approaching that of the normal, but relatively ungrazed situation, where 75% of the plant is dead in early June. Other changes in angiosperms over recent years are insignificant. Empetrum nigrum shows no signs of recovering, but Eriophorum angustifolium has increased under grazing. The cover of mosses remains the same, but liverworts continue to rocover and lichens decrease. Thus there has been a lowering of cover initially, followed by gradual recovery. Analysis of community structure shows little change over the past five years.

Effect of removal of sheep grazing

The long-term effects of excluding sheep from blanket bog is followed at Bog Hill, fenced in 1953. The point quadrat site was not analysed this year, previous examination having shown little change but hinted that even minimal sheep grazing might significantly affect the lichen status. Therefore 100 $\frac{1}{2}m^2$ quadrats were thrown randomly inside and also outside the enclosure for lichen cover estimates. The most prevalent lichen (7 species were recorded) is Cladonia impexa, which occurred in 72 quadrats in the enclosure and 55 outside. The mean percentage cover of the species was 15.4 and 4.6 respectively for the quadrats in which it was present. The distribution of lichens however, is notoriously variable in blanket bog but the evidence of this and other surveys appears conclusive; lichens are more prevalent in blanket bog enclosures. It would, however, be incorrect to claim that they are less on the open fell because of sheep grazing alone.

To extend the survey of following change, other exclosures were examined. The bog pool on Burnt Hill, also fenced in 1953, was re-mapped. The enclosure covers 256 m^2. The respective percentage cover of the vegetation types was as follows:-

	1953	1975
Calluna dominant areas (inc. Trichophorum)	41.1%	56.1%
Sphagnum acutifolium zone	14.4%	5.4%
S. papillosum zone	9.5%	17.8%
S. cuspidatum + Eriophorum angustifolium	19.1%	16.9%
S. cuspidatum	5.7%	2.1%
E. angustifolium	-	2.1%

Leaving aside the dryness of the 1975 season the results show clearly that the bog at this point is becoming less wet; Calluna is increasing and with the reduction in the size of the pool Sphagnum papillosum margins are increasing and S. cuspidatum decreasing.

Elizabeth Telford (Edinburgh) added to the survey of measuring effects of sheep removal by recording the botanical composition at three sites, Bog Hill, Burnt Hill and Green Hole, using domin ratings and measurements of structure with stratified point quadrats. Whereas there was little difference in cover, the enclosed Calluna was more dense and taller. Measurements of Calluna shoot weight also showed improved growth under enclosure whilst the standing crop of lichen was greater. A report will be made and the results utilised in building up the records of exclosure effects.

Effect of drainage

The effects of draining - moor gripping - are particularly relevant when so much hill drainage, which is grant-aided, is being carried out. The hydrology of blanket bog was investigated by Conway and Millar (J. Instn. Water Engineers 14, 415-424) at Moor House in the 1950's and this work is still quoted as a main source of information (see Donald, A., 1973, in 'Some views on the effects of peat drainage', Scot. For., 27, 315-327). The slow movement of water within the peat, shown also by tritium trials at Moor House, support the findings that open drains are likely to have little effect other than in providing channels for surplus surface water to move marginally quicker than otherwise from the fell.

The botanical effects are similarly unspectacular. The range of plant species on blanket bog is small, so that a major change in management is necessary to alter the vegetation beyond that which occurs in the immediate confines of the drains, where heather grows better due to the peat being drier. Burnt Hill, which was last burnt in the late 1940's, was gripped in 1952 and a small exclosure erected in 1954. Botanical analyses using the point quadrat, have been carried out since then within the fence and outside. In 1975, these analyses were completed for the final time, the differences between years now being insignificant and the differences at points along transects placed at right angles to the drains becoming less, due to the drains becoming less effective with age.

The quadrats are grouped according to their distance from the drain. The up-turned turf is normally on the lower side of the drain in contour ploughing. The groupings of quadrats are (1) those within 1½ m of the drain on the top side, (2) the quadrats 1½ m downslope (including the turf), and (3) and (4) quadrats beyond (1) and (2). Where grazing has been excluded the plant cover was most, in all groupings, some 10 to 17 years after burning. But draining resulted in more Calluna being recorded in 1960, 8 years after draining, in all groupings, especially just above the drain (1). The next and subsequent analyses (1967-1975) gave lower values and the effects of drainage cannot now be detected other than in Calluna overhanging the open drain itself. Sphagna remain less close to the drain, and generally bryophytes are fewer above the drain though liverworts are more sparse below, on the grouping (2) that includes the upturned turf. The grazed situation is similar, Calluna being much the same by 1975 though still more within 1½m of the topside of the drain; the remaining groupings are similar. Thus the effects of draining (such as they are) do not last for long.

To provide further information, a survey of eight sites, three elsewhere on Burnt Hill, two by Nether Hearth, two on Sike Hill and one at Force Burn was completed by Rory Post (University College, London). All sites were drained in 1952. The quadrat layout compared with that of the permanent site on Burnt Hill, but fewer quadrats were studied. Analysis of cover, using the Domin scale, and of structure, using the stratified point quadrat, supported, in general, the reference site findings, although there were some site differences. The processing of the data is incomplete.

Effect of burning

Richard Hobbs (Edinburgh) was given a project of surveying previously burnt bog and determining the effect burning had had on botanical composition, vegetation structure, age structure of Calluna, performance of Calluna and its seedling production.

Hobbs concluded his study by saying that approximately 10 years was needed for the vegetation to return to something approaching the 'unburnt' state. After this, Calluna regains dominance before declining. The age structure becomes increasingly uneven with time, the mean age levelling out after 18 years, and little change being found in performance of heather after 10 years. He suggested that the cover of Calluna, and its performance, may decline slightly after 23 years, but further study is needed. A full report has been produced for the Reserve Record where it is available for study.

Despite the restriction imposed by time the survey achieved much of its aim. Data for ten years covering burning done since 1952, were obtained and the information provides useful support to the grouse management study and the experiment started by Elliott in 1954 on the effect of different burning rotations. Monitoring of the latter trial, and its management is continued.

Effect of removal of sheep grazing from *Agrostis-Festuca* grassland

Re-mapping the vegetation of Rough Sike enclosure (fenced in 1956) has been done on a selective basis. The original grid at the time of fencing has been reconstructed and randomly chosen quadrats mapped. An area of this enclosure was separately mapped in 1963 to follow colonisation and the build-up of silt on a largely bare limestone bed-rock alongside the Sike itself. Soil depth has increased on average 6.8 times so that its depth is now 16 cm, whilst the range of plant species has doubled, and in some cases quadrupled, with the whole vegetation cover now being five times as great. The suggestion is that if this pavement had never been enclosed sheep would have prevented colonisation and a build up of soil.

Number and distribution of sheep

It is 10 years since a survey of sheep distribution and numbers was made. This year the sale of one major flock highlights the importance of repeating the survey next July.

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

Evidence is accumulating that even under the adverse soil and climatic conditions of the northern Pennines, plants, and trees, will enter land free of sheep, especially where some disturbance to the existing ground cover has taken place. This has been seen in such intractable situations as blanket bog, where treatment for experimental studies, such as cutting or digging, has resulted in willows and other plants growing. The enclosures of grassland to which arctic-alpines and montane species were introduced mainly in 1956, are, however, not only very small, but vegetation cover is already complete with fewer opportunities for plant incursions. Nevertheless, new higher plants are now being recorded, 18 and 19 years after enclosure. It is of course, conversely true, the loss of the smaller plants, mostly bryophytes and liverworts is high and this reduces the range of species.

Size of enclosure is clearly important. The complete removal of sheep (and rabbits) from the fell would not have a dramatic effect, but it is salutory to recall that even on Moss Flats, a large expanse of inhospitable eroded peat, a pine seedling has been found.

Aggressive growth by native vegetation and grazing by rabbits and the occasional sheep are the most serious threats to survival for some plant introductions in the lowest and most favourable enclosure, Rough Sike. Shrubs and trees are making good progress, though this may be a reflection of the recent mild winters. Rowan (*Sorbus acuparia*) seedlings have been found for the first time. Bird Cherry (*Prunus padus*) and a variety of willows are doing well, particularly the dwarf willows, *Salix arbuscula* and *S. reticulata*. Cuttings of *S. phylicifolia*, from a highly successful shrub in Green Hole, have taken; seedlings of Potentilla crantzii, Juncus triglumis, Angelica sylvestris, Saxifraga aizoides and Draba incana as well as the orchids, Listera ovata and Dactylorchis spp., have been recorded. The aggression of some introduced species, such as Luzula sylvatica, has knocked out other plants introduced with them. Plants on Knock Fell, severely grazed by rabbits last year, are recovering and flowering has been nearly average.

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

Heavy winter grazing of heather, that was rarely, if ever snow covered, was followed by an exceptionally cold and late spring. The heather was therefore in a very poor state and new growth delayed until June. The summer ended with the moor looking in excellent condition, heather shoots grew exceptionally well and profuse flowering was much above average.

In the second year of the management study small strips were burnt on Green Burn (B) and Hard Hill (B), and the treatment of the long-term burning trial on Hard Hill was continued. In this trial two rotations of burning, every 10 and every 20 years, are applied to enclosed and grazed plots. Very dry conditions resulted in exceptionally good burns even of the short rotation plots. The next round of botanical analysis is not proposed until 1982.

Phil Holms repeated the grouse survey, which adverse weather conditions and lack of time made difficult to carry out. His report follows:

The aim of this study is to gain an accurate account of red grouse populations on the Reserve. Counts of adults are carried out in the spring, of nests and eggs in the summer and to establish breeding success in August.

The main parameters of grouse population studied are the following:

1. Numbers of adults
2. Number of nests
3. Clutch size
4. Hatching success
5. Breeding success

This season began with lower spring temperatures than usual which affected the grouse directly by reducing their food supply. Hard ground frosts in May, heavy rain and snow falls in June caused a high mortality among the birds. This breeding season follows a year of lower numbers and young to old ratio of only 1.79/1.

The study areas

The four new areas which were plotted last year on the Hard Hill and Green Burn areas have been increased in size. The main count plots, including the original areas Bog End, Burnt Hill, The Drive and Hard Hill 2, total 350 acres. Though the Hard Hill and Green Burn areas seem similar, their respective grouse densities vary considerably; it is hoped that the increased areas will make for greater accuracty in future study.

Method

The study areas were counted by using a trained pointer which ranged either side of the observer and flushed the birds. The dog was used to locate nests later in the year. Areas were counted from the leeward side so that the birds recorded tended to fly downwind and away from the area and are not counted twice. On each of the eight study areas twice weekly counts were carried out in March to assess the number of breeding birds. Counts were done in August, later than is usual, to estimate the breeding success. The positions of the breeding birds were plotted on maps of the areas involved.

Table 1 Study areas

Area	Grid Ref.	Height (ft.)	Acreage
Bog End	35/765330	1825	25
Burnt Hill	35/754330	1850	50
The Drive	35/763335	1800	50
Hard Hill 2	35/732344	1950	35
Hard Hill A	35/737325	1975	53
Hard Hill B	35/741327	1950	61
Green Burn A	35/772312	1800	39
Green Burn B	35/768314	1850	37

Table 2 Density of grouse per study area in Spring 1975

Site	Area	No. of adults	Birds/ha	Birds/ac.
Bog End	10.1 ha	10	0.99	0.40
Burnt Hill	20.2 ha	16	0.79	0.32
The Drive	20.2 ha	11	0.54	0.22
Hard Hill 2	14.2 ha	8	0.56	0.23
Hard Hill A	21.4 ha	11	0.51	0.21
Hard Hill B	24.7 ha	13	0.53	0.21
Green Burn A	15.8 ha	8	0.51	0.20
Green Burn B	15.0 ha	7	0.47	0.19
Main Area Average			0.61	0.25

Results

Nesting

The winter and early spring mortality greatly reduced the previous August population and the potential breeding birds of the spring. When counting commenced in March, numbers were very low indeed which made later study with nests and chicks more difficult than in a year of higher numbers.

A total of 26 nests were located on areas including the main study plots of which 22 (84.5%) hatched successfully. Black-headed gulls have, in previous years, been responsible for the majority of nests robbed but this season they had little effect on the breeding birds. Nests were very successful and hatching numbers were high.

Nest failures on study areas

Nests	Desertions	Robbed	Total
26	3 (11.5%)	1 (3.8%)	4 (15.3%)

Clutches were quite large this year, 6.7 compared with last year's 5.4.

Table 3 Estimation of clutch size

Area	No. in clutch	Total	Average
Bog End	5,6,7.	18	6.0
Burnt Hill	5,8.	13	6.5
The Drive	8,7.	15	7.5
Hard Hill 2	5,7.	12	6.0
Green Burn areas	5,9,5.	19	6.3
Hard Hill areas	5,6,6,8.	25	6.2
Nests recorded elsewhere on Reserve	6,10. 7,9,8,8. 10.	58	8.2
	Total No. of eggs	160	
	Main area average		6.7

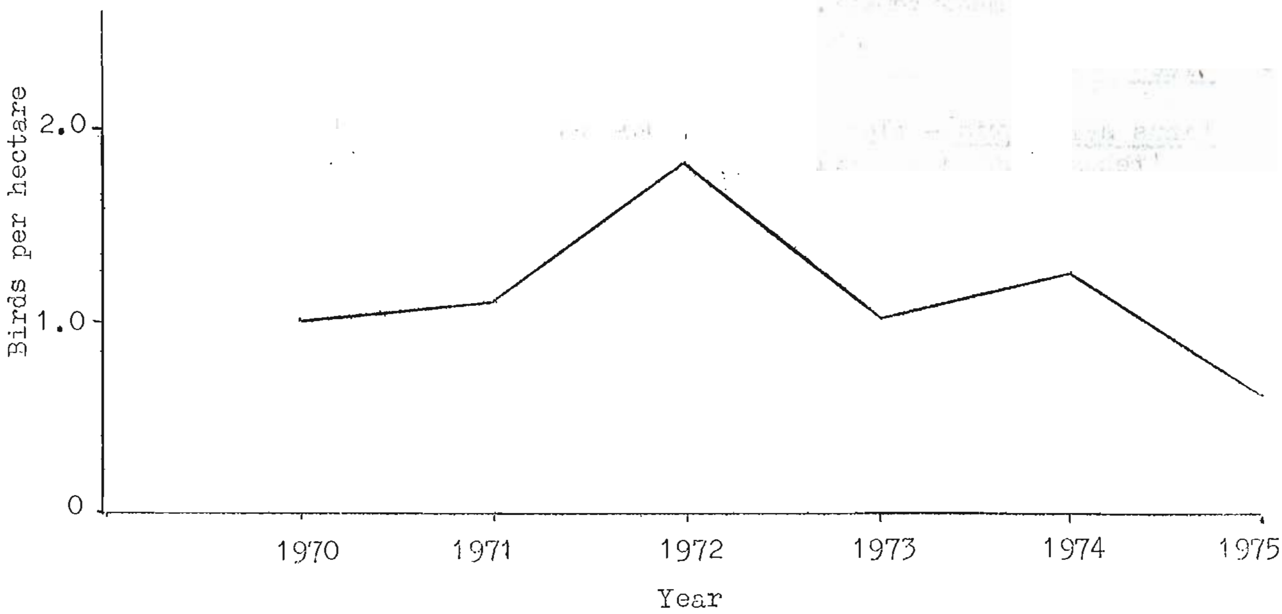
Chicks

Exceptional rainfall in the first week of June exceeded that of the whole month of May. Highest mortality was found among chicks less than 10 days old through drowning and chilling. Two days of snow lie in the first week of June also had an effect upon the chicks. Previous location of nesting sites was found to have been an important factor deciding the success of the brood. The broods which survived this period were most successful and tended to be larger than usual. Many under-developed chicks, the product of second clutches, and the exceptionally warm weather in July made final counting at this time impossible. Counts were delayed until late August when the birds were more advanced.

Table 4 Replicated counts to estimate breeding success

Area	Adults	Young	Young/Old	Av/Site
Bog End	5	11	2.20/1	2.33/1
	4	11	2.50/1	
Burnt Hill	6	14	2.33/1	2.19/1
	10	21	2.10/1	
The Drive	5	12	2.40/1	2.33/1
	7	16	2.29/1	
Hard Hill 2	3	8	2.66/1	2.37/1
	5	11	2.20/1	
Hard Hill A	4	8	2.00/1	2.11/1
	5	11	2.20/1	
Hard Hill B	5	10	2.00/1	2.00/1
	6	12	2.00/1	
Green Burn A	4	9	2.25/1	2.12/1
	4	8	2.00/1	
Green Burn B	6	12	2.00/1	2.20/1
	4	10	2.50/1	
			Overall average	2.21/1

Fig. 1 Density of grouse breeding stock on Reserve



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

In the autumn of 1974 a survey was started to record a sample of trees for performance, growth measurements and survival. The work was done mainly by R.B. Marsh who reports as follows:

As no systematic measurements of tree growth have taken place at Moor House for a number of years, it was decided to make a series of measurements and mark the selected trees for repeat measurements in the future. Tree planting has varied according to enclosure so the manner of selecting the sample differed. The method (the enclosures, number of samples and arrangement of planting vary) is summarised as follows:-

Nether Hearth

Pinus contorta - planted in groups of 25 in Anderson circles. 50 trees sampled, approximately 2 selected at random from each group. The trees were measured for height, shoot increment for the current year (ie. length of main leader) and girth of trunk at 135 cm above ground.

Pinus mugo var *rostrata* - planted in groups of 25 trees in Anderson circles. There are 27 such circles. The group was measured for height of tallest branch and annual increment, taking 10 leaders per group.

Pasture

Pinus contorta - planted in rows of 5 trees, the fifth in 50 such groups was measured for height, increment and girth.

Pinus sylvestris - as above.

Pinus mugo var *rostrata* - 5 leaders were selected from 50 trees for increment measurement.

Green Hole

Pinus sylvestris - planted in Anderson circles and random spacing. 50 trees selected in enclosure, measured for height, increment and girth.

The measurements were made in October and November, 1974 and averages are given below:

HEIGHT in cms.	Pinus contorta	P. sylvestris	P. mugo
Nether Hearth	322.5	-	168.9
Pasture	196.8	172.8	125.6
Green Hole	-	191.3	-
INCREMENT in cms.			
Nether Hearth	25.5	-	15.4
Pasture	31.0	26.4	18.4
Green Hole	-	19.2	-
GIRTH in cms. at 135 cms.			
Nether Hearth	16.4	-	-
Pasture	7.6	7.8	-
Green Hole	-	9.0	-

Certain features of tree growth were looked at further. The sample was of 50 trees and gave the following results:

	Health good	Presence of original leader	As tall or taller than surrounding trees	Typical growth form
Pinus sylvestris (Pasture)	54%	68%	38%	60%
P. contorta (Pasture)	80%	66%	54%	46%
P. contorta (Nether Hearth)	36%	60%	72%	50%

Tree growth in 1975 started well after a relatively storm-free winter, but during early June, Pinus sylvestris showed signs of dying in all enclosures. The cause would appear to have been drought at a time of maximum soil moisture demand by the trees. Only 6 days of 'moist ground' were recorded at the Met. Station between 17 May and 17 June.

A number of Pinus contorta also showed signs of senescence. An examination in September of marked Pinus sylvestris trees in the Pasture showed that of 54% that were recorded as healthy in 1974, only 30% remained so, whilst 62% of the original 50 healthy trees showed signs of dying, two were nearly dead and two completely dead.

In the spring the field station staff planted 100 grey alder and 10 scotch elm in the nursery and 300 Pinus mugo and 100 P. contorta were planted in enclosures around the house.

In 1975 Anne Lowes (Newcastle) undertook a re-survey of most of the permanent quadrats (Braun Blanquet) in Green Hole, and extended the size of a selected number of these quadrats. She recorded also the performance of the trees and listed the plants present, and their abundance, in the more sheltered "dells" and limestone sink-holes of the enclosure.

A comparison of all the quadrats for the number of species/quadrat showed the following changes:

	1965	1972	1975
Vascular plants, including grasses	7.9	5.7	5.0
Angiosperms, excluding grasses	6.0	3.3	3.0
Grasses	2.7	2.5	1.9
Mosses	6.2	3.7	1.7
Liverworts	2.3	1.3	0.2
Lichens	1.0	0.2	-

Changes in composition are similar to the results obtained from other sites, the absence of grazing being important, rather than the effect of trees, other than below the canopy of Scots Pine. So there has been an increase in the cover of the more aggressive grasses, particularly Deschampsia flexuosa, but also Agrostis tenuis, D. cespitosa, Festuca rubra and Holcus lanatus and of Calluna, Carex nigra, Galium saxatile, Vaccinium myrtillus and the mosses Pleurozium schreberi and Rhytidiadelphus squarrosus. Among the liverworts Lophozia ventricosa alone seems to have held, and in some cases increased, its position.

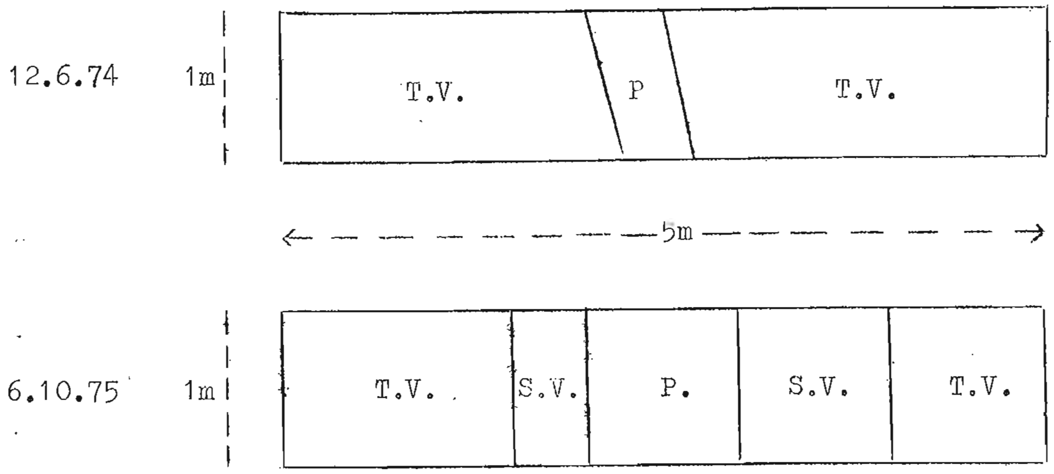
f) Ski-ing (M. Rawes, R.B. Marsh and J. Rose)

Lack of snow led to fewer skiers than usual and only in March, almost solely over the Easter holiday, were numbers higher than the 6 year average. The busiest day was Easter Sunday when 110 skiers were counted, 5 tows were in use, 35 sledges, 64 spectators and 107 cars. It was estimated that about 500 people visited Dun Fell that day. Most ski-ing occurs in an east-facing gulley the vegetation of which was mapped in 1974. The mapping and photography of selected quadrats (started in 1969) will be repeated.

g) Pennine Way (R.B. Marsh)

The monitoring of the sites set up in 1974 and described in the 15th Annual Report continues. All the sites first laid out in spring 1974 show increased signs of wear, not necessarily in creating bare patches but in widening the path by treading, as the diagram overleaf shows.

Diagram of Site 9, set up in 1974 on a *Juncus squarrosus* sward.



T.V. - Tall vegetation - tends to be untrampled.

S.V. - Short vegetation - tends to be trampled but no definite path..

P - Path - trampled vegetation.

If the pathway is examined after a period of extensive rain, signs of erosion in the depression of the pathway can be seen. Small deltas of silt can be seen at the base of steep slopes similar to those described by Bayfield (1974), Biological Conservation, 6, (4), 246-251. Water runs down the slope like small drainage channels.

On the summit of Little Dun Fell the pathway is for the first time giving rise to concern. Treading, perhaps because of the exceptionally dry summer has worn bare patches of *Vaccinium myrtillus* and *Polytrichum* spp. which are unlikely to recover and within a few years much of the path will be denuded of vegetation.

Figures obtained from the Youth Hostel at Knock for the last year show that 4,124 people stayed, of which the majority were on the Pennine Way. From a small survey of walkers it appears that 73% of people asked, stayed at the Youth Hostel, so an estimated figure for people on the Pennine Way last year would be 5,649. The Youth Hostel figures show a 10% increase in the last year, with higher increases in previous years. If a 10% increase is realised in 1975, the number of walkers will reach 6,213 this year. These figures will be checked at the end of the season.

The Pennine Way goes right past the front door of the new Y.H.A. Hostel at Alston, so an exact number should be obtained in future. The old Knock Hostel was 2-3 miles from the official Pennine Way.

L. Heslop (Salford University) completed an M.Sc. Thesis which includes an account of the local use of the Pennine Way. The relevant parts are being made available and are held in the Reserve Records.

h) Meadow (M. Rawes, R. Williams, R.B. Marsh and Linda Teasdale)

Vegetation samples of the standing crop, cut just above ground level, have been taken each year since 1958 from plots laid in a transect across the field. The samples are cut, usually in mid-July, before hay harvest. Yields average 3785 kg dry weight/ha with a range of 2780 to 5170 kg/ha. This year the crop was 3330 kg/ha, a reflection on the late spring, and perhaps dry weather.

The intention had been to lay down a number of permanent quadrats in 1975 to monitor the botanical composition of the field. There was however, insufficient time for this so hay samples were taken, sorted into species and dry weighed to give the following percentage results:-

Alopecurus pratensis	28.0	Cerastium holosteoides	1.0
Festuca rubra	10.0	Ranunculus spp.	0.5
Anthoxamthum odoratum	8.5	Rumex acetosa	0.5
Holcus lanatus	0	Festuca ovina	0.5
Poa pratensis	8.0	Bellis perennis	trace
P. trivialis	6.0	Trifolium repens	trace
Dactylis glomerata	5.5		
Agrostis tenuis	5.5		
Holcus mollis	4.5	Unidentified grass (dead)	13.5%

Alopecurus pratensis and Dactylis glomerata are not found elsewhere on the Reserve.

III. RESEARCH BY MERLEWOOD RESEARCH STATION STAFF (INSTITUTE OF TERRESTRIAL ECOLOGY)

Among the projects undertaken in the past by Merlewood staff have been studies on the nutrition of trees (A.H.F. Brown) and measurements of the rates of plant decomposition (O.W. Heal and Pam Latter) and chemical changes during plant decomposition (S.E. Allen). There is every possibility that these studies will continue and reports become available in future.

a) Plant ecological studies on peat (A.J.P. Gore)

1. Factors limiting plant growth on peat

A manuscript has been completed and should be submitted to the Journal of Ecology in the near future. The effects of climate appear to be primarily due to temperature on net assimilation confirming indications of previous experiments and of predictions of models developed by J. Grace and H. Woolhouse (see previous Moor House Reports).

2. A survey of surface slope and peat depth on Hearth Hill near the Field Station at Moor House has resulted in two computer generated contour maps. The help of Dr. J.K. Lewis of the ATLAS Computer Laboratory is gratefully acknowledged. By superimposing the map of depth contours on that of height contours, the relationships between slope and peat depth has shown variations from an expected simple relationship. Initially, however, it is planned to confine further studies, suggested by previous work and reported completed in the 1974 report, to those areas where surface angle of slope and peat depth are inversely related.

3. Good agreement has been obtained between tho two automatic weather stations on loan from the Institute of Hydrology which are being calibrated this year at the Moor House Climatological Station. The enthusiastic help of Mr. M. Walker and Dr. R. Templeman, both of the Institute of Hydrology is much appreciated.

b) Competition between grass species (Helen E. Jones)

This project is an attempt to determine experimentally the growth of *Agrostis tenuis* and *Festuca ovina* in mono- and mixed-culture; to determine the effect of cropping on this growth, and to build simulation models to predict the effect of cropping on a variety of mixtures of the two species.

A preliminary experiment in which tillers of the two species, which were removed from swards at Moor House, were grown in pots in the greenhouse in monoculture and 1.1 mixed culture has just been completed, although results have not yet been analysed. This was to determine the effects of growing the two species together, without cropping treatment. A second experiment is planned in which the tillers in mono- and mixed-culture will be cut at weekly intervals. Harvesting will take place over a period to time so that the dynamics of the species' interactions may be studied.

IV. RESEARCH BY FRESHWATER BIOLOGICAL ASSOCIATION

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

Studies on fish populations at Cow Green have continued and good progress is now being made in processing the results. These studies include routine observations on fish populations in Force Burn and in the River Tees within the Reserve.

Some preliminary observations on fish populations in Knock Ore Gill and Swindale Beck were made during 1973 (see 1973 Report). During 1975 it has been possible to average a thrice-yearly census and survey of fish populations in Knock Ore Gill and also to make limited supporting observations in Swindale Beck. The results have not yet been processed. When they are, it is hoped that they will form the subject of a short publication on fish population density and production for comparison with similar work already done in Trout Beck.

V. RESEARCH BY UNIVERSITIES

a) A study of the factors influencing the abundance of invertebrates on blanket bog (J.C. Coulson and Dr. Jennifer E.L. Butterfield, University of Durham).

Litter Bag Studies

A preliminary investigation has been made by using standard litter bags in which plant material from fertilized sites or control sites were placed on areas which were untreated or had had low quantities of P and N added (5 g P/m^2; 10 g N/m^2).

The results indicated that there was a small but significant increase in the rate of decomposition on moor edge areas treated with P. In particular, the decomposition of untreated *Juncus squarrosus* litter was increased by 38%. No similar effects were found with *Calluna* or *Sphagnum* litter on treated blanket bog.

In contrast, N fertilization had a depressive effect on the rate of decomposition on moor edge but increased the decomposition on blanket bog by between 10% and 16%. This experiment suggests that the effects of N and P fertilizing are markedly different on blanket bog and moor edge, P increasing decomposition on moor edge whilst N is the effective agent on blanket bog.

In a further investigation, P enriched *Juncus squarrosus* litter placed with controls on a unfertilized site showed a 10% increase in the rate of decomposition whilst the comparable figures for *Festuca* was 8% and *Sphagnum* 48% but there were no significant differences with *Calluna* or *Eriophorum* enriched litter.

In contrast N enriched *Calluna* litter showed an 18% increase in decomposition and *Eriophorum* 9% increase. Neither *Juncus* or *Festuca* showed a significant change in decomposition rate.

These results can be interpreted as indicating that the soil organisms responsible for decomposition are selectively choosing N enriched litter on blanket bog and P enriched litter on moor edge.

Further investigations are in progress.

Fauna on fertilised blanket bog

Pit-fall trap captures on the blanket bog, using both N and P fertilized plots and control areas, showed a 30% increase on N treated but no change on the P treated areas.

Comparison of fauna on Juncus-Calluna interface

Pit-fall traps were situated 1 m apart and 0.5 m in from the *Juncus squarrosus*-*Calluna* interface between April and July 1974.

Highly significant differences were found in all groups examined with a total of 8628 arthropods from 8 traps on *Juncus* and 4496 on *Calluna* i.e. 92% more on the *Juncus*, in the same number of traps. The most marked differences were in beetles (159% more) whilst only harvestmen showed smaller captures on the *Juncus*.

b) Studies on *Tipula subnodicornis* and the Meadow Pipit (J.C. Reynolds and M.G.M. Randall, University of Durham)

A study of the emergence of *Tipula subnodicornis* was made at Bog End on an area where the blanket bog surface increases by 2 m over a horizontal distance of 30 m to a rounded plateau. The date of emergence was found to vary over this short distance. There was also a change in female fecundity.

The mean date of male emergence is described by the regression:-

$$y = 0.8259x + 13.993 \quad (r = +0.889)$$

The regression for females is:-

$$y = 1.35x + 19.293 \quad (r = +0.999)$$

Where y is the mean date (10 May being day 1) and x the distance up the slope measured in 5 m units (equivalent to 0.3 m increase in height).

Female fecundity is described by:-

$$y = -5.4x + 194.35 \quad (r = -0.979)$$

Where y is the number of eggs per female and x is the distance up the slope as in the other regressions.

The effects described above probably reflect the change in angle to solar radiation, modifying the development date, while the female fecundity may be influenced by changes in the chemical composition of vegetation up the gradient.

The investigation on the Meadow Pipit was aimed at determining the nesting area, clutch size, breeding success and food brought to the young.

Laying was exceptionally late with a mean laying date of the first egg estimated as 14 May (based on 9 nests).

The mean clutch size in 9 nests was 4.11 eggs (eight c/4, one c/5).

Exceptional snow fall on 2 and 3 June caused chick mortality in several nests and a marked loss in weight in surviving young. Of 5 nests known before the snow, one successfully hatched all four eggs afterwards, whilst in the remaining four nests only one young survived from 6 eggs laid.

c) Studies on blackfly larvae (Diptera: Simuliidae) in Moss Burn (R.S. Wotton, University of Newcastle upon Tyne)

Further sampling of the larval population was continued in late summer this year and there was a marked change in species composition compared with that found in 1972 and 1974. The collections obtained on three dates can be used as examples:-

		% larval frequency				
Sample	n	S. vernum	S. brevicaule	S. aureum	S. monticola	S. nitidifrons
29 viii 72	159	56	10	0	23	11
26 viii 74	129	51	6	0	35	8
10ix 75	142	20	18	4	1	57

In 1975 S. nitidifrons was the dominant species and S. aureum was found for the first time in the lower reaches of Moss Burn. In both 1972 and 1974 S. monticola had been the second-most numerous species, this year it was very poorly represented. These changes reflect the very different climatic conditions between the three years.

d) The effect of altitude on the ecology of the frog (Rana temporaria) (R.C. Beattie, University of Durham)

The date of spawning in 15 ponds ranging in altitude from 61 to 838 m was recorded in the spring of 1974 and 1975.

The date of spawning in days after 1 January (y) was related to altitude (x) by the following relationship:-

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

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

In lowland ponds there was little difference between the date of spawning in 1974 and 1975. Spawning in high altitude ponds tended to be later in 1975 than in 1974. In both years spawning was later at higher altitudes.

The swelling of the gelatinous envelope surrounding the frog embryo was found to be retarded more in some pond waters than others. The size of this insulating envelope may affect the temperature of the embryo and hence its rate of development.

The hypothesis that the ionic nature of a pond indirectly affects the rate of embryonic development is at present being investigated.

Moor House 16th Annual Report

Correction - M. Ashmore's report, pages 27-34.

Photosynthesis values given throughout are 3 orders of magnitude too high. They should have appeared as

$$\text{nano g cm}^{-2}\text{sec}^{-1}$$

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

This is a long-term study of the dynamics of populations of Homoptera on different vegetation types. Sampling continued this summer during the absence of Dr. Whittaker in Canada and a report will be made next year.

f) Studies on the photosynthesis and water relations of *Calluna vulgaris* (M.R. Ashmore, University of Leeds)

The object of this project was to learn more about the factors controlling the growth of *Calluna* at Moor House. This was done by making measurements of the plant's physiological processes and growth in the field. In this report, I have tried to summarise some of the main results of the work. Brief descriptions of the methods used can be found in earlier Annual Reports.

Photosynthesis

Rates of photosynthesis were measured at regular intervals between June and October in 1974. Over this period, the light saturated rate of photosynthesis of the 1974 season's shoots increased from about 8 mg $cm^{-2}s^{-1}$ to 18 mg $cm^{-2}s^{-1}$, while that of the overwintered shoots of the 1973 season remained constant at about 8 mg $cm^{-2}s^{-1}$. These rates are considerably lower than recorded values for most temperate and sub-arctic species, but are similar to values obtained for other evergreen shrubs growing at other IBP Tundra Biome sites (Tieszen *et al*, 1975).

Grace (1970) found that the photosynthetic rate of *Calluna* plants collected from Moor House, and measured under constant conditions in the laboratory, closely followed the yearly pattern of mean air temperature. He suggested that the photosynthesis of *Calluna* in the field was primarily limited by temperature. Two results obtained in the present study show that low night temperatures are particularly important in limiting photosynthesis:-

(1) A regression analysis showed that the temperature on the previous night significantly affected the photosynthetic rate on the subsequent day. For each 1°C fall in air temperature, the light saturated photosynthetic rate of the 1974 season's shoots fell by 0.8 mg $cm^{-2}s^{-1}$.

(2) 1974 season shoots, which were 'browned', had significantly lower rates of photosynthesis. For instance, on 20 June, soon after budburst, it was estimated that half of the new shoot tissue was browned. The mean light saturated photosynthetic rate of completely browned shoots was only 25% of that of completely green shoots. Now browning of *Calluna* shoots is thought to be due to dessication. Spring browning probably occurs on clear frosty mornings following a cold night, when soil temperatures are low, and thus water uptake is restricted, but transpiration rates are relatively high.

Thus low night temperatures can cause immediate reductions in photosynthesis, and long-term physiological damage due to browning, in the current season's shoots. However, neither low night temperatures nor browning significantly affected the photosynthesis in the over-wintered shoots, which must develop some form of resistance during the winter. The significance of these facts is discussed further below.

Growth

Only shoot growth was measured. The seasonal pattern of shoot growth in 1974 is shown in figure 1. From the smooth curves fitted to these data, it is possible to calculate the seasonal course of shoot net assimilation rate (N.B. this is shoot, not total plant, net assimilation rate). In figure 2, these values are plotted alongside calculated weekly mean values of light-saturated photosynthetic rate. The two y-axes have been scaled on the basis of Grace's model of *Calluna* growth and the data of Grace and Woolhouse (1973), which indicate that daily plant net assimilation rates are 1/8 to 1/10 of the light-saturated photosynthetic rates when expressed in the same units. Thus the difference between the two sets of points on each graph represents the amount of assimilate entering or leaving the shoots at any point in time. Two main features are shown by these figures.

(1) There was a fall in shoot net assimilation rate in July, coinciding with the emergence of new flower buds. This indicates an increasing export of assimilate for stem and root production. Such a growth pattern, in which assimilate is used mainly for shoot production early in the season, will be particularly advantageous in the short growing season at Moor House, since it allows the amount of new leaf material, and thus the photosynthetic capacity of the plant, to be increased as rapidly as possible.

Even so, almost no growth occurs until after the summer solstice, and shoot growth is concentrated in a period of 6 to 8 weeks in June and July. Thus the climatic conditions, especially night temperatures (see above), during this period are of critical importance in determining the annual production of *Calluna*, since wood and root production later in the season will also be limited by the amount of shoot produced in these weeks. For instance, the eleven ground frosts recorded in June, 1974 may have been a major factor accounting for the poor performance of the plant in 1974.

(2) Up to the end of July, the photosynthetic rate of the new shoots was insufficient to account for their growth rate (figure 2(a)), although this was not the case when total shoot growth and photosynthesis (ie. of new plus overwintering shoots) was considered (figure 2(b)). Therefore, assimilate produced in overwintering shoots, and exported to the new shoots, made an important contribution to shoot production over this period. For instance, it was calculated from measurements of photosynthesis that, on 1 July 1974, 70% of the total photosynthate was produced by overwintering shoots.

This indicates that the retention of physiologically active shoots over the winter is important since it allows new shoots to be produced as rapidly as possible at the start of the season. The xeromorphic, sclerophyllous structure of *Calluna* leaves may thus be an important adaption at Moor House, allowing them to withstand the dessicating conditions thought to cause winter browning. Furthermore, since the photosynthesis of overwintered shoots is unaffected by low night temperatures, they provide a 'guaranteed' supply of assimilate which is unlikely to be reduced by adverse climatic conditions. This contribution from overwintering shoots would be especially significant in a poor summer such as that of 1974. If this season had been preceeded by a severe winter, rather than the mild winter which actually occurred, the growth of *Calluna* might have been more severely restricted than was actually the case.

Finally, some comparisons of shoot growth in different years can be made. The mean length of the leading long shoots produced in 1974 was only 51% of that in 1973, while some measurements made in late August, 1975, indicated that the mean leading long shoot length was 250-300% of that in 1974. Flower production was lower in 1974 than in 1973 and 1975, and shoot dry weight production was also lower in 1974 than 1973. An inspection of the climatic records for these years indicates that the data support the contention of Grace (1970) that the growth of Calluna at Moor House is limited by temperature.

Water Relations

The stomatal resistance of Calluna increased in the middle of days of high evaporative demand, when the shoot water potential fell to -8 to -10 bar (figure 3). A similar relationship was obtained under controlled laboratory conditions.

From measurements of stomatal resistance, r_s s cm^{-1}, shoot water potential, ψ_1 bar, and vapour pressure deficit, VPD m bar, the plant resistance to water movement from the soil to the leaves R_p, was calculated using the equation given under figure 4. The values obtained ranged from 9 to 30 bar s cm^2 ug^{-1}, with a seasonal mean for 1974 of 15 bar s cm^2 ug^{-1}. These values are at least ten times higher than values recorded for any other species, although Hinshiri (1973) obtained a value of 8 bar s cm^2 ug^{-1} for Calluna growing in a lowland wet heath community in Scotland. It is highly probable that most of this resistance to water movement lies in the roots. The root system of Calluna is known to be highly sensitive to anaerobic conditions (Gimingham 1972). On the blanket bog at Sike Hill, only small adventitious roots restricted to the top 5 cm of the peat, are found. They constitute only about 5% of the total plant dry weight.

Using the same equation, and assuming a constant value of plant (root) resistance of 15 bar s cm^2 ug^{-1}, the relationship between VPD and ψ_1 can be calculated for different values of r_s. In figure 4, two predicted lines for the highest and lowest values of r_s measured in the field are plotted alongside actual values obtained on different days in 1973 and 1974.

Figure 4 shows that stomatal resistance begins to increase above its minimum value of 3 s cm^{-1} when the vapour pressure deficit reaches 3-4 m bar. Applying an empirical relationship between air temperature and VPD derived from field data to the Moor House meteorological records, I estimated that this VPD would be reached on 80% of days in June, July and August in 1974 and exceeded on 35% of these days. Although this is a very rough estimate, it does indicate that midday increases in stomatal resistance were not uncommon, even in the cool summer of 1974.

Any increase in stomatal resistance must cause a decrease in the rate of photosynthesis. However, the total resistance to CO_2 movement into a leaf also includes a resistance to CO_2 transfer across the mesophyll cells to the site of fixation in the chloroplast. The minimum values of this resistance in Calluna at Moor House were 30 to 50 s cm^{-1}, ie. they were ten times higher than the minimum stomatal resistance. Therefore the reductions caused in photosynthetic rate are relatively small. The recorded reductions in the mean rate of photosynthesis between 11 a.m. and 3 p.m. due to increases in stomatal resistance ranged from 8% to 25% on different days.

The poorly developed root system of *Calluna* restricts the supply of water to the leaves and can cause stomatal closure, and thus some reduction in the assimilation rate of the plant. However, figure 4 shows that stomatal control of transpiration can prevent other, potentially more damaging, consequences of the restricted water supply. For instance, if the stomatal resistance remained constant at 3 s cm^{-1}, the shoot water potential could fall as low as -40 bar, which Bannister (1971) showed to be a lethal level for *Calluna* shoots in summer. Similarly, laboratory experiments showed that plasmolysis of *Calluna* leaf cells began when the water potential fell to -15 bar. Thus, the maintenance of the shoot water potential at, or above -12 bar, regardless of the VPD (cf. Fig 4), by stomatal control of transpiration may prevent disruption of cell structures occurring.

Rawes and Welch (1969) found the performance of *Calluna* was significantly improved on better-drained areas of the bog (eg. where it overhangs drainage channels). This may be due to a reduced frequency of stomatal restriction of the photosynthetic rate, and of physiologically damaging shoot water potentials, because of the improved water supply from a larger, more aerated, root system. However, such a larger root system could have other physiological consequences; for instance, the leaves may receive a greater supply of nutrients, and, as suggested by Armstrong and Boatman (1967), toxic substances which would otherwise enter the transpiration stream can be oxidised in the aerated root zone.

Conclusions

The effects of low temperatures on photosynthesis and shoot growth, and the inhibition of root growth on the waterlogged, anaerobic soil, have been identified as major factors limiting the growth of *Calluna* at Moor House. The summer of 1975 was exceptionally warm and sunny, but frequently the surface layers of the bog became dry. However, the growth of *Calluna* was notably better than in any of the previous three years. Such evidence suggests that temperature, rather than restricted water supply, is the overriding factor limiting growth of *Calluna*. However, differences in the performance of *Calluna* within the reserve may well be explained by differences in the extent of drainage of the bog.

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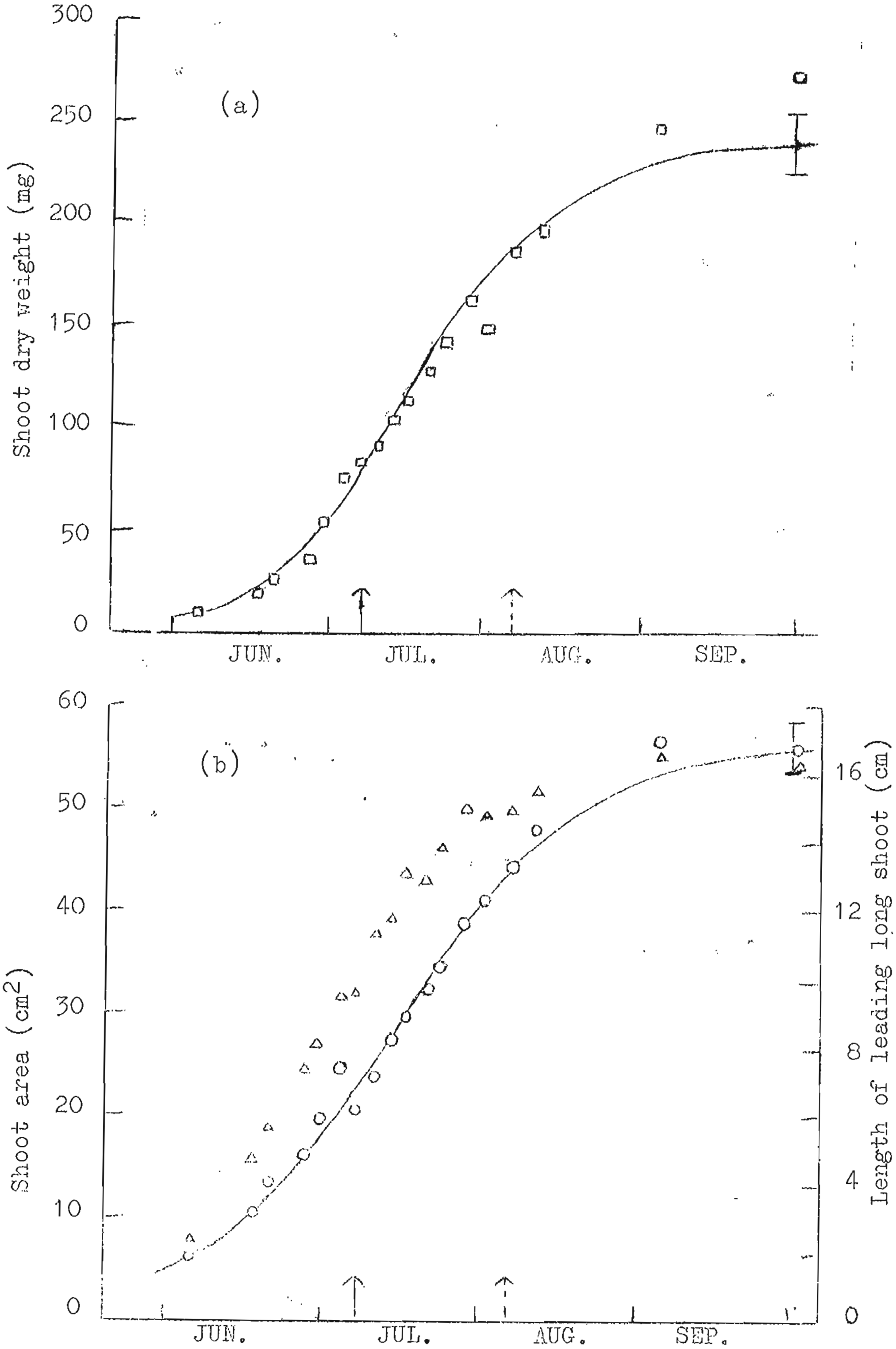
Figure 1 The combined seasonal growth of ten shoots in 1974



Key to Figure:-

□ = total shoot dry wt. (mg)

△ = total length of leading long shoots (cm)

I = standard error of the asymptote of the fitted curve.

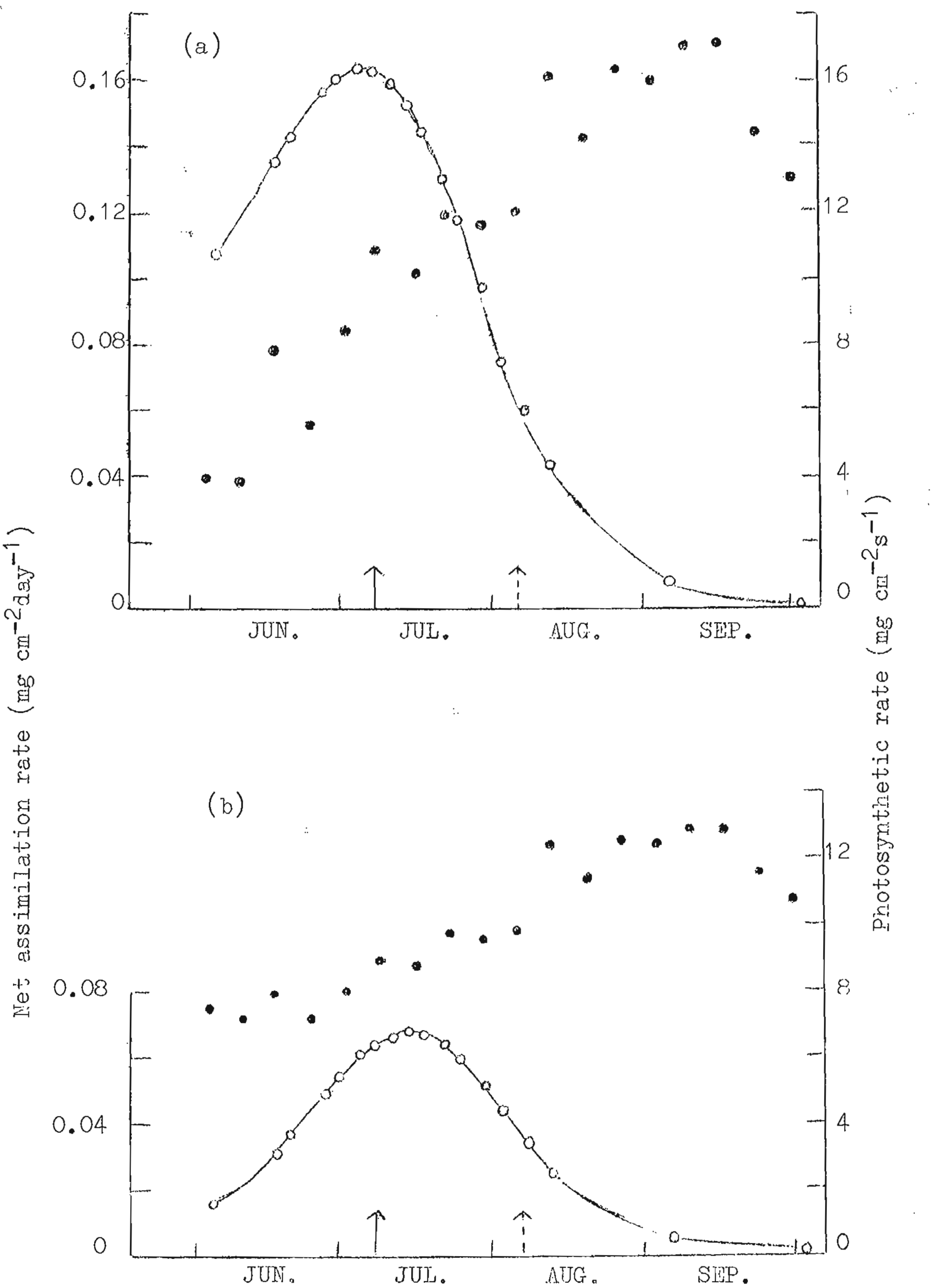
○ = total shoot area (cm^2)

— = logistic curves fitted to the data.

↑ = approx. date of emergence of first flower buds.

⇡ = approx. date of emergence of first flowers.

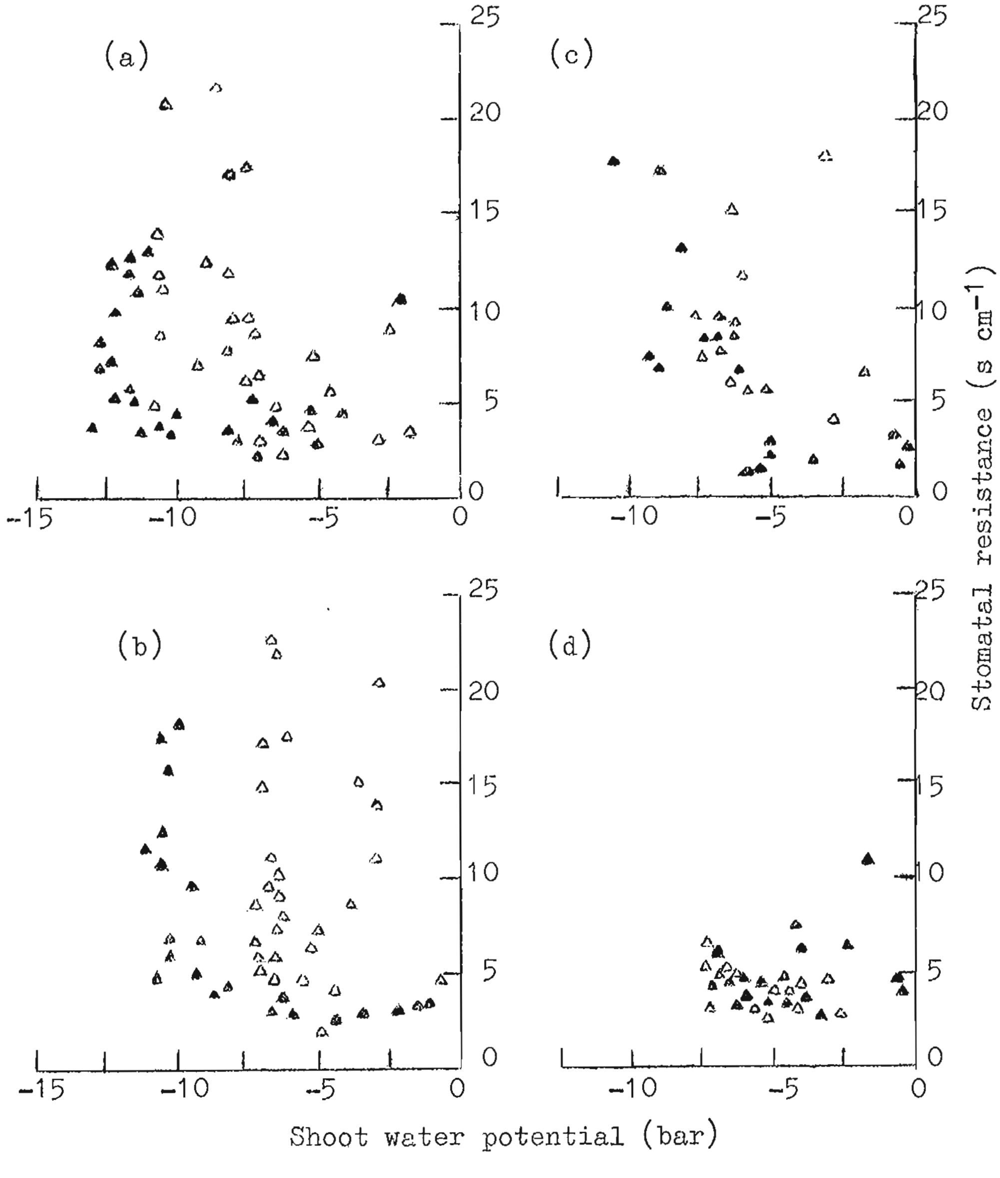
Figure 2 The seasonal course of growth and photosynthesis in 1974.



Key to Figure:-

- • = calculated weekly mean values of light-saturated photosynthetic rate (mg cm^{-2}s^{-1})
- o–o = shoot net assimilation rate (mg cm^{-2}d^{-1}) calculated from fitted growth curves.
- (a) = growth and photosynthesis of the current season's shoots
- (b) = growth and photosynthesis of total shoots (ie. current season's plus overwintering shoots)
- ↑ ↑ = as in Figure 1.

Figure 3 The relationship between shoot water potential and stomatal resistance to water vapour movement on (a) 21 May; (b) 19 & 20 June; (c) 7 July and (d) 16 August.

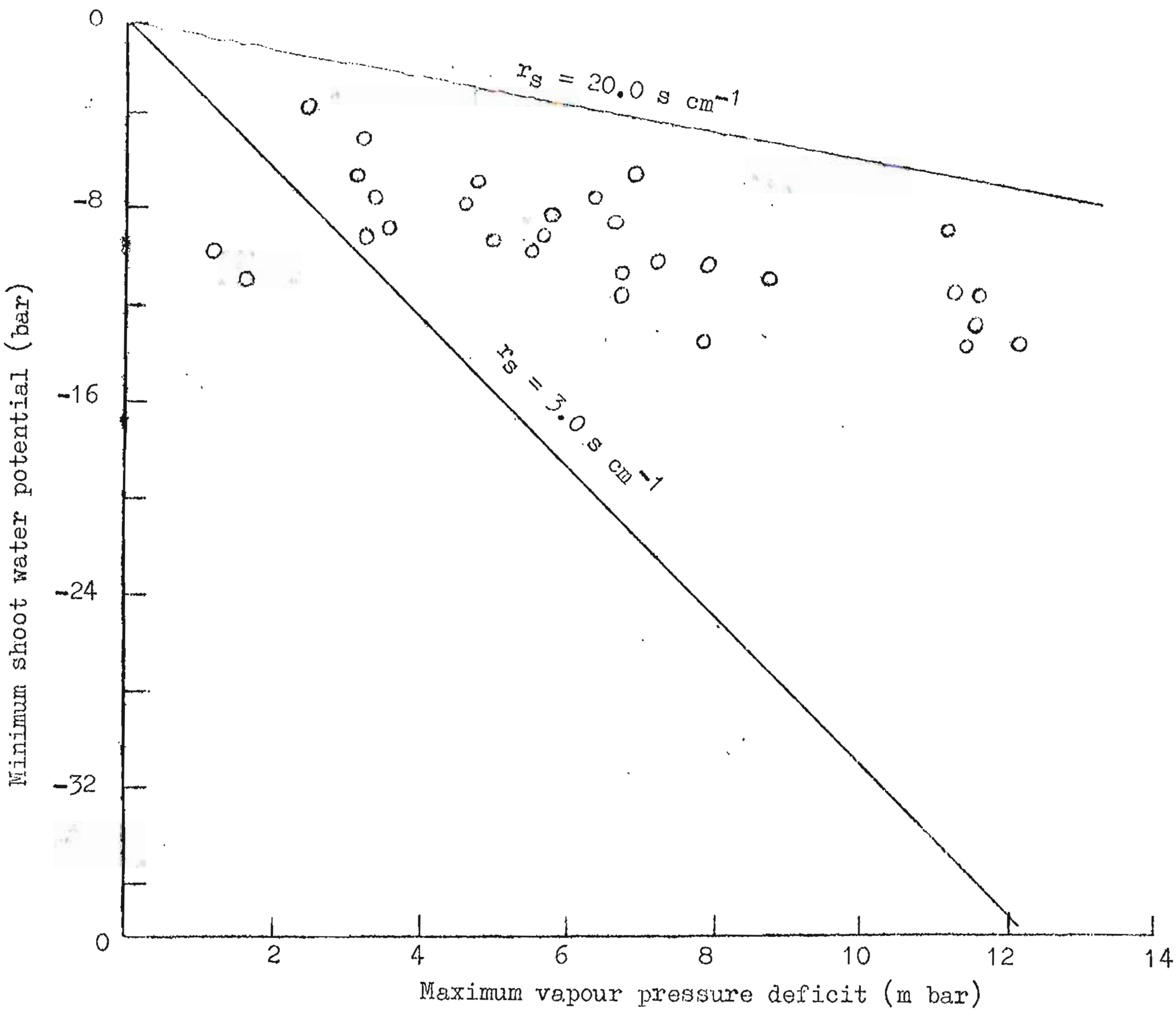


Key to figure:-

▲ = values obtained before 12.00 hours

△ = values obtained after 12.00 hours

Figure 4 The relationship between the minimum value of shoot water potential and the maximum vapour pressure deficit on individual days in 1973 and 1974.



Key to figures:-

o = data points

—— = relationships derived from the equation:-

$$\psi_1 = \frac{0.75.VPD.R_p}{r_s + r_a}$$

where r_a is the boundary layer resistance (s cm^{-1}) and the other terms are as defined in the text.

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

The field experiment described in last year's report was continued until 4 June, 1975. All the plants survived the winter with the exception of *G. urbanum* on Knock Fell where 63% were killed. At harvest the plants were separated into shoots and roots and oven dried at 80°C. A preliminary analysis of the results is presented in the Table and shows that *G. rivale* produced more total dry matter than *G. urbanum* at all sites. Both species increased in dry weight with decreasing altitude. The flowering response of *G. rivale* was generally greater than *G. urbanum* with the exception of the lowest site. At higher altitudes *G. rivale* had a larger proportion of its total dry matter in the shoot system than did *G. urbanum*, but at the lowest site both species showed a comparable increase in the proportion of shoot material. The responses of the species to low temperature stress and growth over a range of temperatures is being investigated further.

Site	Altitude (ft)	Mean No. Inflor.	Mean oven-dry wt. (g)			Shoot/ Root
			Above-ground	Roots	Total	
Geum rivale						
Knock Fell	2450	0.2	0.322	0.176	0.498	1.80
Rough Sike	1800	1.9	0.966	0.604	1.570	1.59
Helbeck Wood 1	1200	3.6	1.728	0.944	2.672	1.83
Helbeck Wood 2	800	3.3	3.149	1.304	4.453	2.41
Geum urbanum						
Knock Fell	2450	*0.1	0.155	0.113	0.268	1.37
Rough Sike	1800	2.0	0.630	0.467	1.097	1.35
Helbeck Wood 1	1200	2.1	1.281	0.741	2.022	1.73
Helbeck Wood 2	800	3.7	2.688	1.063	3.751	2.53

* mean values based on total number of plants in the treatment ie. including those which died.

h) Ecology and conservation potential of mixed deciduous woodland in the northern Pennines (R.A. Hynes, University College London).

The fieldwork and major laboratory analyses of this multi-level study have now been completed.

A map classification of the area has been produced. Information has been tabulated for the ordination analysis of ecological attributes representative of eighteen high-level woodland sites. Detailed results on tree basal area for five of these show close association with habitat, tree age and indirectly, the effects of past and present grazing pressures.

Secondary increment curves for Ash, Birch, Sycamore, Wych Elm and Rowan have predictably shown association with tree age and condition, habitat type and the seasonal march of climatic variables.

Investigation with Birch and Sycamore seedlings in five exclosures ranging in elevation from 750 ft (229 m) to 2700 ft. (823 m) O.D. have given insight into the limiting effects of increasing altitude on the growth and survival of seedlings. Less than 70% of the Sycamore survived the winter on the Great Dun Fell site. Height and diameter increment was measured for all living seedlings during spring and summer this year. While terminal harvests were made on the Sycamore and the 3 year old Birch, the 2 year old Birch were harvested at intervals throughout this period. Additional plant attributes measured where applicable included leaf number, leaf area and root, stem leaf and total dry weights. Derived parameters include various increment rates including relative growth rates and net assimilation rates.

Climatic variables recorded at Helbeck with an ACMS were solar radiation, day length, ambient temperature, depression temperature, wind run, wind direction, and rainfall.

These paralleled records made at Moor House. Soil moisture tension was assessed on all five sites.

Curves for height increment and leaf area increase of Birch on Helbeck Wood sites and higher moorland sites are shown in Figure 1 with temperature data for the same period. These trends reveal close association with the seasonal march of mean temperature for these elevations. Other plant variables show similar relationships.

Investigations related to the density, height, diameter and age of wildings have also produced useful information.

Data collected for 20 sites in Helbeck is being used in the development of a predictive model of 'tree growth and dynamics' for the wood.

The information gained at different levels in the project integrate to produce an overview that it is hoped will be of use in evaluating problems related to the conservation of existing woodland and the re-establishment of similar community types in the region.

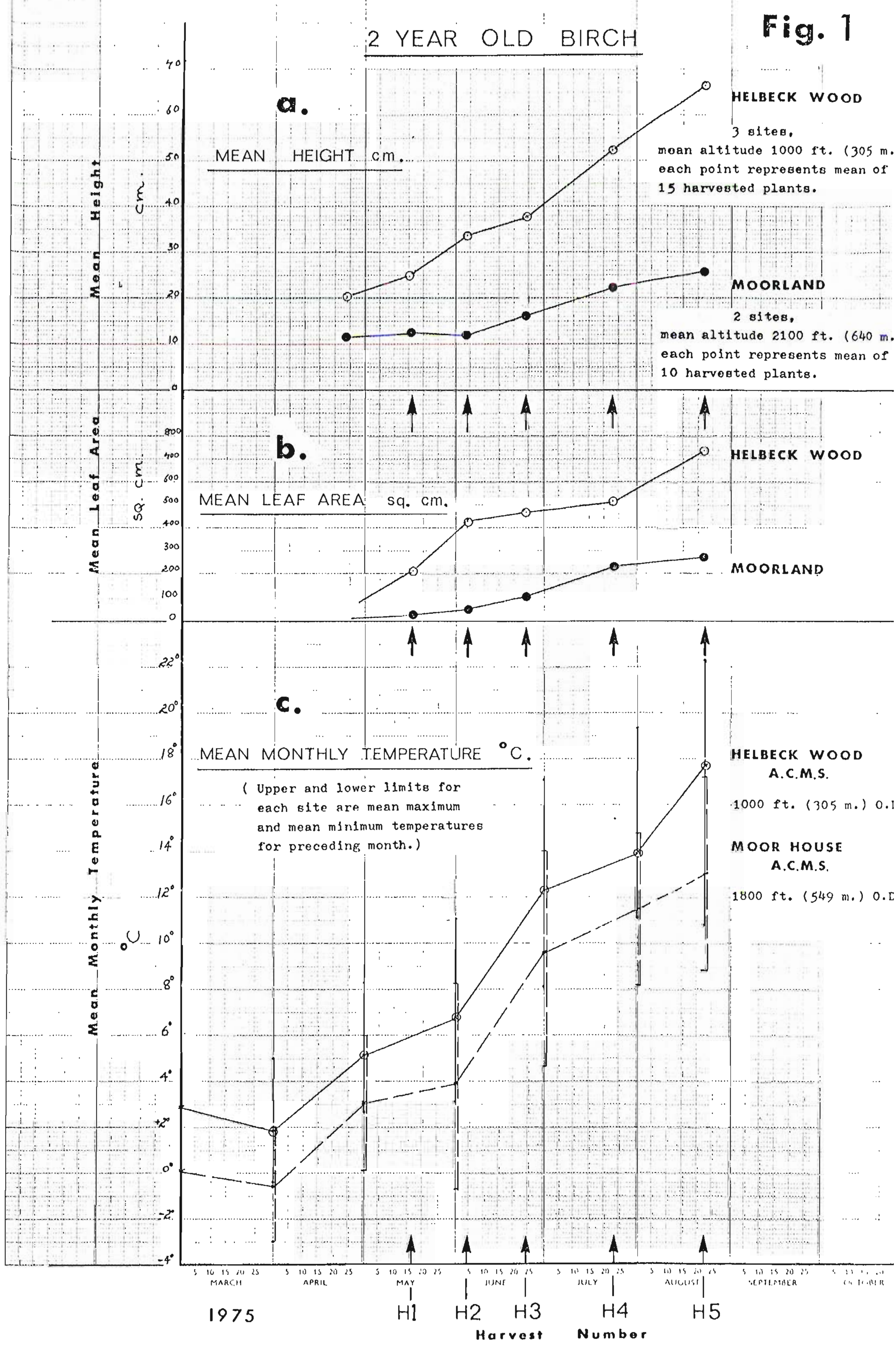


Fig. 1
2 YEAR OLD BIRCH
a.
MEAN HEIGHT cm.
Mean Height cm.
HELBECK WOOD
3 sites,
mean altitude 1000 ft. (305 m.
each point represents mean of
15 harvested plants.
MOORLAND
2 sites,
mean altitude 2100 ft. (640 m.
each point represents mean of
10 harvested plants.
b.
MEAN LEAF AREA sq. cm.
Mean Leaf Area sq. cm.
HELBECK WOOD
MOORLAND
c.
MEAN MONTHLY TEMPERATURE °C.
(Upper and lower limits for
each site are mean maximum
and mean minimum temperatures
for preceding month.)
Mean Monthly Temperature °C
HELBECK WOOD
A.C.M.S.
1000 ft. (305 m.) O.D
MOOR HOUSE
A.C.M.S.
1800 ft. (549 m.) O.D
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
1975
H1
H2
H3
H4
H5
Harvest Number

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

Field measurement of the microclimate of *Sphagnum rubellum*, on Sike Hill, has continued. The irradiance distribution, under the *Calluna* canopy, and the temperature of the *Sphagnum* surface, have been examined, using a system which permits simultaneous and continuous recordings on a battery operated chart recorder.

The microenvironment of *Sphagnum rubellum* is very varied, even within a single patch. Plants under large gaps in the *Calluna* canopy receive a maximum irradiance during the greater part of the day. Plants under the denser parts of the canopy receive a very much lower irradiance, except during the passage of sunflecks. In conditions of direct solar radiation, the temperature of the *Sphagnum* surface at any one time, depends on the radiation reaching it. Temperatures of over 40°C were recorded on a number of occasions in July and August, for *Sphagnum* in full sun and temperatures over 30°C were sometimes maintained for the greater part of the day. Shaded *Sphagnum* however, remained at, or slightly below the canopy air temperature.

Additional data have been obtained throughout the summer from the Grant temperature recorder.

Photosynthesis and respiration are being measured, under controlled conditions in the laboratory at Leeds, using Clark electrodes, in which change in oxygen concentration in solution is measured polarographically. The reponse of the plant is being studied over the range of temperatures and irradiances found in the field. The results so far indicate that no significant decline in photosynthesis occurs at a temperature of 40°C. There is however, evidence that the ability to photosynthesise is severely impaired at low temperatures such as those experienced during the winter. Further investigation on the effects of these extremes of temperature, on the performance of the plant will be carried out.

j) Low temperature growth of grasses and clovers (J. Ollerenshaw, University of Newcastle upon Tyne)

Object: To improve the productivity of hill pastures by introducing grasses and clovers which will extend the growing season in these regions.

The growth of most hill pasture species is highly seasonal with 75% of total annual production occurring in under three months of the year. Consequently, ewes are often poorly nourished prior to mating in early November, during late pregnancy and early lactation. Hence fertility levels, lamb birth weights and growth rates are low and mortality rates are high.

The major factor causing the short growing season is probably low temperature. Mean soil temperatures in upland regions of Eastern Britain rarely exceed 6°C between November and April (approximately the threshold soil temperature for the growth of indigenous grass species). It may be possible to find natural populations of grasses and clovers adapted to winter growth in areas which experience relatively low temperature for a considerable part of the year, eg. Moor House.

Method: Single tillers and stolons of natural populations of Lolium perenne and Trifolium repens, collected from Moor House and other regio in England and Scotland, were established in pots containing John Innes No. 2 compost. Eight to ten plants of similar size and development, were selected from each population and randomly placed in low temperatu cabinets operating at 5°C and 6°C. Fluorescent tubes were used to give a light intensity of approximately 15 W/M^2 over a 12-hour photoperiod.

After two weeks in the cabinets, measurements were taken of leaf lamina lengths and stolon lengths for Lolium perenne and Trifolium repens respectively. Further recordings were taken at 7 day intervals to establish the rates of leaf and stolon elongation. New tiller and stolon development was also noted. Growth was compared with the commercial varieties S24 (Lolium perenne) and S184 (Trifolium repens).

Only the results concerning the Moor House populations are present in this report.

Results

(a) Lolium perenne populations

Table 1 Rates of leaf elongation (cm. plant^{-1} week^{-1}) of three populati of perennial ryegrass at 5°C over three consecutive growth periods (means of 10 plants)

	main tiller growth			main + secondary tiller growt		
periods	1	2	3	1	2	3
population						
S24	2.97	2.22	1.54	5.75	5.73	5.63
Meadow 1	3.28	2.96	2.05	5.81	7.08	6.83
Meadow 2	1.87	1.75	1.45	3.84	3.86	4.03

Period 1 = 6 - 21/11/74
Period 2 = 22/11 - 12/12/74
Period 3 = 13/12/74 - 22/1/75

The average plant dry weights (aerial growth) at the end of this experiment were 61.3 (S24), 64.6 (Meadow 1) and 45.3 mgr. (Meadow 2). The experiment was repeated using a Fison's growth chamber operating at 6°C (similar light intensity and photoperiod) over the period 3 March to 14 April (Table 2).

Table 2 Rates of leaf elongation (cm. plant^{-1} week^{-1}) - means of 8 plan

	S24	Meadow 1	Meadow 2
Main tiller	6.31	4.69	3.67
Main and secondary tillers	15.59	16.32	7.42

(b) Trifolium repens populations

Three populations from Moor House were tested with S184 over the same periods as given in Table 1.

Table 3 Rate of stolon elongation (mm. $plant^{-1} week^{-1}$) of four populations of white clover at 5°C over three consecutive growth periods (means of 10 plants).

	Main stolon growth			Main + secondary stolon growth		
period	1	2	3	1	2	3
population						
S184	0.50	0.50	0.52	0.50	0.83	1.48
Troutbeck 1	1.10	0.70	1.35	1.10	1.90	3.22
Meadow 1	0.45	0.50	0.60	0.45	0.93	1.35
Meadow 2	0.60	0.53	0.68	0.60	0.83	1.20

Seven more populations from Moor House were compared with S184 in the second experiment (Table 4). Growth which had been measured over the 6 week period was removed, dried and weighed.

Table 4 Rate of stolon elongation (mm. $plant^{-1} week^{-1}$) of eight white clover populations at 5°C over the period 16 March - 28 April 1975 (means of eight plants).

populations	main stolon growth	main + secondary stolon growth	plant dry wt.- aerial growth (mgr.)
S184	0.79	1.73	23.3
Knock Fell 1	3.68	4.64	28.9
Knock Fell 2	2.60	3.19	20.9
Knock Fell 3	1.35	1.60	11.6
Knock Fell 4	1.36	1.60	12.0
Knock Fell 5	1.35	1.54	12.0
Troutbeck 2	1.02	1.33	10.0
Troutbeck 3	1.02	1.30	9.8

It must be emphasised that these are only preliminary results. All the populations are being tested again throughout this winter under both laboratory and rigorous field conditions (Cheviot Hills).

From the preliminary results there appears to be considerable variation in the ability of the Moor House populations to grow at low temperatures. Some of these populations exhibited better growth at 5/6°C than commercial varieties used for hill conditions. Further studies are required to establish why some of the natural populations are better adapted to grow at low temperatures than others. Microenvironmental differences between plant habitats may be important in this context.

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

The highlight of a brief field season was the completion of a 10 year record of ploughing block movements. As many people are forecasting a climatic deterioration in the near future, it seems well worthwhile to continue the record for at least another decade, though observations may have to be on a less regular basis than formerly. Such plans mean that the blocks cannot be disturbed, so a full analysis of the reasons for movement will have to be deferred until the record is terminated.

Observations to date are summarized in the two tables. The first shows the annual movement recorded by each block from 1965 to 1975, while the second illustrates how those same blocks have moved at different times of the year in the period 1967-72.

The main points to emerge from this work are:-

1. There must be numerous blocks on the Reserve which are moving at easily detectable rates. The fastest of these (such as No. 1 in the tables) imply that considerable displacements have occurred even within historic times.

2. Movements are variable as between one block and another, and from one year to the next. On the other hand, the blocks have retained their same relative speeds throughout the period of observations. In other words, those which moved fastest in one particular year did so in all others as well. Conversely, some blocks have consistently travelled more slowly.

3. During the colder parts of the year block movements are far greater than in the summer months. This firmly indicates that periglacial activity is the chief factor responsible for block displacement.

Table 1 The location, characteristics and annual (ie. August to August) movements (in centimetres) of 5 ploughing blocks on the Reserve during the period 1965 - 1975.

Block No. 1. Knock Ore Gill valley, N. facing slope, 730 m altitude, slope angle 21°, block size 58 x 55 x 10 cm.

1965-6	= 7.0	1970-1	= 3.8
1966-7	= 5.7	1971-2	= 6.7
1967-8	= 7.0	1972-3	= 7.9
1968-9	= 4.1	1973-4	= 7.6
1969-70	= 6.4	1974-5	= 7.6

Block No. 2. Middle Tongue Beck valley, N. facing slope, 760 m altitude, slope angle 22°, block size 45 x 37 x 20 cm.

1965-6	= 5.1	1970-1	= 2.5
1966-7	= 1.3	1971-2	= 4.4
1967-8	= 3.5	1972-3	= 3.8
1968-9	= 3.2	1973-4	= 4.1
1969-70	= 3.2	1974-5	= 2.5

Block No. 3. Knock Ore Gill valley, S. facing slope, 685 m altitude, slope angle 22°, block size 105 x 90 x 37 cm.

1965-6	= 1.6	1970-1	= 0.0
1966-7	= 1.0	1971-2	= 0.3
1967-8	= 1.9	1972-3	= 0.3
1968-9	= 2.2	1973-4	= 0.6
1969-70	= 2.5	1974-5	= 0.6

Block No. 4. Little Dun Fell, E. facing slope, 820 m altitude, slope angle 5°, block size 95 x 62 x 53 cm.

1965-6	= 0.6	1970-1	= 0.0
1966-7	= 0.3	1971-2	= 0.3
1967-8	= 0.6	1972-3	= 0.0
1968-9	= 1.0	1973-4	= 0.6
1969-70	= 1.0	1974-5	= 0.3

Block No. 5. Little Dun Fell, N. facing slope, 820 m altitude, slope angle 7°, block size 122 x 85 x 65 cm.

1965-6	= 0.0	1970-1	= 0.0
1966-7	= 0.0	1971-2	= 0.0
1967-8	= 0.0	1972-3	= 0.0
1968-9	= 0.3	1973-4	= 0.0
1969-70	= 0.0	1974-5	= 0.0

TOTAL MOVEMENT OF THE FIVE BLOCKS:-

1965-6	= 14.3	1970-1	= 6.3
1966-7	= 8.3	1971-2	= 11.7
1967-8	= 13.0	1972-3	= 12.0
1968-9	= 10.8	1973-4	= 12.9
1969-70	= 13.1	1974-5	= 11.0

Table 2 The movements (in centimetres) of the same ploughing blocks as in Table 1 for the 'winter' (ie. August to early April) and 'summer' (ie. early April to August) seasons of the years 1967 - 1972. Boxes containing question marks indicate that a block was under deep snow early in April, thus making it impossible to obtain a seasonal breakdown of the annual movement. Figures in brackets are for totals based on incomplete data.

Block No.	1967-8		1968-9		1969-70		1970-1		1971-2	
	W	S	W	S	W	S	W	S	W	S
1	6.7	0.3	3.5	0.6	6.4	0.0	3.8	0.0	6.4	0.3
2	3.5	0.0	?	?	3.2	0.0	2.2	0.3	4.1	0.3
3	1.9	0.0	2.2	0.0	2.2	0.3	0.0	0.0	0.3	0.0
4	0.6	0.0	0.7	0.3	?	?	0.0	0.0	0.3	0.0
5	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total movement of the five blocks	12.7	0.3	(6.7)	(0.9)	(11.8)	(0.3)	6.0	0.3	11.1	0.6

VI. RESEARCH BY OTHER ORGANISATIONS

a) Moth Survey (Dr. C.A. Edwards & D.J. Holdaway, Rothamsted Experimental Station)

Object

The light trap at Moor House is one of nine, each at a different site in the British Isles, being used by entomologists at Rothamsted Experimental Station as part of a programme to study those moth species, mainly Noctuids, whose cutworm larvae are known to, or are suspected of, causing economically-important damage to growing crops. Catches from the Moor House trap are also used for a parallel investigation of the tipulids *Tipula oleracea* and *T. paludosa*, whose leatherjacket larvae also cause economically-important crop damage.

Owing to its height, situation and locality, the Moor House trap provides valuable ecological data, which, when the study is complete, will be used with data from other traps to build up a national pattern of the occurrence, distribution and population fluctuations of the various pest species, also relating them to physical and climatic factors. This knowledge, along with that produced by allied studies now in progress, will be used to improve pest-control methods, including, it is hoped, the prediction of attack.

Method

The trap, a Rothamsted-type light trap using a 160W blended mercury-vapour bulb, is operated by Moor House staff, and is usually emptied daily. Catches are packed and sent to Rothamsted Experimental Station for the identification and counting of species, and, although not required for the above studies, detailed reports of catches are sent to Moor House for their own records.

Results

Unusual climatic conditions during the early part of 1975 are reflected in the numbers and flight periodicity times of most moth species. Numbers are high and many species have broken records for early appearance.

Catches of Tipula paludosa have increased by half over the equivalent period in 1974, and Tipula oleracea has to date not been recorded.

One interesting fact to emerge from the recording of economically-unimportant species is the occurrence of Xestia (Amathes) alpicola (Northern Dart). First recorded from Moor House in 1963, although caught in the Northern Pennines as early as 1950, it occurred in the 1973 light-trap catches (Entomologist's Gazette, 25, 87-88, 1974), was absent in 1974, but in 1975 has occurred in sufficient numbers to indicate successful breeding and to reinforce the theory that the Moor House colony is a phenologically distinct race from those found in Scotland and, recently, Ireland.

Moth species caught during trapping period 3/5/75 - 22/8/75.

*Economically important species.

NOCTUIDEA

Noctuidae	Apamea monoglypha (Dark Arches) 4
	Celaena haworthii (Haworth's Crescent) 2
	*Cerapteryx graminis (Antler Moth) 157
	Diarsia mendica (Common Ingrailed Clay) 17
	Eumichtis adusta (Dark Brocade) 2
	Lycophotia varia (True Lover's Knot) 19
	*Mamestra brassicae (Cabbage Moth) 1
	*Noctua pronuba (Large Yellow Underwing) 1
Plusiidae	*Plusia gamma (Silver Y) 1

GEOMETROIDEA

Geometridae	Colostygia didymata (Small Twin-spot Carpet) 3
	Colostygia pectinataria (Spring Green Carpet) 1
	Colostygia salicata (Striped Twin-spot Carpet) 6
	Dysstroma citrata (Dark Marbled Carpet) 1
	Entephria caesiata (Grey Mountain Carpet) 577
	Hydriomena furcata (July Highflyer) 2
	Lygris populata (Northern Spinach) 55
	Lygris pyraliata (Barred Straw Chevron) 27
	Xanthorhoe munitata (Red Northern Carpet) 224

HEPIALOIDEA

Hepialidae Hepialus fusconebulosa (Map-winged Swift) 8

BOMBYCOIDEA

Arctiidae Spilosoma lubricipeda (White Ermine) 1

Tipulid species caught during trapping period 1/1/75 - 22/8/75

Tipula paludosa	576♂ + 84♀	Total 660
Tipula oleracea		Total 0

APPENDICES

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Ph.D. Theses

WOTTON, R.S. 1974. Studies on blackflies (Diptera: Simuliidae) breeding in bog streams in Upper Teesdale. University of Durham.

Occasional Papers

RAWES, M. 1975. Aspects of the Ecology of the Northern Pennines. The Botany of Moor House. Moor House Occasional Paper Series, No. 8, 14 pp.

Staff List

Officer in Charge	M. Rawes
Scientific Staff	R. Williams
	R.B. Marsh
	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 1974 (Met. Office Station No. 7188)
c. 558 m O.D. (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 maximum temperature °C	4.0	3.5	4.1	8.9	10.8	12.8	13.4	13.8	10.0	5.7	4.9	5.7	8.1
Mean minimum temperature °C	-0.3	-0.4	-1.6	-1.9	2.2	4.2	7.1	7.2	4.9	1.0	0.6	1.0	2.0
½(Max. + Min.) temperature °C	1.9	1.5	1.3	3.5	6.5	8.5	10.3	10.5	7.5	3.3	2.7	3.3	5.1
Highest Maximum temperature °C	7.6	7.6	12.6	14.8	16.3	20.4	15.9	16.9	15.0	9.1	8.5	9.1	20.4
Lowest Minimum temperature °C	-6.0	-6.5	-7.0	-6.3	-4.9	-4.8	2.3	0.7	-1.2	-5.0	-5.8	-6.6	-7.0
Lowest maximum temperature °C	-2.3	-1.3	-1.0	1.2	7.1	7.0	11.4	11.2	5.1	0.7	0.8	0.4	-2.3
Highest minimum temperature °C	4.3	3.2	2.4	1.9	6.5	10.4	11.0	11.4	9.8	6.2	5.2	7.1	11.4
Lowest grass minimum temp. °C	-9.8	-8.1	-11.4	-12.1	-11.9	-12.3	-2.5	-4.3	-6.5	-7.9	-8.1	-9.2	-12.3
Earth temp. at 30cm - 0900 hrs	2.6	2.6	2.5	4.4	6.5	9.3	10.4	10.9	9.2	5.8	4.1	3.8	6.0
Rain (mm)	365.1	214.8	151.8	16.4	75.2	118.0	154.2	91.6	189.3	133.1	272.0	449.4	2230.9
No. rain days (0.2 mm)	26	23	19	5	17	14	27	19	23	25	27	29	254
No. wet days (1.0 mm)	26	20	16	3	15	11	21	13	20	18	23	27	213
Days snow/sleet	20	11	13	3	3	1	0	0	3	8	11	11	84
Days snow lying	9	8	12	0	0	0	0	0	0	2	3	10	44
Days with hail	1	1	0	0	5	3	1	0	2	3	1	5	22
Days with snow/ice pellets	0	3	7	1	0	0	0	0	1	0	1	0	13
Thunder	0	0	0	0	2	2	0	0	0	1	1	0	6
Fog	3	5	11	4	1	1	1	3	2	2	5	4	42
Air frost	14	14	24	24	7	1	0	0	3	9	7	12	115
Ground frost	20	21	27	28	16	11	4	4	9	15	18	18	191
Daily bright sun (hrs.)	0.45	1.31	2.96	6.44	6.13	5.99	3.80	4.18	2.98	1.25	0.82	0.47	3.07
Total sun (hrs.)	14.0	36.7	91.7	193.2	190.0	179.7	117.7	129.7	89.5	38.7	24.7	14.7	1120.3
Total snow (cms.)	46	44	81	0	0	0	0	0	0	4	7	85	267
Greatest depth of snow (cms.)	15	16	26	0	0	0	0	0	0	3	5	22	26
Days with gale	4	0	0	0	0	0	4	4	5	2	7	23	49
Solar radiation gm/cals/cm²	927	2252	5532	9869	11532	12497	9111	7999	5202	2634	1276	651	69482

No Great Dun Fell weather readings printed