MOOR HOUSE

23rd ANNUAL REPORT, 1982.

THE NATURE CONSERVANCY COUNCIL

MOOR HOUSE

1982

23rd ANNUAL PROGRESS REPORT

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I. GENERAL

a. Introduction (I. R. Bonner)

This Report covers the period 1 October 1981 to 30 September 1982 and as foreseen covers the final period of a manned Field Station at Moor House.

Michael Rawes retired on 3 June 1982 after 27 years at Moor House, carrying out the Nature Conservancy's research and survey programme, co-ordinating the work of many visiting scientists and running the Field Station - usually under adverse weather conditions and short of funds.

Fortunately, quite a few of Michael's friends were able to join together at the Regional Office, Blackwell, on 21 May to wish him well in his retirement.

Judith Scott, the surviving member of the Field Station team, transferred to Blackwell in June where she has settled into her new role assisting Regional Staff in Cumbria but with time still to keep an eye on Moor House data, maintain the meteorological records, edit the Annual Report and provide field assistance to Dr. R. Marrs of I.T.E. who is continuing with the long term vegetation monitoring work on the Reserve, reported on more fully on page 5.

Phil Holms moved from Moor House in May 1982 to become Estate worker for a group of N.N.R.s in South Cumbria and North Lancashire based on Gait Barrows.

Paul Burnham continues to warden Moor House and other North Cumbrian N.N.R.s and can be contacted for information about the Reserve, proposals for research and survey, etc., at Red Croft, Knock, Appleby, Cumbria, (tel. Kirkby Thore (0930) 61520).

The Field Station is now empty, the running costs being uneconomic for N.C.C. or any of the other bodies either individually or jointly who considered trying to take over the Station.

N.C.C. continue to be especially grateful to Dr. Bill Heal of I.T.E. for providing storage and working facilities for Moor House data at Merlewood Research Station.

Although there are no field station facilities at Moor House now there are no changes to the National Nature Reserve and we continue to welcome its use for research and survey projects compatible with its status and management objectives.

On 22 April 1982 the current users of the Reserve were invited to an informal Moor House Users' Meeting at Blackwell, when the changed arrangements for the Field Station and current and future possibilities for research and survey were explained and discussed. It is our intention to invite all Reserve users to a further meeting in Spring 1983.

b. Natural History Notes 1982 (P. Burnham)

The following natural history account has been compiled from Paul Burnham's diary and is intended to give a general picture of events throughout the year. For more detailed information, the Warden's Quarterly Reports should be consulted.

Despite the severe winter experienced by the rest of the country, conditions on the Reserve were not unusually severe. Winter came early with the first falls of snow in late October, with outbreaks continuing into May, but none, however, were heavy and did not cause any major problems for the resident wildlife, with the possible exception of dipper which is referred to later. Long periods of low temperatures were recorded from early December into the middle of January. A temperature of -17°C ground minimum was recorded during December at Moor House. Spring was a mixed period. Although mainly windy and very cold, some short, warm, sunny periods did occur. The Reserve became tinder dry on the tops and some streams were reduced to trickles during May, after low rainfall and drying winds in March and April. Heavy rain during thunderstorms on 3 to 6 June, however, soon returned the Reserve to its normal wet condition. The summer was the hottest since 1976, although the latter half of June was disappointing, with wet and overcast days. August was exceptionally wet with heavy rain and winds. Autumn, however, did bring some long, warm, sunny periods in September.

As the weather became colder in October mixed flocks of thrushes began moving through the Reserve. A flock of 100+ field fares with redwings, song thrushes and blackbirds was recorded on Gt. Dun Fell on 18 October. An unusual record was a small flock of 12 mistle thrushes feeding in the Moor House meadow for several days around this date. With the onset of lower temperatures all the thrushes moved on and had gone by December.

The small tree plantations act as good shelter and feeding stations, if only temporarily, for small passerines crossing the Pennines at this time of the year. Species recorded using the trees were goldfinch, chaffinch, pipits, goldcrest, thrushes, blue tit, long-tailed tit and two coal tits (a new Reserve record).

Raptors are regularly recorded during this period and several kills of thrush species were found on the Reserve. Peregrine, merlin, kestrel, buzzard and short-eared owl were all seen at this time.

As snow began to cover the tops few birds were recorded, with only raven and grouse regularly seen and, where the streams remained open, dippers too could be found. Occasional sightings of snow buntings also occurred and 5 were recorded together on Gt. Dun Fell on 2 January. Grouse did not appear badly hit by the winter and food was available during most snow falls as large areas remained free of snow with the changing wind direction.

Among the mammals, fox tracks criss-crossing each other in the snow were seen from the western escarpment, on the tops and all around the field station on the eastern side. Two foxes were seen during a visit by the Wensleydale Foxhounds on 18 October but escaped capture.

Two badger setts continued to be used and one badger took advantage of the mild spell in February to take in fresh bedding. Rabbit numbers continue to rise with the relatively snow-free winters of the past two years and with less control around the field station. Stoats are occasionally seen around the field station area and rabbits killed by them have been found there.

With the return of the first mild days in February several species attempted to return to the high fells to breed. Skylark, golden plover and snipe were recorded on 11 February but were pushed down again by snow storms. The majority of breeding birds arrived towards the end of March and the beginning of April.

For the fourth season Paul Burnham has completed a Waterways Bird Survey along a section of the River Tees from Tees Bridge to Cow Green Reservoir and some variations in numbers and species have been noted. Mallard and teal numbers seemed up over the whole of the Reserve when compared to 1981. Teal had increased from 3 to 5 pairs along the survey section. A pair of goosanders were recorded again this year but breeding was not proved. This species was first found breeding on the Reserve in 1979. Seven pairs of lapwing bred along the survey section, a great improvement on 1981 when blizzards in late April pushed the birds down to lower ground with none returning to breed. Dipper numbers were down in the survey section this year, with only 2 pairs, compared with 4 in 1981, and over the Reserve generally, sightings of juveniles seemed low. Perhaps the severe frosts during the winter had taken a toll or the extremely dry conditions experienced in the early part of the year, with some streams reduced to a trickle during the main nesting period, had affected their breeding success. A male goldeneye (a new species for the Reserve) was recorded during the breeding period but no female was seen.

Grouse numbers continued to increase on the Reserve after a relatively good spring and breeding season, with over 100 being recorded in small coveys on 31 August during a routine walk. The recovery of the grouse since the 1978/79 crash seems to be patchy with some adjoining landowners reporting good bags while others still do not shoot because of low numbers.

A pair of short-eared owls bred successfully and, again, as in 1981, a pair of buzzards attempted to breed, laying one egg and then deserting. An immature golden eagle was seen hunting along the western escarpment and surrounding area on a number of dates from April to June.

Among the smaller passerines of note was willow warbler, which bred for only the second time on the Reserve, in the pasture tree enclosure, and at least 2 pairs of whinchat continued to breed.

Conditions for Lepidoptera were good this year, with a reasonable summer, the hot period in June producing a number of butterflies (never many at this altitude) flying over the Reserve. Although mainly whites, several small tortoiseshells, small heaths and 2 red admirals were seen in the Moor House meadow on 8 June and 2 green-veined whites were recorded flying on Gt. Dun Fell at 847m. Also of note was a painted lady beside the River Tees on 5 July and 25 small heaths in the Troutbeck valley on the same date.

Among the usual raptors of this autumn movement was a rare occurence of a female sparrowhawk hunting along Troutbeck up to 700m on 30 August. With the field station now remaining quiet for long periods, kestrels have established a number of roosts around the building which are now used quite frequently.

II. SCIENTIFIC

a. (1) Moorland management
(M. Rawes and Judith Scott)

Much remains to be learnt about managing the extensive blanket bogs which cover much of the British uplands. Almost all blanket bogs in England and Wales are exploited, usually for sheep rearing but the intensity of management varies widely. Preliminary data from experimental burning and grazing regimes at Moor House were published by Rawes & Hobbs (J. Ecol., 1979) who concluded that light summer grazing by sheep, but no burning, was generally acceptable in maintaining the composition of the habitat. However, the Report of the Joint Consultative Muirburn Committee in Scotland (A Guide to Good Muirburn Practice, 1977) highlighted the need to know more about rates of recovery from burning, especially over the longer term and when the same ground is burned repeatedly.

Previous work on blanket bog has shown that the rate of recovery from burning is dependent on a number of factors, not least the degree of burning damage sustained and the weather conditions. However, recovery is always slow when compared to lowland conditions. Ball *et al* (I.T.E., Bangor Occ. Paper No.2, 1981) suggest that it would take 50+ years for grazed and burnt *Eriophorum* - *Calluna* vegetation to recover when the *Calluna* element has been destroyed. However, Rawes (J. Ecol. 1983) found that even under extreme conditions, at 680m. O.D., the rate of rehabilitation of *Calluna* and other vegetation, on two degraded bogs was surprisingly quick after sheep had been removed and the area fenced. Major changes in species composition, pattern and structure occurred within 14 years of enclosure, with an immediate move towards an ericaceous vegetation, dominated by *Calluna* rather than *Empetrum nigrum*. In one bog *Calluna* increased its cover by an average of 14% a year. The amount of *Calluna* and *Sphagnum* is indicative of this habitat's health.

The sheep trials on House Hill have been reported on in previous Annual Reports. One enclosed plot (1/24 of ha) was grazed heavily for 6 years during which the botanical structure and composition completely changed, including the elimination of *Calluna* and *Empetrum* and the quick recovery of *Eriophorum vaginatum*. Protection of the site from grazing began in 1975 and records taken since then can be compared to the control.

Since the monitoring of this plot in June 1982, examination of the data collected has disproved the superficial view formed on site during fieldwork (supported by presence and absence results) that recovery appeared far advanced. Table 1 summarises the botanical composition at four occasions in the past 12 years. In 1970 the effect of grazing was most apparent.

	1970	1975	1980	1982	Control
Vascular species					
live plant	48	75	117	106	132
dead plant	86	88	113	119	108
Lower plants	81	92	114	72	120

Whilst Calluna was found in 90% of the m^2 quadrats recorded in 1982, the frequency (Point Quadrat data) showed it only had 7% cover compared with 58% in the control. However, recolonisation by Calluna had been restricted to a seed source and whilst this is initially slow, a rapid growth can be expected after 7 years. Whilst a small amount of Empetrum was found in the plot, none was recorded in the sample areas. The recovery of Sphagnum is slow and likely to remain so. However, the density and structure of the vegetation are altering considerably, the former having doubled since 1974, this increase mostly at the lower levels ($<$20 cm from ground level) where the vegetation is twice as dense as in the control. The amount of dead plant material is always high in blanket bog, however, the live to dead ratio in the plot rose in 1982 to 1:2.4 (1:1.8 in control). This was mainly due to Eriophorum vaginatum, which having been stimulated by grazing and the removal of competition by Calluna (there is an inverse relationship between Calluna and Eriophorum) now increased to its maximum (1968-82) cover of live leaf (87%) in 1980, and of dead leaf (91%) in 1982. The situation remains dynamic.

It is planned to continue the annual botanical analysis of this small trial during future years.

a. (2) Moorland Management
(R. H. Marrs, Monks Wood Experimental Station and Judith Scott)

On the retirement of M. Rawes, I.T.E. has taken over the monitoring of ten of the long term experiments on vegetation change at Moor House. These experiments are designed to measure the change in vegetation composition and structure, and in particular to assess the effects of sheep grazing and burning (on blanket bog only). Details of the experiments which will continue to be monitored are shown in Table I; only one experiment will be monitored in each year of a ten year cycle.

During 1982 the Hard Hill burning/grazing experiment on blanket bog was monitored. This experiment consists of four replicate blocks at different altitudes, three burning regimes (no burning, short rotation - every 10 years, and long rotation - every 20 years), and ± sheep grazing. Monitoring of this experiment was done this year, before burning is applied to the short rotation plots in 1984. The vegetation of three of the blocks (Blocks A, C and D) was assessed using point quadrats to obtain presence/absence data for each species. In addition at Block B stratified point quadrats were used (see Rawes & Hobbs 1979) to obtain more information about vegetation structure. No further analysis of this data has yet been done.

A start has also been made in transferring the raw field data to computer storage so that further manipulation of the data for retrieval and modelling purposes can be done more easily.

References

Rawes, M. & Hobbs, R. 1979. Management of semi-natural blanket bog in the northern Pennines. Journal of Ecology 67, 789-807.

Table 1. Experiments which will be continued to be monitored by I.T.E.

Vegetation Type	Factor Investigated	Code	Started
Blanket bog	grazing + burning	D35-38	1954
Calcareous flush	grazing	D44	1972
Juncus squarrosus grassland	grazing	D20	1967
Nardus grassland	grazing	D33	1967
Festuca grassland	grazing	D40 D42	1955
Agrostis/Festuca grassland	grazing	D31	1966
Blanket bog - *Eriophorum*	grazing	D30 D34	1966
Blanket bog - *Calluna/Eriophorum*	grazing	D26	1971
Blanket bog - *Calluna*	grazing	D13	1969

b. Climatological Recordings

Judith Scott reports on the weather, October 1981 - September 1982, as follows:

One feature of the weather over the last year that most people will remember for some time was the severe cold spell which began in early December and carried on through to mid-January, after which temperatures became less extreme. Air minimums of -15.3°C recorded for December and -20.5°C for January were noted, the latter being the lowest ever recorded

January air minimum temperature at Moor House. Days of snow-lie, when the ground was completely or more than half covered, totalled 55, compared with the 29-year average of 69. Most of the snow fell in December and January with a lesser peak in March, leaving February relatively snow free.

April, although variable, with some sleet and snow towards the end of the month which carried on into early May, turned out to be one of the driest Aprils ever recorded, with a total rainfall of 47.7mm. This was followed by a dry period during 4 - 19 May, when only 3.9mm of rain was recorded, although wetter at the beginning and end of the month. July became the driest July recorded at Moor House with a total rainfall of 42.7mm.

The summary table for 1981 is given in the appendix.

c. <u>Altitudinal Comparisons in the Ecology and Reproduction of the Common Frog (Rana temporaria temporaria L.)</u>
(P. Holms)

The study forms a substantial part of a two year extra-mural course towards the Certificate in Field Biology, run by London University.

Common frog breeding ponds at an altitude of 500m on the Reserve were compared with pools at lowland sites of 100m near the village of Belsay in Northumberland. An ecological characterisation of each body of water was carried out together with comparative climatological data. The times of emergence from hibernation, spawning and tadpole development were recorded at both sites.

In the wild, the process of pairing and egg laying occurred 3 to 4 weeks earlier in the lowland populations, however, development up to metamorphosis was about 33% faster in upland embryos. Control experiments involving the transference of spawn from each altitude to laboratory aquaria, under identical light and heat regimes, compared times of development with those of natural populations. Under laboratory conditions, lowland spawn took approximately 44% and upland 56% longer to develop than in the field. Thereafter, growth rates under control conditions were similar for upland and lowland populations.

The results indicate little innate difference between the two frog populations, though upland frogs appear to be adapted to short season development in upland pools where predation is low, but winters are long and severe.

A paper describing this study has recently been published.

d. <u>Natural durability exposure trial of asbestos substitute building boards</u>
(M. Rawes)

The existence of sites subject to harsh climatic conditions yet relatively secure, and having a Weather Station with a long run of records, makes Moor House unique and an ideal site for testing industrial products. The Central Electricity Generating Board has taken advantage of this in the past, and now the asbestos industry has shown interest.

The present trial started in October, 1982. Cape Boards and Panels Ltd. have selected Moor House as one of a number of sites in the U.K. and elsewhere, including Australia (for hot desert conditions) and Norway (for cold). Three products are being tested over a 25 year period. The sample boards are fixed to a wooden rack directed to the north and the south. Samples will be removed for laboratory analysis. A further set of boards is displayed for biological examination. The latter study is again worldwide and is undertaken by a research team from the Biological Department, Aston University. The colonisation of the asbestos substitutes by lichens, bryophytes and algae will be recorded.

III RESEARCH BY THE INSTITUTE OF TERRESTRIAL ECOLOGY

a. Assessment of a soil phosphate bioassay for field grown trees

(J. Dighton, Merlewood Research Station)

Studies are continuing.

b. Climate and tree growth

(A. Millar, Merlewood Research Station)

The main objectives of the project are:-

1. To determine relationships between annual radial increment of Scots pine and climatic factors at Moor House.

2. To review the Moor House climatological observations with particular reference to tree growth.

3. To relate the results to the British uplands generally.

Objectives 1 and 2

Stem sections have been cut from the middle of each stem internode of 12 sample trees from the Pasture Enclosure and are being processed prior to a complete stem analysis of each tree. Climatic data are being transferred to computer tape.

By observation, tree growth at Moor House takes place mainly from June to September, and this period has a mean temperature of 10.1°C (1952-1979). Using this information it is possible to determine the altitude of a theoretical average treeline in Britain by estimating the altitude of the 10°C isotherm for this period above long term climatological stations in the upland regions, assuming a temperature lapse rate of 0.7°C/100m (Met. Office 1975). The altitude of the actual treeline was obtained by extracting the altitudes of high level woodlands from O.S. 1:63 360 and 1:50 000 maps. Map squares of 50km x 50km were selected to represent areas within the upland regions of Britain and the average height of the 8 highest hill summits calculated. Woodland altitude and average summit height were plotted against grid northing of each woodland and the centre of each square respectively, and the curvilinear regression line relating theoretical treeline altitude to grid northing ($r = -0.95^{***}$ $n=37$) was drawn (Figure 1), thus relating the position of the

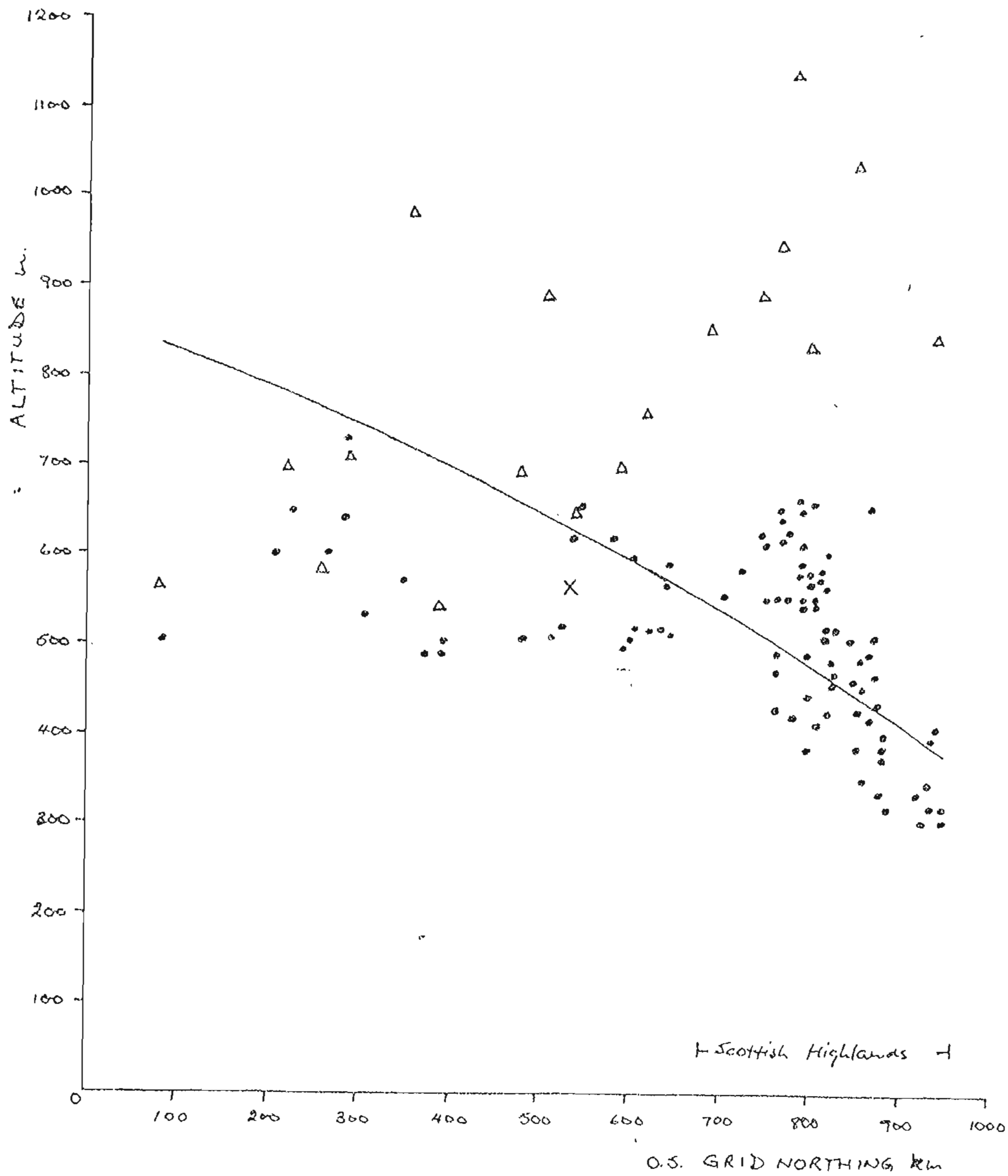

Figure 1. The relationship between high level woodland altitude (•), average summit height (Δ) and O.S. grid northing. The line represents the relationship between theoretical treeline altitude and O.S. grid northing ($Y = 864 - 0.35x - .00017x^2$)

X - Moor House climatological station.

Moor House climatological station, in a general way, to theoretical and actual treelines in the British uplands.

A preliminary analysis has shown that multiple linear correlation of high level woodland altitude in the Scottish highlands with woodland grid northing ($\simeq$ latitude) and grid easting ($\simeq$ continentality) accounts for 72% of the variation in altitude ($r = 0.85^{***}$, $n = 80$). Although man has had an impact on the treeline, this can be taken as evidence that the actual treeline is related basically to climate. Where average summit heights are well below the theoretical treeline, other factors, such as tree species composition at the actual treeline, will have to be considered.

Further analysis, particularly in relation to wind exposure, requires the extraction of data from maps to quantify site position and environmental characteristics more accurately before the results of the Moor House data analysis can be related to other parts of the country.

References

Meteorological Office, 1975. Maps of mean and extreme temperature over the United Kingdom, 1941 - 1970. (Climatological Memorandum No.73). London: H.M.S.O.

c. Fungal Communities in Relation to Altitude
(P. Widden - Merlewood Research Station)

Dr. Paul Widden from Concordia University, Montreal, Canada, spent a sabbatical year (1981-82) at ITE Merlewood to extend his research on fungal distribution, in particular of the genus *Trichoderma* in which he has used field sampling and laboratory model systems to examine competition between species of that genus. Although similar in many aspects of their physiology, *Trichoderma* species have quite different ecological distributions in relation to forest cover, soils and climate. Experimental work showed that differences in seasonality can be attributed to the influence of temperature on competition.

From his previous work (Widden, 1979) he developed the hypothesis that *T. hamatum* predominates in deciduous forests, *T. viride* in conifer forests and *T. polysporum* in spruce forests. Climatically *T. polysporum* and *T. viride* tend to increase in abundance with altitude and degree of exposure as mean soil temperature decreases. Previous work at Moor House (Latter, Cragg & Heal, 1967) showed that in the blanket bog *Trichoderma* is found in the litter but not the F layers. Only *T. polysporum* and *T. viride* had been recorded from Moor House, suggesting an opportunity to test the hypothesis, and expand it to other fungi.

Dr. Widden sampled the microfungal communities seasonally in a series of *Festuca-Agrostis* grasslands on an altitudinal gradient from 364m to 909m on the west side of Moor House and Cross Fell. Additional samples were taken from deciduous and coniferous plantations at Gisburn (Lancashire) planted 27 years ago on rough grazing land, from a heath soil at Banchory, Scotland, and from a spruce forest at Grizedale, Cumbria.

The results are still being analysed but there was no obvious pattern of distribution in Trichoderma but species of Penicillium show some distortion of seasonal differences in growth within each site. The fungal communities observed in the forests at Gisburn were similar to those from the Moor House grassland rather than to other forests, indicating that the community in the surface soil horizons (A_1) responds to soil conditions rather than to the plant community.

References

Latter, P.M., Cragg, J.B., & Heal, O.W. (1967) - Comparative studies on the microbiology of four moorland soils in the northern Pennines.
J. Ecol. 55, 445-464

Widden, P. (1979) - Fungal populations from forest soils in southern Quebec.
Can. J. Bot. 57, 1324-1331.

d) Effect of soil type on celluloytic ability of Fungi
(P. M. Latter and J. Gillespie* - Merlewood Research Station)

Losses in tensile strength of standard strips of cotton material placed vertically in the soil profile are used to assess celluloytic ability in soils. The method, initially developed for work at Moor House, is being increasingly used as a simple measure of celluloytic activity in management and land use studies.

The method is semi-quantitative and little work had been done on the causal microorganisms, though pigmented colonized areas are often observed on the strips. It cannot be assumed that all colonizing organisms are celluloytic or that all celluloytic organisms will colonize the strip.

Dr. Paul Widden (p. 10) isolated fungi from a limestone brown earth on the west slope of Dun Fell, a peaty gley at Gisburn Forest, Yorkshire and a podzolic soil at D.D.French's plots at Banchory, Scotland. Fifty of his isolates were tested for their celluloytic ability on soil obtained from the same three sites. However the soil obtained from Moor House was taken from molehills. The soils and cotton were first sterilized in glass petri dishes. The tensile strength loss and pigmentation of cotton was recorded after 9 weeks incubation at room temperature.

The growth of fungi varied between the 3 soils with 22% of the fungi growing well on only 1 or 2 of the soils and in most cases this included the Moor House soil. Thirteen fungi grew best on the Moor House soil compared to 8 for Gisburn and 4 for Banchory.

* Sandwich student from Bell College, Hamilton.

Celluloytic ability varied from zero to 100% loss for the different fungi and similarly between the same fungus placed on the different soils. The highest rates were recorded for 7 fungi placed on the Moor House soil (Table 1). Only 2 other fungi showed a similar high rate.

Pigmentation on the cotton was not consistent between the three soils so this cannot be used as an indication of particular fungi.

The results indicate the importance of soil type in controlling growth and cellulose decomposition by fungi. They will be analysódin relation to Dr. Widden's results for the distribution of fungi in the 3 soils.

Tablo 1

Celluloytic ability of fungi on diffcrent soils

The four categories represent final tensile strength of cotton in kg, high (0-20), medium (21-35), low (36-45), none (>45) celluloytic ability

Species	High	Medium	Low	None	No Growth
Group 1					
Allescheria sp	M				G,B
Collybia dryophila	M			B	G
C. peronata	M			G,B	
Chrysosporium pannorum	M			G,B	
Chrysosporium sp.	M				G,B
Flammulina velutipes	M				G,B
Oidiodendron teniussimum (G147)	G			B	M
Trichocladium opacum	M			G,B	
Trichoderma viride (G23)	G	B		M	
Group 2					
Botryotrichum piluliferum		G	M	B	
Chloridium sp.		G	B	M	
Gilmaniella sp.		G	B		M
Penicillium daliae (G19)		G	B	M	
P. daliae (G191)		G	B	M	
Plectomycete		M		G,B	
Trichoderma polysporum		G,M	B		
T. viride (G167)		G,B		M	
Group 3					
Chrysosporium medarum			M,G	B	
Cylindrocarpon obtusisporum (G84)			M	G,B	
" " (G142)			M	G,B	
Oidiodendron tenuissimum (G83)			B,G	M	
Penicillium thomii			G,M	B	

M = Moor House soil
G = Gisburn soil
B = Banchory soil

e. <u>Microbial characteristics of soils. Their relationships to plant growth and soil properties</u>
(P. M. Latter - Merlewood Research Station)

The experimental work for this project is now completed and data analysis is in progress.

The weight loss of <u>Eriophorum</u> litter is one of the substrate tests being used in these experiments as an example of natural litter. It is 1 - 2 yr. old material obtained from tussocks in an area near the road bridge over Troutbeck. It is cut into pieces approximately 8cm long and rolled into hair-net material. Weight loss after placement in pots of 64 soils from 8 major soil groups varied from 30-65% while maintained at the same climatic conditions at Merlewood for 1 year. Weight losses showed a wide range within the various soil groups with exception of podzols (Table 1). The highest rates were found among brown podzolic and peaty gley soil types and the lowest rates among gleys and podzols. In general, the other substrates tested (chitin, cellulose, lignin) showed highest rates for some of the brown earth soils.

<u>Table 1</u>

% weight loss of <u>Eriophorum</u> litter after 1 year in sieved soils. The range of mean results (n = 6) for 8 soils within each soil type is given.

Brown podzolic	42 - 65
Peaty gley	41 - 59
Basic brown earth	33 - 58
Acid brown earth	40 - 55
Peat	33 - 55
Podzol	40 - 49
Peaty podzol	40 - 45
Gley	30 - 54

In a second experiment aimed to manipulate soils experimentally, blanket bog peat from Moor House was among the 5 soils stored at moisture levels varying from about 20% to more than 100% of field capacity for 6 months. The soils were then subjected to the same climatic conditions during the plant growth and decomposition tests. Initial results show that activity of Moor House peat was similar to that of Gisburn Forest and Banchory soils but the highest activites were shown by the 2 brown earths when stored at the lower moisture levels. Among the five soils, the Moor House peat showed the least response in both plant growth and decomposition teststo the pre-treatment at different moisture contents.

In this experiment, the weight loss of Eriophorum litter in Moor House peat was highest (52%) in the dry pre-treatment and lowest (44.5%) in the peat after storage at field capacity. All results will be analysed to show how far the relationships between plant growth and decomposition processes can be explained by soil physical or chemical characteristics.

IV RESEARCH BY FRESHWATER BIOLOGICAL ASSOCIATION

a. Fish populations
(D. T. Crisp)

During the year, our studies on fish in the freshwaters of the Reserve have been confined to examination of trout from Cow Green reservoir during their autumn spawning run into the streams of the Reserve. During late October and early November 1982 c. 60 reservoir trout have been taken in the waters of the Reserve (chiefly the R. Tees and the lower reaches of Trout Beck). Most of them have been tagged and released.

V. RESEARCH BY UNIVERSITIES

a. Dynamics of upland Homoptera
(J. B. Whittaker, Department of Biology, Lancaster University)

Strophingia ericae, the heather psyllid has been sampled on 6 occasions since my last report (Nov. 1981). Sampling has been confined to Sike Hill where the density was experimentally reduced to one half of that on a control plot in 1978. Whilst the experimental plot still showed a significantly lower density than the control plot in the spring of 1982 (as it had done since the experiment was established), after recruitment of the 1982 cohort had started in June and July, the density of S. ericae was no longer significantly lower on the treated plot.

Further samples taken in September have still to be analysed. These include a continuation of the observations started in 1980 of flower production on the experimental and control plots.

Neophilaenus lineatus

A sample taken in June 1982, revealed a density of $93/m^2$ on the Juncus squarrosus site at Bog End which was the highest at this time in the life cycle since 1970.

b. Gas Production during Peat Formation
(J. Claricoates, School of Biological Sciences, Botany & Biochemistry, Westfield College, London)

In October 1981, 15 gas samplers were positioned in the peat on Burnt Hill. They were buried in three sets of five samplers, each group spanning the peat profile from 0.2m to 3.0m depth. These are used for the collection of deep peat gas samples.

At the same time, a total of 18 stainless steel cylinders were put out on the surface of the peat on Burnt Hill, in 3 groups of 6. Within each group there are a pair of cylinders on each of a lawn, pool and hummock. The cylinders mark the areas of peat which are used for the collection of gases being evolved from the surface of the bog. Since then the stainless steel cylinders have been replaced by bottomless polythene buckets.

Sampling of both the deep peat gases and of those gases being evolved from the surface of the bog has been carried out at more or less monthly intervals from that time, with a break of 4 months between visits over the winter period of 1981-82.

Results from the deep peat gas samplers so far indicate a very significant increase in the concentrations of CH_4 down the peat profile. An increase in the order of one hundred-fold is common, but larger increases have also been measured. Concentrations of CO_2 also increase markedly down the profile, but to a lesser degree. The results below illustrate this.

Depth	Concentration (vpm)	
(m)	CH_4	CO_2
0.2	1900	11100
0.5	35700	20900
1.0	40700	31200
2.0	78100	39400
3.0	140300	70900

Results from the surface gas samples show fairly clear differences in the efflux of CH_4 and CO_2 from the 3 microhabitats. The results have not yet been analysed in detail, but it appears so far that CO_2 fluxes are higher above hummocks than above lawns and pools, whereas the highest CH_4 fluxes appear above the latter 2 microhabitats.

At the same time as sampling the peat gases, profiles of pH, redox and S^{2-} activity are measured. Data for this have been collected since March 1982, but have not yet been processed.

A similar set of peat gas and profile data is being collected simultaneously on Coom Rigg Moss NNR, situated approximately 50 miles north of Moor House. The peat there is of a very similar nature to that at Moor House, but its total depth varies considerably within the area of the Reserve. The two sets of results will be compared, with a view to elucidating the effect which total peat depth has on the efflux of CH_4 and CO_2 from the surface and on the concentrations of the gases measured at different depths.

The approximately monthly measurements of the gases being evolved from the surface of the peat cores installed in the garden at Westfield, has continued this year.

It is planned to make these field and garden measurements for a further field season.

c. Mechanisms of Plant Interaction in a Blanket Bog Community

(K. Taylor and C. H. Thomson, Department of Botany, University College London)

Previous studies on the growth and mineral nutrient status of Rubus chamaemorus in relation to burning and sheep grazing, have shown that Rubus increased in shoot numbers, dry matter yield and nutrient uptake per m^2 after removal of the Calluna canopy (Marks & Taylor, 1972).

An experiment described in last year's annual report and repeated this year, was set up to test the effect of an increase in nutrients applied at different depths in the peat as solid fertiliser, on the growth of R. chamaemorus in unburned control plots. Fertiliser placements with factorial combinations of nitrogen, phosphorus and potassium at high and low levels produced no effect on individual shoot growth or population dynamics of Rubus. Additions of N and K did not alter the N, P or K concentrations of leaf dry weight, although treatments with high P showed a slight increase in P concentrations (Table 1). The results suggest that N, P and K supply is not limiting the growth of Rubus in the untreated plots with a complete Calluna canopy.

Attempts to separate the effects of change in nutrient supply and microclimate changes resulting from the removal of the Calluna canopy by cutting have been made. The following treatments were applied: cutting only; cutting plus shading (50% daylight) with woven polythene sheeting supported on small wooden frames; pulling aside and tying the Calluna shoots to increase daylight reaching Rubus but not to alter the nutrient supply; and finally, all the above treatments were split and half the plots given an addition of N + P + K at high level. Preliminary findings indicate an optimum microclimate for R. chamaemorus, intermediate between a cut i.e. open plot, and a closed canopy (Table 2). Shading and fertiliser placements on cut plots demonstrated a possible interaction between microclimate and nutrient supply, N, P and K only affecting total leaf numbers/m^2 when applied to a shaded cut plot (Table 3).

Possible changes in the pattern of phosphorus uptake down the peat profile produced by experimentally altering the microclimate have been investigated by injecting carrier-free ^{32}P into the peat at 5, 10 and 15 cm depth. It was thought that R. chamaemorus might utilise an additional (or different) pool of phosphorus, i.e. that normally taken up by Calluna, which is made available by canopy removal. Results suggest that any interference with the *Calluna* canopy produces an altered pattern of ^{32}P uptake (Table 4). As well as changing the relative amount of ^{32}P taken from each level, the total amount of ^{32}P has been affected (Table 5). It appears that in an intact canopy, a greater proportion of ^{32}P is taken from the upper levels, in contrast to the treated plots in which the major zone of uptake is lower down. Total ^{32}P uptake was highest from intact canopies (Table 5). The significance of the differences has still to be tested statistically.

Results to date suggest interesting interactions between microclimate and mineral nutrient uptake in blanket bog communities, and reflect the manner in which *Calluna vulgaris* affects the growth of *Rubus chamaemorus*.

Table 1

Fertiliser addition: mean nutrient concentrations in dry leaf laminae

Fertiliser application	% N	% P	% K
Nitrogen high	3.47	0.32	2.06
Phosphorus high	3.41	0.52	2.24
Potassium high	3.32	0.28	2.01
N + P + K high	3.39	0.63	1.66
Control	3.33	0.20	1.92

Table 2

Effect of altering the microclimate on mean leaf numbers/m^2

Treatment	Mean Total Leaf Numbers/m^2
Shade + cutting	135
Cutting	108
Intact canopy	110
Pull aside canopy	135

Table 3

Effect of altering the microclimate and nutrient balance on growth of *Rubus*

Note: all plots are cut

Treatment	Mean total leaf Number/m^2	Mean total leaf dry wt g/m^2
Shade	271	14.46
Shade + NPK	421	21.97
+ NPK	265	15.16
Control (cut)	279	15.59

Table 4

Effect of altering the microclimate on the pattern of ^{32}P uptake

	Disintegration per minute/g dry leaf weight x 10^3		
Depth cm.	5.0	10.0	15.0
Treatment			
Intact canopy	152	140	107
Cut	64	102	76
Cut + shade	58	63	127

Table 5

Total mean uptake of ^{32}P (sum of the 3 depths)

	Disintegration per minute		
Treatment	DPM/g x 10^3	DPM/leaf x 10^3	DPM/m x 10^3
Cut	243.22	15.33	966.24
Cut + shade	247.33	12.75	999.70
Canopy pulled aside	186.71	12.79	672.37
Intact canopy	398.20	20.00	1470.78

d. The effect of altitude, climate and soil status on the Growth of Agrosto-Festucetum Grass Swards at Moor House N.N.R.

(J. C. Hatton, Department of Botany, University College London)

The project described in the previous report is continuing.

Microclimate data from each of the 4 altitudinal sites has been correlated with above-ground productivity and availability of soil nutrients status throughout the growing season.

All sampling has been carried out on a stratified random basis taking into account the two main topographic sequences viz. hummocks and hollows. Five samplings have been made throughout the 1982 growing season from mid-April to mid-October.

Grass sward productivity (standing crop at the time of sampling) has been determined using movable cages (1.0 x 0.5 m^2) to exclude sheep. Seasonal variation in dry matter production is presently being determined for each of the 4 sites.

Soil nutrient status at each of the 4 sites has been determined with particular reference to the 2 major limiting nutrients nitrogen and phosphorus. It is apparent that the processes of ammonification and nitrification are proceeding in these high altitude soils, even though the pH is relatively low.

An exception, however, is Rough Sike where nitrification is almost completely inhibited, thereby limiting the supply of nitrate nitrogen for plant growth. It is of interest that this site is in an old lead mining area and the possibility of heavy metal toxicity cannot be excluded.

Plant available phosphorus (i.e. Olsen's extractable phosphorus) has been determined in these soils, and is found in relatively small amounts and is restricted mainly to the upper 5 cm soil.

Soil Depth	Extractable Soil mg/100g D.W. soil
0 - 5 cm	2.0 - 3.3
5 - 10 cm	1.4 - 2.3

There does not appear to be any clear correlation between altitude and P availability, and these small amounts may represent equilibria values viz. that pool of organic P being released into soil solution and being taken up by plants. A "bioassay" has therefore been applied to *Festuca ovina* plants to determine the phosphorus stress experienced by these plants at each of the 4 altitudinal sites. This bioassay relies on root responses (i.e. uptake) to test solutions of phosphate with ^{32}P as the carrier molecule, and it has been shown that the greater the P-stress experienced by a plant the greater the uptake of ^{32}P. Using this method it has been possible to show that with increasing altitude *F. ovina* experience increasing P-stress, with the notable exception of Rough Sike (580 m) site where plants experience some of the highest P stress. As mentioned earlier this site is on a disused lead mine which may account for this anomaly.

From these results it is intended to determine the individual roles of the separate but interacting physical and biological factors viz. climate, soil, plant and animal.

e. Surfaces and lines in drainage basins: the influence of three-dimensional form on run-off

(Sarah A. Bell, Department of Geography, University of Durham)

Studies are continuing.

Appendix 1.

Publication List

CRISP, D.T. & HOWSON, G. 1982. Effects of air temperature upon mean water temperature in streams in the North Pennines and English Lake District. Freshwater Biology, 12, 359 - 367.

DAGGITT,S. 1981. The Carbon Dioxide exchange of Sphagnum capillifolium (Ehrh.) Hedw. growing in a blanket mire habitat. Ph.D. Thesis, University of Leeds.

DIGHTON, J. & HARRISON, A.F. 1983. Phosphorus nutrition of Lodgepole pine and Sitka spruce as indicated by a root bioassay. Forestry 56, 33 - 43.

HOBBS, R.J. 1981. Post-fire succession in heathland communities. Ph.D. Thesis, University of Aberdeen.

HOLMS, P.J. 1982. Altitudinal comparisons in the ecology and reproduction of the common frog (Rana temporaria temporaria L.). Transactions of the Natural History Society of Northumbria, 49, 14 - 24.

JENNINGS, A. 1982. Biological studies on certain forms of the Harvestman Mitopus morio (Fabr.) (Opiliones, Arachnida). Ph.D. Thesis, University of Durham.

JENNINGS, A.L. 1982. A new species of harvestman of the genus Mitopus in Britain. Journal of Zoology, 198, 1 - 14.

RANDALL, M.G.M. 1982. The dynamics of an insect population throughout its altitudinal distribution: Coleophora alticolella (Lepidoptera) in northern England. Journal of Animal Ecology, 51, 993 - 1016.

WHITE, E.M. 1981. Classification of climate in Great Britain. Journal of Environmental Management, 13, 241 - 257.

WILLIAMSON,P. 1981. Aspects of the hydrology of a small peatland gully. B.Sc. Dissertation, Department of Geography, Manchester University.

Appendix 2.

Meteorological Summary for Moor House 1981
c 558 m OD (Instrument Site) Lat 54° 41' N. Long 2° 23' W Nat Grid Ref NY/758328

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean max temp °C	3.2*	1.5*	5.5*	7.7*	12.1*	12.2*	14.4*	15.7*	13.4*	6.8*	6.2*	-0.9*	8.2*
Mean min temp °C	-2.4*	-3.4*	-0.4*	-0.3*	3.3*	5.4*	7.5*	7.5*	6.9*	0.5*	1.1*	-6.6*	1.6*
½ (max + min) °C	0.4*	-1.0*	2.6*	3.7*	7.7*	8.8*	11.0*	11.6*	10.2*	3.7*	3.7*	-3.8*	4.9*
Highest max temp °C	7.7	8.5	12.4	15.8	19.8	18.6	18.4	20.2	18.4	11.9	10.5	8.8	20.2
Lowest min temp °C	-12.5	-12.0	-8.6	-7.2	-7.4	-0.7	2.8	0.7	1.7	-8.9	-4.9	-15.3	-15.3
Lowest grass min temp °C	-10.0	-12.5	-7.5	-10.9	-10.1	-3.6	-2.0	-3.4	-3.1	-9.5	-7.2	-17.0	-17.0
Earth temp 30cm °C	2.4*	2.2*	3.4*	5.0*	7.2*	9.8*	11.4*	12.4*	10.8*	6.9*	5.1*	2.1*	6.6*
Rainfall (mm)	186.2	81.7	252.7	93.8	135.3	113.9	124.8	57.7	262.5	265.8	280.5	76.6	1931.5
Days snow lying	[15]	[11]	[9]	[4]	0	0	0	0	0	0	[3]	[25]	[67]
Air frost (days)	21)	22)	17)	16)	7)	2)	0	0	0	9)	10)	29)	133)
Ground frost (days)	30)	27)	23)	24)	13)	5)	2)	8)	5)	23)	17)	30)	207)

* = estimates reached by using thermometers and thermograph at Moor House. In the case of mean, max. and min. - comparisons made with Widdybank Station, (Teesdale, Co. Durham).

[ ] = estimates using Moor House, Widdybank and Newbiggin-in-Teesdale (Co. Durham) data.

) = results gained by using Moor House and Widdybank data.