MOOR HOUSE

12th Annual Report, 1971

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THE NATURE CONSERVANCY

MOOR HOUSE

1971

12th Annual Progress Report

M. Rawes

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CONTENTS

I. GENERAL

The Report covers the period 1 October, 1970 to 30 September, 1971.

There has been a reduction in the number of research workers visiting and using the Reserve. A number of projects, mainly those concerned with the International Biological Programme, have been, or are shortly to be concluded. On the Station itself, Dr. Forrest (I.B.P.) left at the end of 1970 after being with us for three years, and the I.B.P. Scientific Assistant was transferred to Merlewood Research Station. During the summer we have had P. Taylor, working on grouse and S. Bell, a Liverpool Polytechnic Sandwich Student, studying Collembola. Four University students have been employed for shorter periods. The Freshwater Biological Association Unit under Dr. Crisp continues to be based at the Field Station and for six months the three permanent members of staff have been joined by a student, C. Edwards.

A number of short-term projects by Durham University M.Sc. students have been undertaken on the Reserve and two reports appear in the University Research Section. A new enterprise, an examination of some of the old Lead Mines, features under Miscellaneous Research. The I.B.P. projects, a number of which have been concluded and others commenced, appear with Dr. Heal's report, on their own at the end of the Report. This is a matter of editorial simplicity and does not infer that I.B.P. has no relevance to other research, or Reserve management; rather most projects subscribe to a furtherance of our knowledge of the moorland ecosystem and it is this aspect that enables Moor House data to become increasingly valuable, especially when comparisons are made with other areas. In future more attention will be paid to utilising these data in this way.

Progress has been made, using an edge-punch card system, to index site information. The need for such a record was mentioned in last year's report. New projects now require the completion of a standard form, which simplifies future recording.

Visits to the Field Station have included a party from the National Agricultural Advisory Service and Agricultural Land Service (Durham) (now the Agricultural Development and Advisory Service), from the Botany Departments of Leeds University and University College London, from Durham University and elsewhere. Individual visits have been paid by, among others, Dr. Jerry Brown (U.S.A.), Dr. Moldung and A.K. Veum (Norway), Lars Osterdall and T. Rosswall (Sweden), Madame Ricou and L. Hedin (France), J. Tothill (Australia) and Dr. Z. Vulterin (Czecho-Slovakia). The Director, Dr. M.E.D. Poore, visited the west side of the Reserve in July.

The hostel which was closed in September, 1970, as an economy measure was re-opened in July 1971, when Mrs. Dunn, was appointed house-keeper. The hostel will be closed for the winter and Mrs. Dunn will work at the Conservancy's Newcastle Regional Sub-Office until Easter 1972.

Mr. J. Rose served as part-time warden on the west side of the Reserve during the winter and continued to supervise the ski-ing scheme.

II. CLIMATOLOGY - Project 1/06 (R.B. Marsh)

The weather summary for 1970 is to be found in the appendices.

During 1971 two changes have occurred in recording; since the beginning of the year rainfall has been measured in millimetres and from 1 September temperatures have been measured in degrees Centigrade.

Winter began with 12 days of snow-lie in November, but this was followed by a mild winter for Moor House, with snow-lie 18 days less than average. Earth temperature at 30 cm depth was above average for 10 months, October and June being the colder months. The mean air temperature was above average for 7 months of the

year, but both in ground and air temperature the mean for the year was no more than 0.4°C above average. For the second year running rainfall was below average with 1665.4 mm compared with a 19 year average of 1936.3 mm. There were four particularly dry months, April 53.6 mm, May 76.4 mm, July 63.7 mm and September 56.0 mm.

III. STAFF RESEARCH

Research by the permanent staff is primarily concerned with following vegetational changes on the Reserve due to management, sheep grazing and exclosure, but this year monitoring has not been restricted to plants; also areas outside the Reserve have been surveyed. M. Rawes was involved in conservation surveys of North and West Cumberland as a contribution to the compilation of Structure Maps for the County Planning Authority. The biological interest of riverside habitats was high-lighted by these surveys and in the latter part of the summer a test survey was made of the River Caldew and some of its tributaries. Advice on sampling method was given by Dr. R. Bunce and Mr. W. Shaw (both of Merlewood) and the field work was largely undertaken by Miss A. GreatRex (Durham) and Miss L. Teasdale. Dr. Crisp and his team gave additional help by sampling the fish populations and Dr. Armitage the freshwater invertebrates.

a) Studies on the interaction between sheep and vegetation - Project 1/01 (M. Rawes, R. Williams, R.B. Marsh & Miss L. Teasdale)

Previous work has provided a vegetation map of the Reserve (Eddy, Welch & Rawes, 1969) and information on sward production and sheep grazing (Rawes & Welch, 1969). In the present project, and this year we have been assisted by M. Smith (Lancaster), R. Laycock (U.C.L.), and Miss Langhorne (Kings, London), the following management aspects are being studied.

1. Some effects of removing sheep grazing.
2. Some effects of the present free-range grazing regime.
3. Some effects of modified management.

1. Exclosure - no grazing

Point quadrats, to follow botanical change, were used in two blanket bog exclosures, on Burnt Hill and Bog Hill, whilst species presence was recorded on the limestone grassland of Green Hole, where point quadrats had previously recorded the vegetation in 1955. The Burnt Hill exclosure was erected by Dr. Conway in 1954 to record the changes due to moor draining recently burnt (Circa 1948) bog. Records have been made in 1954, 1960 and 1968 at which time it was clear that insufficient samples were available to make valid comparisons. Thus using the original transect line the number of quadrats was increased in 1971 and, so that changes in vegetation height and density could be better demonstrated, half the points were stratified. On Bog Hill a sampling area on the north side of the hill was marked out and protected, by temporary fencing, in Spring from trampling by research workers. The area of grazed limestone at Green Hole is very small, much smaller than the original enclosed point quadrat site. This fact and the lack of data collected at a meaningful and repeatable time of year (previous point quadrats were done in April 1954) required a different approach and the re-examination was confined to recording species presence and making counts of tiller numbers.

Preliminary examination of the data confirms observation of very slow change in blanket bog when enclosed. On Burnt Hill the frequency of Calluna, which is more abundant close to the drains, is no greater overall than in 1966. Empetrum is significantly less in the enclosure than when grazed, but Eriophorum angustifolium is more than 3 times as frequent. The differences here in E. vaginatum reflect the dryness or otherwise of the habitat more than enclosure.

Examination of the Bog Hill results is restricted to difference, if any, in the current year between enclosed and grazed bog and the suggestion is that differences will be small. There is more Empetrum and lichen inside but less, also significantly so, bryophyte and liverwort cover. Whether this is a site or treatment effect is not known.

The grassland at Green Hole, however, has undergone major changes since 1954 comparable in species change and sward structure to Knock Fell exclosure. There is a 50% decrease in species when compared with the grazed turf.

Further analysis of previous botanical data, from all the exclosures (see last year's Report), has been made, and, in this we are indebted to members of the Botany Department, Newcastle, for their assistance.

An examination of differences in invertebrate fauna has been undertaken in Knock Fell and Rough Sike. This study is being done with the assistance of Dr. M.G. Morris (Monks Wood) who has agreed to identify samples taken on six occasions in the summer. A vacuum sampler was loaned from the Zoology Department, Durham.

2. Present grazing regime

Only on Burnt Hill did earlier data exist to enable comparisons to be made and in this case there has been little change.

3. Modified management

a) The reaction of blanket bog to increased grazing

That increased grazing of blanket bog will lead to the development of a Juncus squarrosus sward is the hypothesis of this trial, now in its fourth year. Grazing treatments have been continued and the yearly analysis of vegetation made. The heavy grazed plots have developed a more closed sward dominantly of Eriophorum vaginatum, the old Calluna being largely dead, but many Calluna seedlings and young plants are now growing. Agrostis spp., Holcus lanatus, and several plants of Juncus squarrosus and J. effusus are firmly established, the J. squarrosus seedlings being associated with grouse droppings.

b) Establishment of Juncus squarrosus

Juncus squarrosus seed was sown in the Autumn of 1968 and treatments shown in the following table have been carried out twice yearly. Mortality is shown to be very high. It is concluded that the plots, 25 cm^2, were too small for the treatments, especially treading, when it resulted in many seedlings being drowned in the pool created. Even so it is evident that a treatment involving removal of the light factor is essential for Juncus establishment.

Number of seedlings or plants of Juncus squarrosus per 20 cm^2, counted in August

Treatment	Site J1			Site House Hill		
	1969	1970	1971	1969	1970	1971
Sown on untreated bog	19	1	0	48	2	0
Sown and vegetation cut	265	12	1	1215	148	5
Sown and vegetation trodden	274	19	4	822	57	12
Sown, vegetation cut and trodden	859	95	41	1620	70	4

b) The establishment of natural grassland communities - Project 1/02 (M. Rawes & Miss L. Teasdale)

Annual recording of presence and performance (flowering, propogating and leaf size of selected introduced vascular plants) has continued. There have been few losses and flowering has on average been earlier than usual especially in the case of normally early flowering species. Saxifraga oppositifolia and Seslaria caerulea, both flowered 3-4 weeks earlier than in recent years.

A paper "Trials to recreate floristically rich vegetation by plant introduction", has been accepted for publication by the journal, Biological Conservation. The paper summarises results of observations made in the past 15 years, on arctic-alpine and montane plants introduced to four exclosures on the Reserve.

c) Grass Species Trial - Project 1/04 (M. Rawes, T.H. Davies & Miss L. Teasdale)

A further series (see Table below) of herbage plants were tested for survival under field conditions. This seed, from the National Seed Development Organisation Ltd. Cambridge, is only available for trial purposes. No fertiliser was used.

Seed was sown in 1970 in plots 70 x 100 cm and spaced plants were planted in rows. Whether the exceptionally mild winter led to these lowland varieties surviving as well as they did is not known. Very high yields of Red Clover - Maris-Leda and hybrid ryegrass, Sabrina, were obtained from individual plants, but when grown in a sward the number of tillers/plant was reduced, and, except for the tetraploid Italian Ryegrass - Sabalan, standing crops were not exceptionally high.

	Variety	Survival %	Yield g dry wt in August: Individual Plant	Yield g dry wt in August: Sward per m^2
+	Dactylis glomerata, Saborto	50	44.9	280
*	Lolium, hybrid, Sabrina	65	141.0	434
*	Lolium italicum, Sabalan	90	57.5	704
*	Agrostis, Saboval	93	54.0	250
	Trifolium repens, Sabeda	61	10.0	43
	Trifolium, Maris-Leda	77	140.7	278
+	Trifolium, Sabtoron	5	0.9	354
+	Lucerne, Sabilt	12	8.5	-

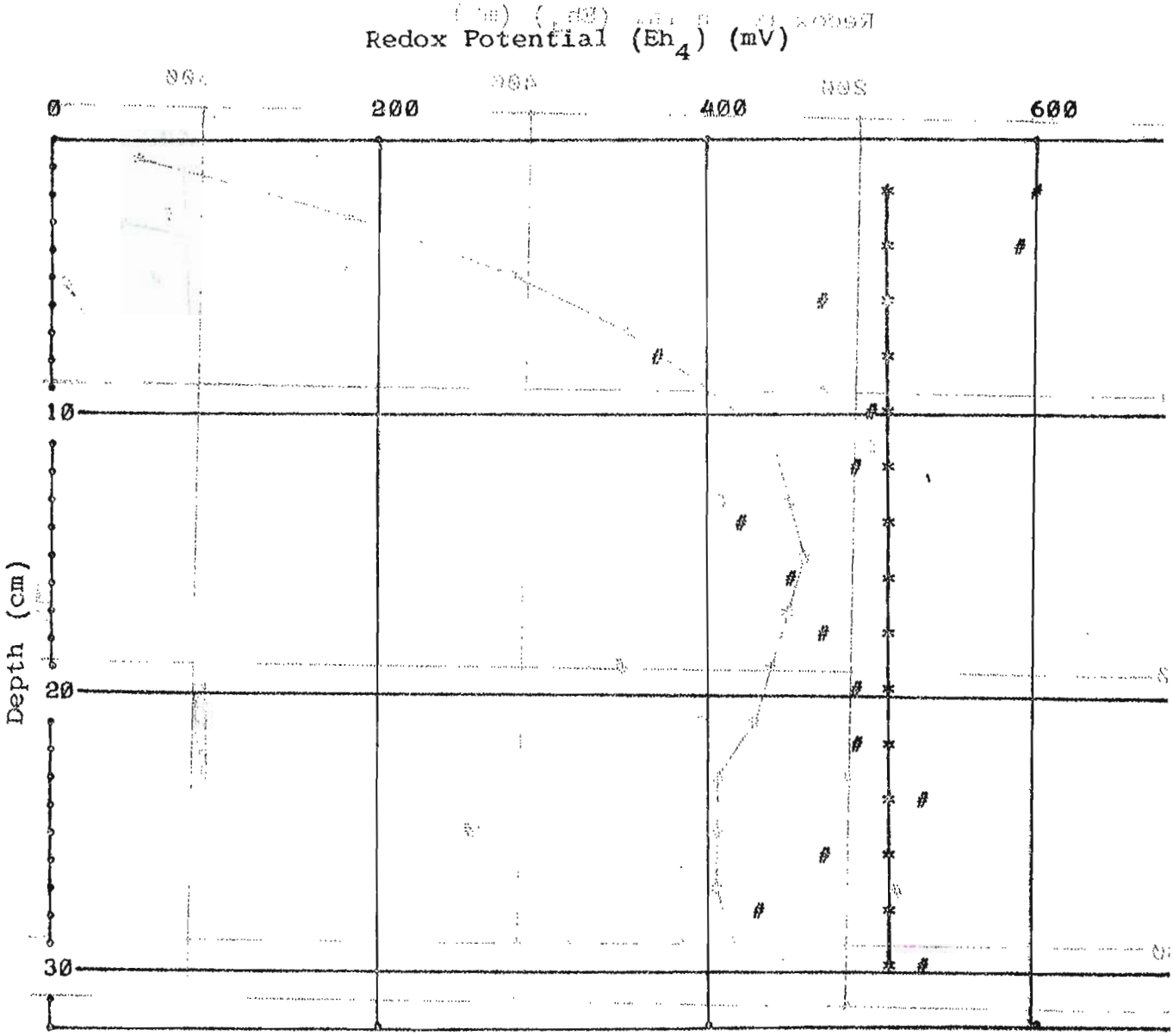
\+ Frost damage - Severe
* Frost damage - Slight

IV. RESEARCH BY MERLEWOOD STAFF

a) Tree Growth and Nutrition - Project 3/03 (A.H.F. Brown)

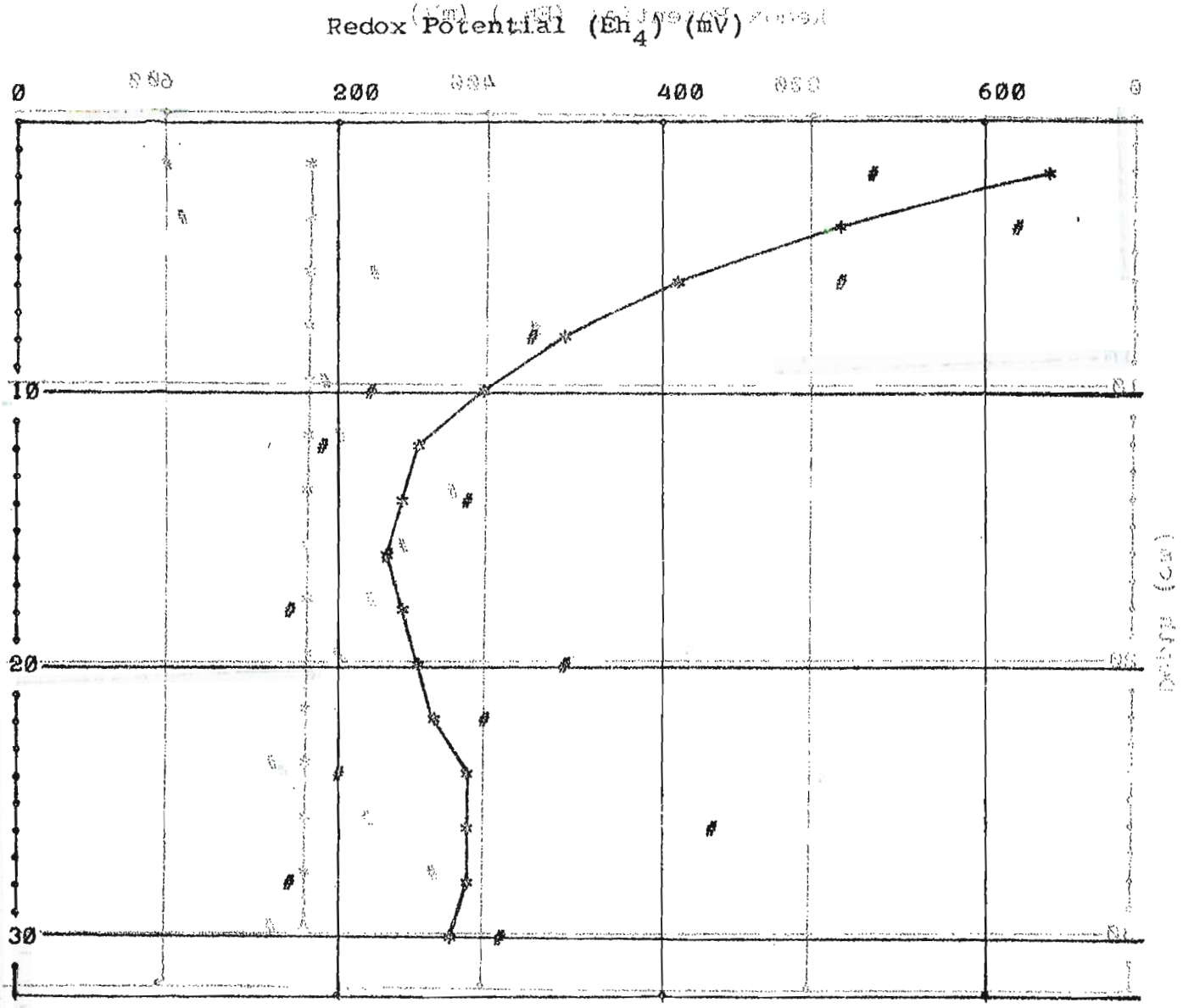
Trees on the better soils have responded well to a good growing season. The pasture plot looks particularly promising with many of the Scots Pine (Pinus sylvestris) growing as well as or even better than the Lodgepole Pine (P. contorta). The Pines are now providing sufficient shelter for the Swedish Whitebeam (Sorbus intermedia) and the occasional other remaining hardwood to respond favourably in places.

At Green Hole, Scots Pine is generally successful, though a few continue to die back. The larger standard Rowans (S. aucuparia) also remain quite vigorous.



Redox profile from Deer Dike Moss

* is the mean value curve



Redox profile from Stimberton Moss

are observed values, * are fitted values for a third degree (cubic) polynomial significant at P<0.01

The two lower-most groups of Lodgepole Pine at Nether Hearth now contain a high proportion of moribund or dead trees. Otherwise the three species of Pine (P. Sylvestris, P. contorta and P. mugo var. rostrata) continue to grow, albeit shortly, on the better parts of this unfavourable site. The small groups of Sitka Spruce (Picea sitchensis) and Hybrid Larch (Larix eurolepis) are growing well.

Height growth of Lodgepole Pine in the Bog End fertiliser trial appears to be a little less than that of the last year or two, and needle colour is poor. Chemical analysis of foliar samples is due to be made this autumn following which a decision will be made on the application of further fertilizers.

b) A report from the Systems Section (A.J.P. Gore)

Descriptive models of the energy flow through the primary producers at I.B.P. Tundra sites in Alaska, Moor House, Norway and South Georgia were presented at a meeting of the Primary Producers group at Glenamoy, Co. Mayo in March 1971. Dr. Jones has described the detail of this work in her report (see p.). The object of these models is to estimate the net throughput of energy at different sites from a knowledge of cropping data only. These estimates will be used to check the results obtained from models which are based on relationships of growth to temperature and radiation.

c) Plant ecological studies on peat - Merlewood Project 3/01 (A.J.P. Gore)

(i) Factors limiting plant growth on peat.
(ii) Productivity of blanket bog vegetation.

Work has continued on the analysis of these two studies and the latter (ii) is almost completed. A paper dealing with the phosphorus cycle of Eriophorum vaginatum was presented at The British Ecological Society Symposium held in Grange-over-Sands, in March, 1971.

(iii) A study of the redox characteristics of wet and dry peat profiles at Moor House and Deer Dike and Striber's Mosses in North Lonsdale.

A computer programme developed by D.K. Lindley and Miss L. Goldsmith is being used to evaluate orthogonal polynomials fitted to these redox data. This programme and a plotting programme provides an efficient way of reducing the large data set, giving quantitative expression to visual results obtained using silver plates due to C. Urquhart (1966), Nature, 211, 550. So far, cubic equations are found most appropriate to those sites not drained artificially. In drained peat oxidizing conditions persist not significantly differently to a depth of 30 cm. The figures illustrate these two conditions using the results of the curve fitting programme with the plotting programme

V. RESEARCH BY FRESHWATER BIOLOGICAL ASSOCIATION

a) Studies on Freshwater Fauna - Project 4/01

1. Fish Project (D.T. Crisp, R.H.K. Mann & Miss J. McCormack)

During the course of 1970-71 the regular three yearly sampling of fish census reaches on the Moor House Reserve has continued. In addition a fish survey of the whole Trout Beck system was made in May 1971, and was repeated in August and October and will be done again in May, 1972.

Material and data from the pre-inundation phase (1967-70) of the Cow Green study are now being processed and prepared for publication. The data from Moor House are being processed at the same time, though final publication will be later than that for Cow Green.

2. Invertebrate Studies (P. Armitage)

Regular sampling of invertebrates from Moor House streams was continued until the end of the 1970 season, but has now been suspended. The results are being analysed.

VI. RESEARCH BY UNIVERSITIES

a) The effect of burning and sheep grazing on the nutrient status of Rubus chamaemorus L. - Project 6/01 (K. Taylor, University College, London)

This project is now completed.

A detailed analysis has been made of the mineral nutrient status of Rubus chamaemorus in an experiment designed to determine the effect of sheep grazing and rotational burning, the usual management practice, on typical Pennine blanket bog. Evidence is presented (Marks & Taylor, J. appl. Ecol., in Press) to support the hypothesis that macro-nutrient supply is not limiting the growth and reproduction of the plant in any of the experimental treatments. It is thought likely that this conclusion will also apply to the widespread tracts of Calluna-Eriophorum bog in the uplands, of which R. chamaemorus is characteristic, and which are so remarkably constant in composition.

b) The effect of burning and grazing on the production of Rubus chamaemorus L. - Project 6/02 (T.C. Marks & K. Taylor, University College, London).

The bulk of the field work in connection with this study was completed by the end of 1970 and the results are being written up.

Limited sampling was undertaken in July, 1971 to provide an estimate of the proportion of above-ground standing crop to below-ground rhizome at the time of seasonal maturity.

Samples were taken from two areas : House Hill, where there was a mature Calluna canopy, and at Green Burn on an area burned in 1965 and which consequently had little Calluna present. R. chamaemorus material was removed from 3 x 1m^2 at each site and split into leaf lamina, stem + petiole, rhizome and root fractions before drying. It is estimated that rhizome retrieval was probably better than 90% but root retrieval was poor and probably no better than 10%.

The results showed a high degree of variability. At the Green Burn site where the mean dry weight of above-ground parts was 21 g/m^2 the weight of rhizome was on average 2.4 times the weight of the above-ground parts. At the House Hill site the comparable values were 5 g/m^2 for the shoots and rhizome averaged 3.7 times this value. Thus when considered on a square metre basis the proportion of rhizome to above-ground parts decreases as the amount of the above-ground parts increases. This situation is not likely in a rotational burning system where the standing crop of R. chamaemorus is probably decreasing in many areas following a flush of growth in the years immediately after a burn.

Carbohydrate analysis

Rhizomes and roots of R. chamaemorus were sampled periodically during 1970 and 1971 and analysed for alcohol - soluble sugar and alcohol-insoluble carbohydrate content in order to follow the course of depletion of stored food material during the long inactive period from September to May:

Mean percentages of the alcohol insoluble residue dry weights of root and rhizome of R. chamaemorus

Date of Sampling	14/7/70	8/9/70	15/12/70	3/3/71	12/5/71
Rhizome:					
Soluble sugar	12	10	18	18	13
Insoluble carbohydrate	20	24	4	3	3
Total	31	33	22	21	17
Root:					
Soluble sugar	13	-	18	19	16
Insoluble carbohydrate	17	-	6	5	5
Total	30	-	24	24	21

Both roots and rhizomes serve as sites for the storage of food materials. If it is assumed that no new growth of rhizome takes place between September and early May, over 50% of stored carbohydrate is lost from the rhizomes during the inactive period and two thirds of that loss takes place before the end of December. During the early autumn most material is stored in the form of alcohol insoluble carbohydrate but by mid-December almost all the reserves have been converted to sugar.

Superficially the pattern of storage in the roots is similar to that in the rhizome although percentage losses are somewhat less. However, interpretation of the root values is not straightforward because it is likely that some root growth takes place during the "resting" period. The autumn of 1970 and winter of 1971 were comparatively mild so the losses of carbohydrate due to respiration during the period of sampling were probably higher than normal.

c) Study on the relationship between egg number and density in Tipula subnodicornis Zetterstedt - Project 6/06 (Mrs. J. Butterfield & J.C. Coulson, University of Durham).

Population estimates for Tipula subnodicornis are being continued. By spring the density of 4th instar larvae at Nether Hearth had dropped to 12 ± 4 larvae/m^2. The blanket bog sites which maintained relatively high larval densities (Bog End 36 ± 5/m^2, Troutbeck 31 ± 7/m^2) in the Spring yielded a small number of adults so that this year there was no relationship between Spring larval densities and the number of adult females trapped at each site. Larvae are now being reared under a number of different regimes in the laboratory and it is hoped that this will indicate some of the causes of differential mortality between sites in the field.

As it is unlikely that there will be an opportunity to evaluate the effects of high densities under natural conditions, a number of high density areas have been created by introducing large numbers of fertilised females into enclosures at Nether Hearth.

Estimates of larval density for T. pagana and T. paludosa have also been made on two limestone areas. At 2050' on the west side of Dun Fell in August the larval density of T. pagana was 64 ± 9. T. paludosa at Troutbeck Flats had a density of 75 ± 9 larvae/m^2 in April which dropped to 24 ± 5 larvae/m^2 in June, indicating either a drop in extraction efficiency or a higher mortality than usual (Coulson found no significant difference between March and June population densities on a similar alluvial area in 1956).

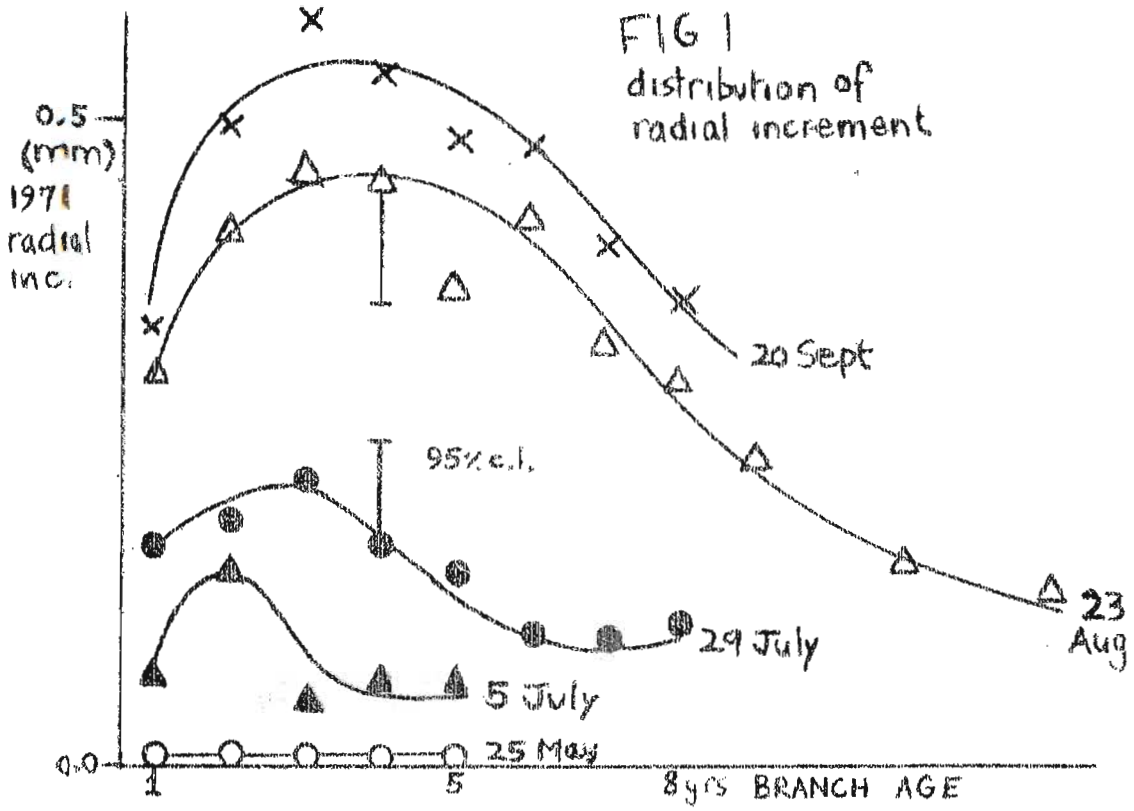


FIG 1
distribution of
radial increment

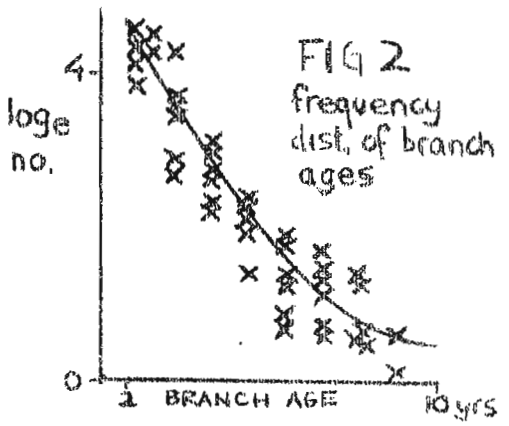


FIG 2
frequency
dist. of branch
ages

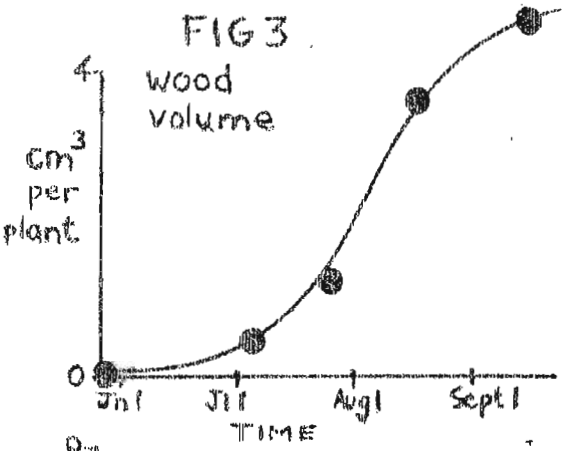


FIG 3

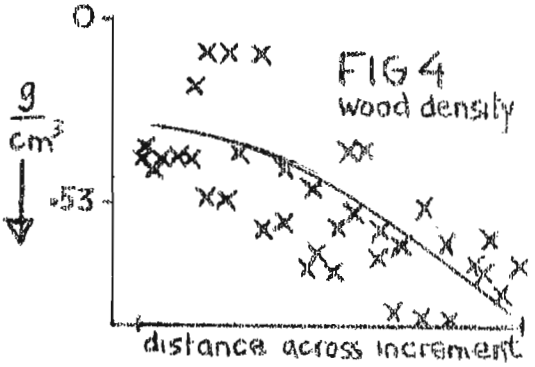


FIG 4
wood density

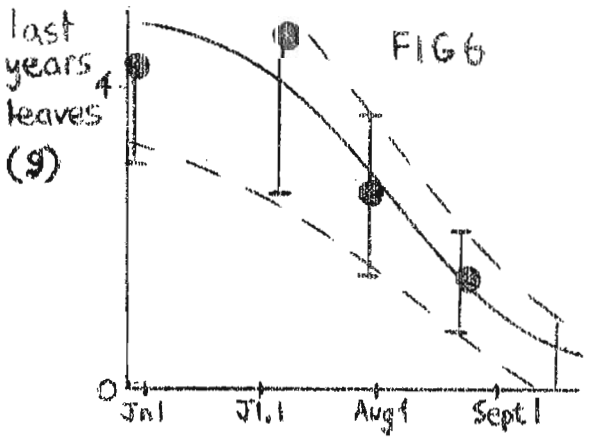


FIG 6

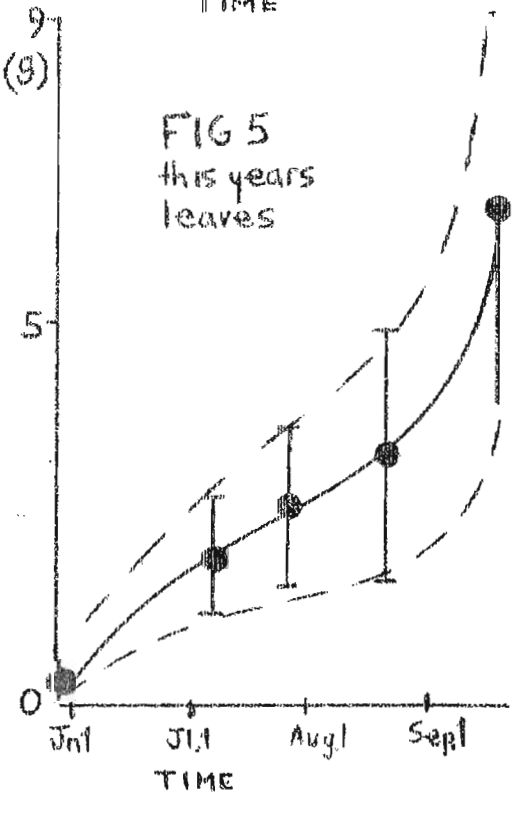


FIG 5
this years
leaves

Respiration studies show that 4th instar T. subnodicornis larvae absorb 143 ± μLO_2/g wet wt/hr at 15°C in December and that respiration rate increases in the spring (206 ± 25μLO_2/gm wet wt/hr at 13°C). These measurements will be checked and further studies carried out. Larvae kept at 5°C and larvae kept at 15°C for three weeks before testing showed no difference in their respiration rates when these were measured at 15°C.

A number of species are being subjected to different temperature and photo-period regimes in the laboratory in an attempt to find the factors influencing the date of emergence in the field.

d) Shoot and wood production in Calluna - Project 6/07 (J. Grace, Department of Forestry and Natural Resources, University of Edinburgh).

The accumulation of dry matter in any plant depends not only on the rate of photosynthesis per unit of leaf, but also on the pattern of photosynthesate distribution. Blackman (1919) first pointed out that a plant with an inherently high rate of leaf growth may be expected to have a high relative growth rate compared to one which places its photosynthate into non-photosynthetic tissue.

The FORTRAN model of Calluna growth described in Grace (1970) used regression equations calculated from laboratory measurements of photosynthesis to predict photosynthetic rates in Calluna under any set of climatic conditions. The present season's work has attempted to measure the way in which the photosynthate is distributed, using periodic field samples of Calluna plants from Sike Hill, and measuring the growth of photosynthetic and non-photosynthetic parts.

To estimate wood production, the size of the current season's wood increment was measured in transverse section at different times during the season and at different places in the plant (Fig 1). To convert these increments to wood volumes (Fig 3), the frequency of wood stems and branches of different ages within the plant (Fig 2), and their diameter and length must be known. To convert wood volume to weight the mean density of the wood and its variation across the annual increment is being measured (Fig 4).

Present and previous season's leaf weights are given in Figs 5 & 6.

To deduce the seasonal pattern of photosynthate from these data requires a knowledge of the carbon content of leaf and wood tissues. The work is still incomplete but reference to Figs 3 and 5 would seem to indicate that the season can be divided into three phases. In the first (June) the emphasis is on shoot production. In July and August this slows, and the greater part of the wood increment is formed. During September a second flush of shoots occur and wood growth is retarded. The consequences of these changes of distribution patterns to the growth of the plant will be examined using the FORTRAN model.

e) Studies on periglacial activity - Project 6/10 (L. Tufnell, The Polytechnic, Huddersfield).

The work on ploughing blocks has been completed, except for the observations on rates of movement which will continue at least until 1975. Results will appear shortly in "Biuletyn Peryglacjalny" No. 21 under the title "Ploughing blocks with special reference to north-west England".

Erosion associated with snow patches was observed during April, 1971: a paper entitled "Erosion by snow patches in the north Pennines" has been accepted for publication in "Weather".

The main research effort during 1971 has been concentrated on elucidating the characteristics of screes and block fields: it represents a continuation of work begun in 1970. The main parameters investigated have been fragment orientation, size, shape and roundness. To date, the sites examined have been in the upper Knock Ore Gill valley and just outside the Reserve on Knock Pike.

f) Studies on black flies (Simuliidae) breeding in bog streams in Upper Teesdale - Project 6/15 (R.S. Wotton & L. Davies, University of Durham)

1. Object: To determine the seasonal cycles, populations and mortality of black flies existing as larvae and pupae in various streams in the area.

2. Methods: Periodic sampling of streams by removal of larvae and pupae from known units of natural substrata (leaves or stones as appropriate) to obtain numbers of different size-groups at each sample date. Additional material is obtained using polythene tapes to determine the proportions of larvae that grow to the next size group between sample dates. This enables the changing duration of each size-group to be determined approximately in different streams at different times of year, an essential step in determining mortalities in the different size groups. Because of inherent errors involved in sampling these larvae and the short duration of the First instar, analyses on the above lines can only be done from the second instar onwards (7 instars all told).

3. Results: Measurements and counts of larval samples as above is sufficiently advanced to report results in detail at present. The first year's sampling and general survey of many streams, show the following facts of species composition and seasonal cycles.

In 3 streams in the Cronkley area at least 7 species occur, with 3 (and possibly 4) sufficiently abundant to be studied quantitatively. Populations of larvae of Simulium brevicaule, S. latipes, S. naturale exist in these streams in all months of the year, with the highest populations in October-November in 1970, but with pupae present over a long span (May to October, or December in the case of S. brevicaule). One of these streams has large enough populations of a fourth species, S. nitidifrons, to be studied in detail.

In contrast with the Cronkley streams, 2 streams near Cow Green (Borderonmere Sike and Dubby Sike) and 4 at Moor House (Rough Sike, Nether Hearth Sike, Moss Burn and Force Burn) had vanishingly small numbers of the aquatic stages of the above-named species during the winter 1970/71. Numbers of larvae in these streams rose to high levels in July--August, with small larvae starting to appear in May or June, and total larval numbers falling during September. Thus although the same species occur in all the areas, seasonal events are quite different at Moor House and Cow Green to what they are at the lower altitude at Cronkley.

Field work during the coming year will be concentrated on 2 or 3 streams with contrasting seasonal events in the Cronkley and Cow Green areas, with analysis of past year's samples being completed to give 2 year's figures for these chosen streams.

Adult females reared from pupae have been kept alive in the laboratory and these will be dissected to determine which if any of the bog stream species are able to complete ovarian development without a blood meal. Preliminary results suggest that S. brevicaule does require such a meal, but the possibility exists that the separate populations in the different study areas mentioned above may differ in this respect, so that some consist of autogenous individuals, that is, are able to complete egg maturation without a blood meal.

g) A study of Gerris species - Project 6/11 (Miss S. Roberts & J.C. Coulson, University of Durham).

The object of this Durham M.Sc. Course project was to measure migration between ponds and growth rates and to study life cycles. Populations were compared with those at low altitudes around Durham. Adult development is delayed at Moor House as compared with Durham and there is also evidence of greater mobility at the higher altitude.

Project thesis is held in the Zoology Department, Durham.

h) Research on Frogs - Project 6/12 (K. Falconer & K.R. Ashby, University of Durham)

This Durham M.Sc. project intended to examine aspects of breeding success, mortality and behaviour. In the end most of the work was done near Durham.

Spawning started at Moor House on 21 March and the spawning period was very long, almost a month. Most of the spawning occurred either towards the beginning or end of that period. In the Durham area in contrast spawning began on February 26th and was completed by 12 March. Although spawning took place at a late date at Moor House, development there was very rapid and metamorphosis took place in early June. In the Durham area, in spite of the lower altitude, the tadpole stage was much longer and metamorphosis took place at the end of June. Falconer attributes this partly to fine spring weather giving warm conditions in the exposed pools at Moor House in which the tadpoles there were living. The newly metamorphosed frogs were 12-15 mm in length. The smallest frogs from the previous year were about 22 mm long in the spring at Moor House.

i) Sedimentology of the Great Limestone Cyclotherm - Project 6/13 (T. Elliott & H. Reading, University of Oxford)

The northern part of the Reserve was viewed in the course of the first year's field work. The object of the study is to give an interpretation of the condition of deposition of the above sedimentary rocks in terms of Sedimentation and environments. Samples are being taken in the field and sections measured.

Analysis will include X-ray diffraction, thin section analysis and Electron scanning microscope work.

j) Microclimatic factors and their influence on soil animal populations - Project 5/03 (I. Haines & C.A. Edwards, Rothamstead Experimental Station).

This is an experimental attempt at correlating environmental factors with their influence on animal populations in the soil with respect to peaks of abundance, fecundity and emergence of pests from the soil.

Soil cores 6 in deep x 2 in diameter are taken. Animals are extracted from the soil by the Berlese-Tullgren method (at Rothamstead).

k) Quaternary investigations of Valley Bog - Project 6/14 (Chambers & J. Turner, University of Durham)

Boring to establish more accurate dating of peat strata has been undertaken but results are still to be analysed.

VII. MISCELLANEOUS RESEARCH

a) Examination of old Lead Mines (Mrs. A. McChesney, Northern Cavern and Mine Research Society)

General Intent:

1. To trace the history of the mines on and around Moor House National Nature Reserve.

2. To photograph and catalogue with map references all remaining traces of mining in the area.

3. To explore and survey accessible mine workings.

4. To catalogue minerals found.

Progress to date:

1. Plans have been obtained of most of the mines in the area, principally:-

a) Troutbeck (Hardshins Vein)
b) Overhearth
c) Greenburn
d) Loppysike
e) Swathbeck
f) Hunters
g) Dun Fell/Silverband

(N.B. Little information on Troutbeck Providence Mine)

Work is progressing on correlating these plans with the 6" O.S. maps by photo-superimposition.

2. From the above plans which are of differing dates, the progress of mining can be deduced to some extent.

3. Most of the surface features, e.g. air-shafts, levels etc. obtained from these plans have been inserted on O.S. maps and these are being located, photographed and, where applicable, the possibility of entry examined.

The only easily accessible level so far found has been the Troutbeck-Hardshins Level. Access is by means of No. 2 air-shaft, a 45' shaft into waist deep water. Exploration has been carried out to the level mouth (visible, but not a means of access due to chest-deep mud, too thick for walking), and to a point 2500' from the level mouth where carbon dioxide has been encountered. Surface work has shown two other points of entry - No. 6 air-shaft and a water blast shaft. Incidentally, this mine is in good condition and if the mouth were dug out the mine would provide a good example of the method of working. The mine itself appears to have been unproductive and very little extraction has taken place.

Other possibly accessible mines so far noted are Swathbeck, Dun Fell Low Level, Greenburn and Overhearth High Level. Information received indicates that the Silverband Mine be left strictly alone due to its alleged unsafe condition at the time of closure.

One very interesting surface feature is the carved stone at the head of Rough Sike, thought to be a Mere stone indicating the boundary of the mineral rights held by the Earl of Thanet.

Further Work:

It must be emphasised that not all levels have yet been visited, and that until this has been done no estimate of the amount of further work can be given. The remoteness of the majority of these mines, particularly when carrying equipment, and the difficulty of locating shafts makes for slow progress.

VIII. RESERVE MANAGEMENT

The exceptional weather, a mild snow-free winter, an early spring and a dry summer has had a considerable effect on wildlife. Plant growth has generally been earlier and above average. The standing crop of grass in the meadow at hay time in July was 4600 kg dry wt/ha, one of the highest yields recorded in 10 years. The production of blanket bog, however, has been similar to 1968 and 1969 (see Smith & Jones p 20. Flowering of some plants was up to four weeks earlier than usual (see Rawes & Teasdale p. 4). Locally, hay crops have been above average and fine weather at hay time resulted in good quality feed being obtained. At Moor House the meadow was cut in July and most of the crop was harvested for winter feed for the wethers. The 19 wethers graze the pasture paddocks and in the winter, the meadow, when they are not used for grazing trials. The grass swards of the Reserve retained an unusually large amount of ungrazed vegetation in September, reflecting both a good year for growth and the overall reduction in sheep with fewer sheep turned out on Milburn Forest. Heather, however, has in many places been heavily grazed by grouse, the population of which is greater than at any time in the past 20 years. P. Taylor's study (p. 36) of the breeding success of grouse gives exceptionally good figures, which are not confined to the Reserve but common locally where large bags have been recorded in recent shoots. Taylor and T. Hodgson have marked over 400 grouse and numerous other species have been ringed by Hodgson. It is of interest to note that like grouse, meadow pipits have been plentiful but very few young Dippers have been found, whilst the studies of Tipulids (a preferred food for grouse chicks and meadow pipits) by Coulson and Butterfield (p.7) show that some species have had a poor season. Thus the survival and performance of birds, particularly grouse, will be of particular interest over the next 12 months.

Ski-ing within an agreed area of Great Dun Fell has been permitted under licence for the last four years and each season has been markedly different. Last winter conditions for ski-ing were exceptionally poor there being only 50 days of snow lie. So despite an increase in the popularity of the sport there was a decrease in numbers. The most popular run remained the east-facing gulley just below the fell summit and a total of 450 skiers was counted here on 20 occasions in the year. 150 used the run in March, whilst in 1970, it was used by 320 people on 14 days. March is the most popular month for ski-ing.

39% (slightly more than in previous years) of the skiers came from Cumberland or Westmorland but many travelled big distances. The effect of the new motorway (M6) is most noticeable; last year the number coming from Lancashire and Yorkshire was about similar but this season 23% of the total were from west of the Pennines and only 9% from Yorkshire.

Whereas there was no ski-ing at Easter the number of visitors to the west side of the Reserve was considerable. Over 250 vehicles were recorded as having entered the Reserve during Easter week-end. The number of casual visitors to the Field Station has increased at week-ends and experiment markers on the more accessible parts of the Reserve have been tampered with. A recorder was stolen and another damaged. There have been reports of poaching and firearms are said to have been used.

Permission to examine mineral veins was sought, and given, for the second year by officials of the British Steel Corporation. A request to re-work the Silverband Barytes Mine was refused by the Planning Authority, Westmorland County Council, but a further proposal from the same company, to mine a much smaller area has now been received and it is likely to be accepted.

The Northern Cavern and Mine Research Society (see p.14) have taken an interest in recent years in some of the older mines on Alston Moor and this year they have been given permission to examine underground workings on the Reserve. They have been particularly active in Hardshins and Troutbeck Mines. Plans, which emphasize the accuracy of early surveyors, have been drawn and photographs taken.

Whilst the weather was open there were few occasions for heather burning. 10 acres were burnt in March in the Green Burn area. Five burns have now taken place in this catchment since 1957 and the intention is to concentrate most of the burning in this part of the Reserve.

The maintenance of the access road continues to take much time and money. Limestone waste has been brought in to fill pot-holes and re-surface, and tar-macadam has been used for the first time. A tar laying machine surfaced $\frac{1}{4}$ mile and further stretches have been laid by hand by Conservancy staff.

The roof of the house and cottage have been re-treated after being turnerised in 1968. Modifications to the plumbing have eliminated a source of air-locks and supply failures in the water system of the main house. The septic tank last attended to in 1968 was emptied.

IX. APPENDICES

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HODKINSON, I.D. 1971. Studies on the ecology of Strophingia ericae (Curtis) (Homoptera:Psylloidea). Lancaster University.

HOROBIN, J.C. 1971. Studies on the biology of moorland Tipulidae with particular reference to Molophilus ater Meigen. Durham University.

M.Sc. Dissertations

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ROBERTS, S. 1971. Studies on selected aspects of the ecology of Velia caprai and some Gerris species.

STALLYBRASS, H. 1970. A study of the upland and lowland forms of the Harvestman Mitopus morio.

Meteorological Summary for Moor House 1970 (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.	YEA
Mean Maximum Temperature	°C	1.6	0.4	1.9	3.9	12.8	16.8	13.5	15.7	12.9	9.4	5.3	2.9	8.
Mean Minimum Temperature	°C	-2.7	-5.3	-3.6	-1.2	3.9	5.8	7.4	7.7	7.4	3.3	0.4	-1.2	1.
½ (Max. + Min.) Temperature	°C	-0.5	-2.5	-0.9	1.3	8.3	11.3	10.5	11.7	10.1	6.3	2.9	0.9	4.
Highest Maximum Temperature	°C	6.1	5.6	6.1	10.0	18.3	23.3	22.8	21.1	20.0	16.1	11.7	7.2	23.
Lowest Minimum Temperature	°C	-14.4	-15.0	-10.6	-8.3	-1.7	0.0	2.2	2.2	-0.6	-1.7	-5.6	-6.1	-15.
Lowest Maximum Temperature	°C	-5.0	-3.9	-1.7	-2.2	8.9	10.6	8.3	10.6	8.9	2.8	-0.6	-0.6	-5.
Highest Minimum Temperature	°C	2.8	2.2	1.7	5.6	7.8	9.4	16.1	12.8	11.7	8.9	7.2	5.6	16.
Lowest Grass Min. Temperature	°C	-18.9	-18.3	-13.9	-11.1	-6.1	-6.1	-2.2	-1.1	-5.6	-5.0	-8.9	-9.4	-18.
Av. Earth Temp. at 1-foot 0900 GMT	°C	0.8	0.7	0.4	2.0	7.3	11.1	11.0	12.1	10.5	7.9	4.8	3.3	6.
Rainfall, inches		6.18	11.03	6.06	7.99	2.41	3.77	6.71	7.29	6.09	10.50	9.47	6.80	84.
Greatest Daily Rainfall, inches		1.18	1.55	1.17	2.15	0.40	1.24	1.09	1.76	1.39	1.26	1.24	1.20	2.
Av. rate of Rainfall, inches/hr*		-	-	-	-	0.032	0.080	(0.051)	0.088	(0.056)	(0.061)	-	-	-
No. of rain days		23	23	24	27	17	9	24	12	23	22	28	22	254
No. of wet days		21	21	19	24	13	9	20	11	16	19	26	17	216
Days with Snow or Sleet falling		8	17	14	12	0	0	0	0	0	3	12	9	75
Days with Snow lying 0900 GMT		14	26	6	14	0	0	0	0	0	0	12	8	80
Days with Hail		0	3	5	5	1	0	3	0	0	3	1	0	21
Days with Snow or Ice Pellets		1	3	2	1	0	0	0	0	0	0	1	2	10
Days when Thunder heard		0	0	0	0	2	3	2	1	0	0	0	0	8
Days with Fog at 0900 GMT		8	2	3	4	7	2	1	2	6	4	6	5	50
Days with Air Frost		18	26	25	20	3	0	0	0	1	3	12	20	128
Days with Ground Frost		24	28	30	23	8	7	3	3	3	10	20	27	186
Total Sunshine, hours		25.9	64.5	107.5	109.5	171.0	234.3	121.5	174.2	91.0	80.6	23.1	36.2	1239.3
Av. Daily Bright Sunshine, hours		0.83	2.30	3.47	3.65	5.52	7.81	3.92	5.62	3.03	2.60	0.77	1.17	3.3
Total Snow fallen, inches		6	66	19	29	0	0	0	0	0	0	13	40	173
Greatest Depth Snow lying, inches		2	17	4	7	0	0	0	0	0	0	6	11	17
Average Wind Speed, knots*		(13.2)	(20.0)	(16.9)	(17.0)	13.0	(10.0)	15.0	(10.7)	(16.9)	(18.4)	(17.6)	(15.2)	15.3
Dats with Gale (anemograph record)		5	8	10	7	4	3	8	3	10	12	11	6	87
Potential Evaporation Data														
Potential Evaporation, inches		-	-	-	(1.3)	2.9	3.7	2.8	2.9	1.8	-	-	-	-
Rainfall, inches		6.2	11.0	6.1	8.0	2.4	3.8	6.7	7.3	6.1	10.5	9.5	6.7	84.3
Potential Water Deficit, inches		-	-	-	0.0	1.2	2.8	0.0	1.4	0.3	-	-	-	-
Potential Water Surplus, inches		-	-	-	6.7	0.7	2.9	3.9	5.8	4.6	-	-	-	-

* Brackets indicate incomplete record, but for more than half the month

Meteorological Summary for Great Dun Fell 1970
c. 655 m O.D. Lat 54° 35' N. Long 02° 28' W. National Grid Ref: No. NY/710322

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Mean maximum	°C	-0.2	-2.1	-0.8	1.1	9.7	14.1	10.2	13.6	10.2	7.0	3.0	0.9	5.6
Mean minimum	°C	-3.0	-5.2	-4.5	-2.6	3.5	6.7	5.7	7.6	5.8	2.6	-0.3	-2.2	1.2
½ (Max. + Min)	°C	-1.6	-3.7	-2.7	-0.7	6.6	10.4	7.9	10.6	8.0	4.8	1.3	-1.3	3.3
Highest Maximum	°C	4.8	4.4	4.0	7.2	16.0	21.6	27.6	20.3	17.2	14.4	9.2	9.0	27.6
Lowest Minimum	°C	-9.6	-10.8	-9.0	-8.2	-1.6	1.4	8.5	3.9	2.0	-5.7	-5.7	-7.7	-10.8
Lowest Maximum	°C	-	-	-	-	-	-	-	-	-	-	-	-	-
Highest Minimum		-	-	-	-	-	-	-	-	-	-	-	-	-
Total sunshine	hours	0.77	2.01	2.44	2.22	3.67	6.59	1.94	4.87	1.61	1.39	0.34	1.02	2.41
Days with sleet or snow		-	-	-	-	-	-	-	-	-	-	-	-	-
Days with snow lying		18	27	30	19	0	0	0	0	0	1	13	12	120
Days with hail		-	-	-	-	-	-	-	-	-	-	-	-	-
Days with thunder		-	-	-	-	-	-	-	-	-	-	-	-	-
Fog at 0900 GMT		23	20	22	20	19	9	21	18	21	24	23	19	239
Days with air frost		25	28	30	24	1	0	0	0	0	5	20	26	159
Days with gale		5	10	7	12	5	2	6	4	8	13	0	-	(82)
Av. hourly wind speed		16.2	21.1	19.8	20.7	18.3	15.5	20.0	15.2	19.8	22.0	21.6	-	(19.1)
Greatest snow depth, inches		-	-	-	-	-	-	-	-	-	-	-	-	-

Note Maximum is from 9h to 21h
Minimum is from 21h to 9h

Staff List

Officer-in-Charge

M. Rawes (Senior Experimental Officer)

Scientific Staff

R. Williams (Assistant Experimental Officer)

R.B. Marsh (Scientific Assistant)

Miss L.M. Teasdale (Scientific and Secretarial Assistant)

Warden

T.L. Hodgson

Estate Worker

P.L. Elliott (until April, 1971)

Housekeeper

Mrs. G.G. Dunn (July - October)

Part-time Warden

J. Rose (December - March)

F.B.A. Staff

Dr. D.T. Crisp (Senior Scientific Officer)

Dr. P. Armitage (Experimental Officer)

Miss S. Carrick (Scientific Assistant)

IV INTERNATIONAL BIOLOGICAL PROGRAMME

Introduction (O. W. Heal, Merlewood)

The research during the year September 1970-September 1971 has started to produce some of the main conclusions from the individual projects and much of the work is now being prepared for publication. About half of the main projects have now ended but full interpretation of the research results has a long way to go.

The results show that primary production on the blanket bog is in the range 500-950 $g/m^{-2}/yr^{-1}$ taking into account between site and between year variation. The variation between the seven bog sites at Moor House shows no marked trend related to vegetation composition or waterlogging but further analysis needs to be carried out. The intensive grouse study during 1971 shows that, despite larger populations than in previous years, less than 4% of the Calluna shoot production is consumed. The sap-sucking psyllids which also feed on Calluna consume less than 1% of the shoot production. The minor role played by herbivores in the energy and dry matter transfer in this system is again emphasised.

The detailed studies on enchytraeids have shown that they assimilate 2-3% of the annual input to the decomposer cycle and the preliminary results indicate that they can markedly increase the rates of litter decomposition, presumably through stimulation of the microbial activity. Although the results from the fauna studies - both herbivore and decomposer - show that they contribute relatively little to dry matter and energy circulation, it is becoming apparent that they play a larger role in nutrient circulation. For example, the N content of many of the invertebrates is of the order of 10% of the dry weight, thus with the relatively low concentration of N in the vegetation, the proportion of N used in annual primary production which passes into psyllid and enchytraeid tissue production may be up to 4% and 15% respectively.

The studies on nitrogen fixation indicate that at least small quantities may be fixed by asymbiotic micro-organisms but it is still uncertain whether these will be sufficient to compensate for the losses recorded in the catchment study made earlier by D. T. Crisp.

A number of small new projects were carried out during the year to answer specific questions and fill gaps in our information. Paul Taylor under the supervision of Peter and Dianne Evans (Durham) carried out an intensive study of grouse breeding and continued the small mammal work. Stephen Bell supervised by Bill Hale (Liverpool Polytechnic) has examined the efficiency of Collembola extraction and population estimation by comparing core sizes, populations in the plant canopy and using soil sections to show what proportion of the population is not extracted. The latter has been paralleled by work on mites by Bill Block and Don Goddard (Leicester University), in both cases the sectioning has been done in conjunction with Dr. John Anderson (Oxford).

Dr. Barbara Mosse and Dr. D. S. Hayman (Rothamsted Experimental Station) have examined various plants for the occurrence of vesicular arbuscular mycorrhizae which are concerned in phosphorus nutrition. This is a comparative study on various IBP sites and the results indicate that these associations are of very little significance at Moor House.

The extension of the primary production estimates to seven blanket bog sites at Moor House has been followed by an examination of rates of decomposition on these sites using standard materials. A vegetation description was carried out during 1971 to ensure that these sites were adequately described and related to Burnt Hill where the intensive Sphagnum studies are concentrated. This was done by Dickie Clymo, Helen Jones and Rosalind Smith.

It is only in the last 12 months that major papers on Moor House IBP have appeared in published form. Ian Forrest's paper in J. Ecol. 1971, 59, 453 defines the primary production on blanket bog estimated from field cropping. His subsequent studies have provided evidence of the between site and between year variation in production. John Grace's thesis and papers (Grace, J. and Woolhouse, H. W. (1970) J. Appl. Ecol. 7, 363) although not funded by IBP provide valuable data on some of the physiological aspects of Calluna production. The paper by Helen Jones, Ian Forrest and Tony Gore in the Proceedings of the Tundra Biome Meeting in Finland describes the main features of the mathematical modelling of the primary production and this approach will be used in future modelling.

John Grace, John Horobin and Ian Hodkinson submitted Ph.D. theses on primary production, tipulids and psyllids respectively. These, and the remaining theses and the other research results must be written up soon for publication if we are to complete the project in the next 2-2½ years. The individual research papers and theses form the bases for the synthesis phase. In this the combined results must be analysed further to describe the more general features of the production of and circulation within, the blanket bog ecosystem. These characteristics must be compared with those of other systems, or parts of systems, in UK and in the Tundra Biome and the results compared with environmental variables. Because there has been no policy of manipulation of the blanket bog in the IBP project and it has been intensive rather than extensive, a correlative approach using results from other studies is particularly important.

The comparison of results has already begun, for example, in Ken Taylor's comparison with Rubus growth in Sweden and in the modelling by Helen Jones, as an important part of the Tundra primary production activities. Rosalind Smith, who has just replaced Ian Forrest, will be concerned with the synthesis of the Moor House results. Initially she will prepare a detailed paper on site description which will incorporate climatic, vegetation and peat profile results which have recently been obtained. She will then concentrate on summarising the results on primary production, including further analysis and comparisons.

International aspects

The close involvement in the Tundra Biome work has been maintained since the meeting in Finland in 1970. The following have participated in the Subject Group Meetings - John Holding, Barbara D'Sylva, Vera Collins, Pam Latter and Bill Heal (microbiology and decomposition), Helen Jones

and Tony Gore (primary production) John Whittaker (invertebrates). These meetings have all required considerable effort in the preparation and examination of results with the aim of comparing data from the 40 or so Tundra sites. It is essential that this activity goes in parallel with the analysis of Moor House results to allow those involved in the research to develop and be involved in the broader interpretation.

a) Vegetation Description of IBP sites - Project 2/15 (R. S. Clymo[1], H. E. Jones,[2] R. A. H. Smith[2], [1]Westfield College, London, [2]Merlewood Research Station)

In July 1971, qualitative records (presence/absence of plant species) were made next to the seven sites at which primary production estimates have been made by G. I. Forrest, and also on Burnt Hill. The sampling areas (usually 25 m x 25 m) were contiguous with the primary production sites and were subjectively selected for floristic similarity of the more conspicuous plants with those remaining on the primary production sites. Samples were 25 cm x 25 cm, randomly arranged on a grid within the sampling area. At the first seven sites 50 samples were examined; on Burnt Hill 119.

Classification, (divisive monothetic using the information drop) produces primary division based on Eriophorum angustifolium, which is present in the majority of the Cottage Hill and about half the Burnt Hill samples. "Green Burn" is fairly distinctly separated in the other group from the Bog End, Sike Hill and "Bog Hill" sites on the presence of Sphagnum magellanicum. The 4th division is of the drier Sike Hill site from most of the others.

These divisions correspond roughly to the "wetness" of the sites. The inverse analysis (producing groups of species) also gives groups which may be related to "wetness".

An ordination (principal components analysis) is not very helpful; the first axis accounts for 0.18 of the total variance, and the first four axes account for only 0.39 together.

It is satisfactory to find that there seems to be, on the whole, a high degree of floristic similarity between samples within a site, although there are quite conspicuous differences between sites only a few tens of metres apart.

A full report of this survey is being prepared.

b) Studies on Sphagnum - Project 2/02 (R. S. Clymo and E. J. F. Reddaway, Westfield College, London)

No experimental work has been done at Moor House this year. The microclimatic measurements have been continued, and analysis of these is about half complete.

A paper giving a tentative dry matter balance sheet for the Burnt Hill site should appear shortly in Hidrobiologia. Others are in preparation.

c) Primary Production of Blanket Bog - Project 2/01 (G. I. Forrest[1], H. E. Jones[2], R. A. H. Smith[2], [1]Forestry Commission Northern Research Station, Roslin, Midlothian, [2]Merlewood Research Station)

The detailed primary production studies on the blanket bog sites were completed during the growing season of 1971 with the third year of cropping on the Sike Hill (wet) site, and the final harvesting of litter trap samples.

1. Calluna litter fall

Four sites were chosen by G. I. Forrest, from those where detailed production measurements were made, to record between-year variation in litter-fall.

At each site 3 transects were laid out with 10 litter dishes staked at 1 m intervals. On Sike Hill (wet), Green Burn and Bog Hill the dishes were staked out on 22 April 1969, and at Bog End at the end of April 1970. Collections were made at the following times and results are summarised in Table 1:-

(i) 29-30 July 1969
(ii) 20-22 October 1969
(iii) early May 1970
(iv) 26 June 1970
(v) 9-15 October 1970
(vi) 27-29 April 1971

2. Sike Hill (wet site) Interyear biomass and production comparisons

For the third consecutive year cropping was carried out on this site at the end of April (15 quadrats) and the beginning of September (20 quadrats). Results are shown in Table 2.

As in previous years there was no significant difference between the biomass of massive perennial Calluna components at spring and summer harvests in 1971.

Some of the differences between the 1971 results and those of previous years may reflect handling and sorting error due to change of personnel rather than between year variation in biomass and production. This applies in particular to the shoot growth of Calluna; production figures for 1969 and 1971 are probably not comparable. There is no significant between year variation in the biomass of Empetrum nigrum, but the biomass and production of Eriophorum vaginatum is significantly lower in 1970 than in 1969.

Biomass and production of the less frequent components of the vegetation (Eriophorum angustifolium, Rubus chamaemorus, Listera cordata and Vaccinium myrtillus)are relatively constant. There was also no significant difference in the total dwarf shrub biomass or the total above ground crop at the 1969 and 1971 harvests.

3. The detailed studies made in 1968 and 1969 on the Sike Hill site have been published (Forrest 1971).

Table 1 Summary of Calluna litter fall data at 4 primary production sites
(95% confidence limits are shown on the 1969 (-70) data)

		May-July	Aug-Oct	Nov-Apr	Total
Sike Hill (wet)	1969 (-70)	25.1	20.2	49.3	94.7 ± 34.3
	1970 (-71)	21.8	39.2	33.5	94.5
Bog Hill	1969 (-70)	40.5	18.0	31.9	90.4 ± 28.0
	1970 (-71)	9.1	32.0	33.4	74.5
Green Burn	1969 (-70)	21.6	22.2	28.8	72.6 ± 29.2
	1970 (-71)	18.7	25.8	20.9	65.4
Bog End	1970 (-71)	46.9	31.6	43.7	122.2

Table 2. Sike Hill (wet site) - Interyear comparisons (with 95% confidence limits)

		1969			
		April	September	Mean	Production
Calluna vulgaris	% shoots	14 ± 3	48 ± 4	31	
	shoots	66 ± 18	306 ± 41	186	240 ± 59
	wood	433 ± 62	338 ± 66	385	
	standing dead	287 ± 76	197 ± 38	242	
	total live	499 ± 69	644 ± 97	571	
	total (above ground)	786 ± 109	841 ± 118	813	
Empetrum nigrum	shoots				
	wood				
	standing dead	4 ± 2	4 ± 2	4	
	total live	18 ± 7	18 ± 7	18	
	wood + standing dead				
	total (above ground)	22 ± 9	21 ± 9	22	
Eriophorum vaginatum	green leaves	67 ± 21	81 ± 25	74	81 ± 25
	inflorescences	1.0			
	total	68 ± 21	81 ± 25	74	
E. angustifolium	total	0.2	0.4	0.3	
Rubus chamaemorus	total		1.4		1.4
Listera cordata	total		0.04		0.004
Vaccinium myrtillus	total	0.01	0.5	0.3	0.5
$\sum$ live *Calluna* + *Empetrum* + *Vaccinium*		517 ± 69	661 ± 96	589	
$\sum$ dead *Calluna* + *Empetrum*		291 ± 78	201 ± 38	246	
total (above ground) dwarf shrubs		808 ± 113	862 ± 118	835	
above ground crop		876 ± 115	945 ± 123	910	

NOTE: Production was only estimated for those components which showed a marked annual variation. Compensation for losses will be calculated at a later date.

all weights given g dry weight/m^{-2}

1970				1971			
April	September	Mean	Production	April	September	Mean	Production
	43 ± 3			6 ± 2	31 ± 3	19	
	319 ± 34		319 ± 34	36 ± 13	212 ± 7	124	212 ± 27
	434 ± 50			505 ± 58	487 ± 84	496	
176 ± 30	219 ± 46	198		246 ± 46	190 ± 36	218	
675 ± 38	753 ± 70	714		541 ± 61	670 ± 107	620	
851 ± 63	972 ± 104	911		787 ± 63	890 ± 130	838	
	11 ± 4			0.9 ± 0.3	6 ± 2	4	6 ± 2
				9 ± 3	8 ± 4	9	
				0.8 ± 0.4	1.4 ± 0.8	1.1	
	15 ± 6						
20 ± 5	26 ± 9	23		21 ± 7	32 ± 13	26	
12 ± 3	41 ± 8	27	41 ± 8	23 ± 7	48 ± 12	36	48 ± 12
				0.3 ± 0.3			
	41 ± 8			23 ± 7	48 ± 7	36	
0.01				0.1 ± 0.1	0.4	0.3	
	1.5 ± 0.7		1.5	0.02 ± 0.02	0.7 ± 0.3	0.4	0.7
	0.02		0.02		0.01		0.01
	0.03		0.03				
695 ± 38				560 ± 61	728 ± 101	644	
				248 ± 46	193 ± 36	220	
				808 ± 64	921 ± 124	865	
				831 ± 64	970 ± 119	901	

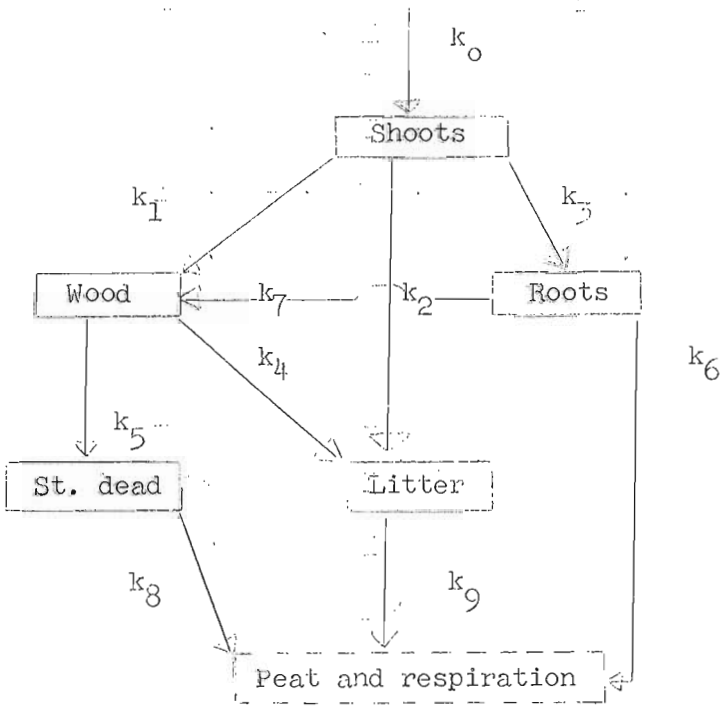
d) IBP: Systems Analysis for Moor House and Tundra - Project 2/09
(Helen E. Jones, Merlewood)

Several attempts have been made this year to apply modelling techniques to the data in order to study the dynamic dry matter and energy flow. Some of these have involved Moor House data only, others have included data from other Tundra sites for comparison.

1. A 5-compartment model of Calluna (Fig. 1), using successive integration and driven by a 6-month negative cosine wave to simulate seasonal changes in production, was developed to describe the field data of G. I. Forrest. The biomass changes of Calluna at Moor House are relatively simple to simulate since there is no significant seasonal change in any compartment except the green shoots, and therefore constant coefficients are suitable.

Attempts are now being made to incorporate the variation of the field data into the transfer coefficients of the model, in order to compare within and between-site variation in the Calluna production data.

Fig. 1 5-compartment model for Calluna at Moor House



This type of model was adapted for 3 compartments, and developed for the comparison of primary production data of 4 Tundra sites including Moor House. The model was discussed at the Tundra Biome Primary Production meeting at Glenamoy, and illustrated the use of information on growing season length, plus production of aerial parts, below ground parts and litter. The chief drawback to the model in this preliminary form was that changes in below-ground biomass, due to back-translocation, were not allowed for, and therefore the input derived to account for the above-ground production represented a hypothetical maximum figure. Further work is to be carried out on this, possibly developing it for more sites. A general comparison of the maximum net input figures (k_o in Fig. 1) would appear to be a realistic aim within the context of IBP and such estimates are thought to be more useful biologically than, for example, comparisons of production of live green parts only.

2. A model for E. vaginatum, using field data of G. I. Forrest, is currently being developed, to simulate seasonal variation in the biomass of its component parts. Unlike Calluna, there is significant variation in components other than the green in this species, which cannot be accounted for solely by seasonal variation in photosynthesis. It will therefore involve some preliminary assumptions about seasonal translocation which, although they cannot be checked except by 'goodness of fit' of the field data, may be useful in studying the effects of possible translocation on the maximum net input figures as derived in 1.

3. Following discussions at the Glenamoy meeting of the Primary Production Group, a model for Calluna was developed to predict seasonal growth from temperature and radiation. 'Textbook' relations of photosynthesis and respiration against radiation and temperature, used by Father J. J. Moore for a grass species, Festuca arundinacea, provided a reasonably good simulation of biomass changes (energy flow) in the field, as checked by data collected in 1968 by G. I. Forrest. Although these relationships are only very approximate, it has been possible to compare this approach with the type of model in 1, which may be useful in the wider Tundra context since sites which have obtained the detailed physiological data on photosynthesis may be able to adopt both approaches of describing energy flow dynamically; sites with field cropping data only will be limited to method 1.

4. Decomposition data have been used to derive some coefficients that could be added to the primary production models. As there is no information on the feedback effects of decaying vegetation on plant growth, this can only act as a sink in the modelling. The preliminary assumption was of exponential decay giving rise to constant decay rates for each litter component. The decay rates obtained indicated that Rubus chamaemorus leaves decomposed about three times more rapidly than Calluna wood; Calluna shoots and E. vaginatum leaves were intermediate.

5. A report was presented at the Tundra meeting in Kevo, Finland in September 1970 by A. J. P. Gore entitled "First stage of a model for the growth and decay of Calluna vulgaris" (H. E. Jones, G. I. Forrest and A. J. P. Gore). This has been published in the proceedings.

e) A Comparison of the Productivity of Rubus chamaemorus L. at Moor House, UK, and Stordalen, Sweden - Project 2/21 (K. Taylor and T. C. Marks, University College, London)

The sites compared are situated close to the IBP sites:

Moor House - Burning and grazing experiment on Hard Hill (610 m)

Stordalen (350 m) - a big hummock site described by Sonesson (1970) (Opera Botanica, No. 26, 1-120) and comparable with the major habitat type 1A of Sonesson and Jonsson (1971) (In- Tundra Biome working meeting on Analysis of Ecosystems, Kevo, Finland, (Ed. O. W. Heal,), 129).

Vascular plants common to both sites in addition to R. chamaemorus are:

Vaccinium vitis idaea
Eriophorum angustifolium
Eriophorum vaginatum

The major competitor with Rubus at Moor House, Calluna vulgaris is completely absent from the Stordalen site.

Sheep grazing at Moor House brings about a significant reduction in aerial dry matter production and fruit yield in R. chamaemorus (Taylor and Marks 1971, In: The Scientific Management of Plant and Animal Communities for Conservation (Ed. by E. A. G. Duffey and A. S. Watt), pp. 153-66, Oxford). At Stordalen the vertebrate herbivores are reindeer, moose and rodents but their effects on the vegetation are unrecorded.

Some results obtained from both sites using comparable sampling methods are given in the following table:

		Mean apparent aerial production ($g/m^2/yr$) ± standard error	mean oven dry weight /fruit (mg)	Number of fruits in 10 x 1 m^2
Moor House, UK				
1969	Burned and ungrazed (C/SF)	25.8 ± 6.2	130	29
	Ungrazed (C/LF)	10.2 ± 4.8	123	15
	Burned and grazed (C/S)	10.0 ± 2.5	0	0
	Grazed (C/L)	3.0 ± 0.6	0	.0
Stordalen, Sweden				
1970	Mire expanse	11.7 ± 3.0	165	12
	Mire edge	50.77 ± 3.7	353	44

Even in the absence of sheep grazing the dry matter production, fruit yield and numbers of fruits per unit area were much lower at Moor House than at Stordalen.

A detailed comparison of the performance of R. chamaemorus in these sites in terms of the effects of climate, competition, mineral nutrients and soil moisture is being prepared for publication.

f) Studies on Red Grouse - Project 2/17 (P. R. Evans and Paul Taylor, University of Durham)

Funds became available in 1971 to employ a full-time worker on the grouse project from May to September inclusive. The following report is based entirely on Paul Taylor's work.

Studies on production of grouse were made at three sites, Bog End, Burnt Hill and The Drive. An average density of 1.14 birds/ha was estimated from the numbers of nests found; this density is about double that recorded in previous years from direct counts (using dogs). 54 nests were found and detailed observations maintained on about thirty. The results are summarised below:

		No. of clutches used	No. of eggs used
Clutch size	8.82 ± 0.52	33	
Hatching date	25 May ± 2.8 days	31	
Incubation period	21 days	6	
Hatching success	94.5%	32	275
Egg size	45.8 ± 0.91 mm	10	40
Egg weight	24.4 ± 0.67 g wet	9	31
Hatching weight of chicks	17.9 ± 0.24 g wet	11	

(Values are means ± 95% confidence intervals)

Comparisons with data from Banchory (Scotland) show that egg and clutch size and chick hatching weight were high, hatching success was good, the incubation period short and the hatching date more than a week earlier than normal. Counts in July revealed a very high survival of young, such that the ratio of young to adult grouse was 3.2 to 1. This measure of breeding success is one of the highest recorded anywhere in the British Isles to date, and far above the Moor House values of 1.2 and 1.1 young per adult recorded in 1965 and 1967 respectively.

From information on breeding output, and chick survival, together with data on growth rates of the chicks, an estimate of biomass production was made. This was of the order of 2.0-2.5 kg/ha.

An estimate of Calluna consumption was also made, on the basis of figures supplied by John Savory of Banchory. It would seem that grouse removed approximately 1.9 to 3.6% of the annual shoot production in 1971.

Additional studies were carried out on the movement of chicks and broods after hatching, and on the growth rates of chicks maintained on different diets. The latter study did not yield useful results, as the keeping facilities for chicks were not satisfactory.

From the 1971 study, together with the outline information from previous years, it is clear that production of grouse and population densities vary considerably from year to year at Moor House. Hence the impact of the birds on the primary production (chiefly Calluna) must vary accordingly. The study of breeding output needs to be maintained in future years if the quantitative importance of grouse in the workings of the Moor House IBP ecosystem is to be evaluated. The importance of insect availability to the chicks immediately after hatching also remains to be determined.

g) Small Mammal Studies - Project 2/11 (Dianne and Peter Evans, University of Durham)

Traps were laid in May 1971 on the 16 rows x 16 points IBP grid near Bog End. These break-back traps were inspected at two day intervals for a week by Paul Taylor; only one Microtus agrestis and a few Sorex minutus were caught. Thus there had been no effective re-colonization by Microtus of the 2.25 ha grid on the blanket bog since the area was trapped out in September 1970.

A further trapping on the IBP grid was carried out by Paul Taylor in September 1971. No Microtus were caught in a week, in contrast to the September catch of nine, a year previously. It now seems fairly certain that Microtus does not breed regularly on the blanket bog, but merely disperses on to the bog in autumn, perhaps in response to high population density on the breeding areas.

In July and August, one such breeding area - in a small plantation on limestone grassland at Green Hole, about a quarter of a mile from the IBP grid - was studied intensively by live-trapping. Microtus, taken in Longworth traps, were individually marked by toe-clipping and then released. Subsequent recaptures indicated that the home ranges of almost all the marked animals overlapped considerably, and that each home range may extend over almost the whole fenced area of the plantation. Break-back traps set at varying distances outside the perimeter fence failed to intercept any animals that might have dispersed. The population density in August in the limestone grassland enclosure was 90 animals /ha. The age composition of the 29 animals caught was:

3 adult males (born in 1970)
4 adult females (born in 1970)
8 juvenile males (early litters 1971)
5 juvenile females (early litters 1971)
6 juvenile males (late litters 1971)
3 juvenile females (late litters 1971)

(The juveniles were aged by their weight)

Unfortunately it is not known what the population density was in Green Hole in late summer 1970, when the nine Microtus found their way on to the IBP grid. Thus any relationship between density and emigration requires further study in 1972.

A collection of Microtus, caught accidentally in pitfall traps around the IBP study area, awaits carcass analysis.

h) Studies on the Ecology of Strophingia ericae Curtis - Project 2/03 (I. D. Hodkinson and J. B. Whittaker, University of Lancaster)

This work is now concluded and has been written up in thesis form. Preparation of papers for publication is under way.

1. Population dynamics

Analysis of three years population data has shown that peaks of nymphal mortality occur at the moult. Life tables (Table 1) have been constructed for all three sample sites (Sike Hill, Bog Hill South and Valley Bog Gate) and they show that approximately half the total nymphal

mortality occurs in the "second summer" period of the two year life cycle. The nymphal mortality rate (R) is lower during the winter than during the summer.

2. Energetics and feeding study

The rate of respiration for the adult instar is given by Y = 0.144 + 0.023 X (where Y = respiration in ml. O_2 per gram dry weight psyllid per hour and X is temperature in ^{o}C). The respiration figures for 4th and 5th instar nymphs are very close to that of the adult.

The total production parameters for each site are given in Tables 2-4. The production figures are expressed primarily per 100 gm Calluna, as this permits comparisons, in terms of intensity of psyllid feeding, between sites having different standing crops of Calluna. The "production" of minerals represents the amount of mineral nutrients incorporated into psyllid tissue and does not include any figure for losses via the excreta. In Table 4 production parameters have been converted to a metre square basis to permit comparison with other studies. However, no conversion was possible for the Gate site as the standing crop of Calluna on this site was unknown. Psyllid feeding at normal Moor House field densities has no measurable effect on shoot length, dry matter accumulation, flower production and mineral content of Calluna.

Table 1 Life Table for Sike Hill 1968 Cohort

L is the total number of animals present on a given date, D is the number dying between two successive dates and R is the mortality rate per day between two successive sampling dates.

* represents the date on which maximum numbers of nymphs are moulting.

Date	L	D	R
25.10.68	1,000.0	115.4	1.1
4. 2.69	884.6	210.1	3.1
21. 4.69	674.5	0	0
21. 5.69	680.1	221.8	12.1*
17. 6.69	458.4	58.7	8.5
2. 7.69	399.6	57.6	10.3
16. 7.69	342.0	43.9	9.2*
30. 7.69	298.1	10.5	7.0
4. 8.69	287.6	46.1	7.0
27. 8.69	241.6	128.7	12.7*
8.10.69	112.8	57.8	10.5
26.11.69	55.0	8.5	1.6
3. 3.70	46.6	9.9	4.1
24. 4.70	36.7	12.6	10.1
27. 5.70	24.1	15.7	43.5*
11. 6.70	8.4	4.4	40.1
24. 6.70	4.0	0.1	1.6
8. 7.70	3.9	2.4	42.9
22. 7.70	1.6	0.7	31.6
5. 8.70	0.9	0.1	7.4
19. 8.70	0.8	0.4	25.6
9. 9.70	0.4	0.3	38.6
2.10.70	0.1		

Table 2. Total production parameters for each site (in calories/100 gm Calluna/year) and the ecological efficiencies.

	Sike Hill 1969	Sike Hill 1970	Bog Hill 1970	Valley Bog Gate 1970
Production due to growth	260.3	29.0	39.6	55.5
Respiration	550.6	27.8	36.4	52.4
Excretion	1692.1	197.8	255.0	412.9
Assimilation	810.9	56.8	76.0	107.9
Consumption	2503.0	254.6	331.0	520.8
A/C (%)	32.3	22.3	22.9	20.7
P/A (%)	32.1	51.1	52.2	51.4
P/C (%)	10.4	11.4	11.9	10.7

Table 3 "Production" of minerals (gm x 10^{-6}/100 gm Calluna/year) for each site

	Sike Hill 1969	Sike Hill 1970	Bog Hill 1970	Valley Bog Gate 1970
Potassium	358	40	55	76
Nitrogen	4860	990	740	1036
Phosphorus	859	96	131	185

Table 4 Total production parameters for each site (cals/m^2/year)

	Sike Hill 1969	Sike Hill 1970	Bog Hill 1970
Production due to growth	686.7	76.5	85.5
Respiration	1452.4	73.3	78.5
Excretion	4463.8	521.8	550.3
Assimilation	2139.1	149.8	164.0
Consumption	6602.9	671.6	714.3

i) Studies on Moorland Craneflies - Project 2/04 (J. C. Coulson, University of Durham)

Life table data for Molophilus ater have been collected for eight successive generations and they are now sufficient to make some preliminary analyses concerning key factors in determining population change and density-dependent processes. The following summarises the main conclusions:

1. The population density of adult craneflies has been remarkably constant over eight years on two Juncus squarrosus sites; no changes in population occurred in excess of ± 30% of the mean and the coefficient of variation of the log. adult population was 6%. Typical densities are of ?,000 adults per sq. m.

2. Such stability suggested that density-dependent processes were operating. Egg and first instar mortality rates, female fecundity and possibly the sex-ratio of adults were density dependent while the mortality rate in instar 3 was inversely density dependent. None were perfectly density dependent and a slope of about 0.5 was obtained for the first two (1.0 being the slope of a perfect density-dependent effect).

3. No significant differences in the form of the mortality were found between the two Juncus sites.

4. The mortality in the egg and first instar stages accounted for 90% of all mortality in each generation and this was also the key mortality stage which primarily determined the size of the next generation.

5. The sex-ratio of adults varied between 15% and 50% females. The preliminary analysis, using additional data from other sites, suggests that this ratio is influenced by i) population size in the autumn (instar 2), ii) the mortality rates in instars 3 and 4, and iii) inversely with the mortality in instar 2. There is no evidence of differential mortality of pupae. Thus it appears that certain larval stages have a greater risk of mortality of potential male or female larvae, long before sexual differentiation takes place. Since a high proportion of males is, effectively, reducing the fecundity per individual, this can be regarded as a differential mortality which acts as a density-dependent mortality factor, reducing the number of females at high densities (because the mortality rate was relatively low to produce this density).

6. Only a small amount of information has been obtained on respiration rates on larvae owing to technical difficulties of using such small animals. Further results will be obtained this year. Respiration appears to be temperature dependent even in acclimatised animals.

7. Growth of larvae in the field is temperature independent over the normal autumn and spring temperature ranges encountered. Thus larval development is actually slightly quicker at 2,700 feet than at 1,400 feet although the average and accumulated temperatures are some 40% less at the higher altitude. Such an effect is interesting and important since it is a valuable adaptation to living in habitats with a large, but consistent difference in temperature which, as here, occurs over a wide altitude range.

8. The only difference detected in relation to altitude is that emergence is later at the higher levels. Experiments show that this is caused by all larvae requiring a similar temperature threshold to initiate pupation and this level is reached first at the lowest and last at the highest sites. No diapause has been found.

j) Production Studies on Oribatid Mites under Calluna vulgaris - Project 2/10 (W. C. Block and D. Goddard, University of Leicester)

Research was concentrated upon the measurement of respiration rates of two species of oribatid mites (Acarina) from blanket bog on the Moor House National Nature Reserve, Westmorland. These data will be extrapolated to field temperatures and combined with estimates of field production to give data on field assimilation in these species.

A Cartesian Diver micro-respirometer with a sensitivity approaching 10^{-6} µl has been used for determinations of oxygen uptake on individual animals. Samples were collected from the IBP site (Sike Hill) in May, July and October in 1970; January, March, May and August 1971. After extracting the mites from the samples in Tullgren funnels, specimens of two species were selected and placed in cultures with plentiful food material at three temperatures: 5°, 10° and 15°C. At least 15 days were allowed for acclimatisation to these temperatures before measurements of oxygen uptake were made.

Respiration rates of adults (♂ and ♀), tritonymphae, larvae and ova have been measured for Belba (Damaeus) clavipes and Platynothrus peltifer at 10° and 15°C. A summary of the data obtained so far for B. clavipes is given in the attached table.

These data show that a temperature increase affects the respiration rate of the adult ♂ and ♀ differently. Over the range 10° to 15°C the rate increases in ♀ , but in ♂ it decreases. This is seen both in oxygen uptake per animal and per unit fresh weight. Respiration rates for different life stages show marked differences at the same temperature. At 15°C, the adult ♀ respires at a faster rate than the adult ♂ , but at 10°C the adult ♂ has a faster rate than the ♀ on a weight specific basis. For 10°C both the tritonympha and ova respiration rates are considerably greater than either the adult ♂ or ♀ . At 15°C the larva respiration rate is almost four times the rate measured for the adult ♂ and ♀ .

Similar data are being accumulated for P. peltifer, but they are less complete at present. A comparison is being made of respiration rates of the Moor House species, which are subjected to a sub-arctic climate, with another cryptostigmatid mite, Alaskozetes antarcticus, collected from Signy Island in the Antarctic.

At present, work is being done to complete respiration measurements for B. clavipes at 10° and 15°C, with at least 10 measurements being made for each life stage at each temperature. These will include protonympha and deutonympha stages. It is proposed to measure oxygen uptake for each life stage of B. clavipes at a third temperature, 5°C, and it is hoped to complete these experiments by October 1971.

Two sets of samples from Bog End have been examined, in conjunction with Dr. John Anderson (Oxford University), to test the extraction efficiency of the Macfadyen high gradient extractor. After extraction of mites, the cores have been embedded, section and the mites remaining in the peat have been counted. This work will be completed soon.

Stage	Fresh Weight µg	Temp. °C	No. of specimens	Oxygen uptake µl x 10^{-4}/h /individual	/µg Fresh weight
Adult ♀	230.75 (26)*	15	11	254.8	1.05
		10	15	231.8	1.01
Adult ♂	170.12 (20)	15	7	160.4	0.93
		10	13	207.7	1.22
Tritonympha	86.50 (8)	10	8	135.3	1.55
Larva	6.06 (5)	15	5	22.8	3.91
Ovum	5.50 (7)	10	7	11.1	1.92

*N.B. Figures in parentheses denote total numbers of animals weighed

k) A Population Study of Collembola on Heather Moor - Project 2/12 (W. G. Hale and S. N. Bell, Liverpool Polytechnic)

The sampling programme, started in April this year and due to continue for a year, is aimed at obtaining a true population figure for the Collembola of heather moor. Although work has been done on the Collembola of Moor House on previous occasions, the present project is confined to Collembola of the Calluna-Eriophorum blanket bog on the IBP site (Sike Hill). A variety of sampling methods is being used, some of recent development.

A number of factors have been considered. Collembola move freely and occur in the canopy as well as the litter, the canopy population must therefore be sampled, an exercise not carried out in previous studies. Various methods have been tried, including the vacuum cleaner technique, but this was rejected because of the work involved sorting the Calluna debris picked up and because it sampled from the surface litter as well as the canopy. The canopy is now being sampled using heat extraction of 20 samples per month of about 20 g of cut Calluna shoots. The figures obtained for a known weight of Calluna green shoots are converted to numbers/m^{-2} using a figure for mean biomass of Calluna green shoots of 227 gm/m^2 obtained by Ian Forrest for Sike Hill.

Table 1 Mean Total Collembola in Calluna Canopy (/m^2). Further analysis is in progress

May	30.42
June	17.20
July	-
August	38.58
Sept.	8.30
Mean	23.62

In an attempt to eliminate errors associated with sampling the litter, two cores sizes 1/100th m^2 and 1/1000th m^2 were used, thirty and thirty-two sample units respectively of 3 cm depth being taken monthly. Errors may arise from core size effect on aggregation or compression on sampling. After extraction, using a modified Macfadyen high gradient extractor, the 1/1000th m^2 cores are embedded in gelatine under vacuum (Anderson and Healey 1970), sectioned and examined, any remaining Collembola being counted thus enabling the 1/1000th m^2 results to be corrected and the relative efficiency of the extractor to be determined.

Of the results obtained to date there is a wide diversity between the two sample unit sizes used for the litter, the smaller core giving a much smaller population figure.

Table 2 Mean total Collembola in litter (/m^2), preliminary results

	1/1000th m^2 core	1/100th m^2 core
Feb	10,410	15,760
March	-	-
April	-	-
May	1,910	18,687
June	530	23,197
July	500	10,927
Aug	625	-
Sept	719	-
Mean	2,449	17,143

N.B. These results are suspect because of faults in the extractor

After embedding and sectioning some of the cores, the values obtained for the 1/1000th m^2 cores were corrected but the values were still low.

Table 3 1/1000th m^2 figures with corrections (/m^2), preliminary results

	1/1000th m^2 core	Section	Total	
July	700.0	3100.0	3800.0	(for 10 cores)
Aug.	857.1	3285.6	4142.9	(for 7 cores)
Mean	764.7	3176.5	3941.2	

At present tests are being conducted on the extractor in an attempt to discover the reason for the descrepancy.

In the litter the most abundant species are, in order, Isotoma sensibilis (6730.0/m^2), Folsomia brevicauda (4970.0/m^2) and various Sminthuridae (1584.0/m^2). In the canopy the majority of the Collembola found are the active jumping species, especially Sminthuridae and Isotomidae. The present sampling programme is however only half complete and therefore these results must be regarded as provisional.

1.) Production and Respiration of Cognettia sphagnetorum" Project 2/05 (V. Standen, University of Durham)

Cognettia sphagnetorum is the dominant enchytraeid occuring on blanket bog, comprising approximately 90% of the total biomass of Enchytraeidae. This species reproduces by fragmentation when the worm splits to form a head and tail fragment and sometimes a middle fragment. The segments then regenerate their parts and continue to grow by the addition and enlargement of segments.

The death rate of the population has been estimated using rates of fragmentation regeneration and growth determined in the laboratory. The total number dying in each category in a year is summed to give the annual turnover and this plus the difference in standing crop gives the annual net production (Table 2). Production turnover, i.e. the ratio of net production to average standing crop is 1.15 for 1968/1969 and 0.78 for 1969/1970.

The rate of respiration of C. sphagnetorum was measured using a Cartesian Diver. For whole worms there is no relationship between the size of the worms and the rate of oxygen consumption. The rate of respiration of fragments was approximately 1-3 times that of the whole worms. For whole worms two rates of respiration were obtained according to whether the worms were active or passive in the diver and this behaviour response was determined by temperature. Individuals became active when moved to a higher temperature and passive when moved to a lower temperature. No evidence of acclimatisation to temperature was found unless this was immediate. In computing a field respiration rate the:

$$\frac{\text{active rate} + \text{passive rate}}{2}$$

was used. At 5°C and 10°C this is 115 and 230 µl O_2/g/hr respectively.

The rate of oxygen consumption/hour at the mean field temperature, the biomass/m^2 of each category of worm and the number of days between samples was then used to compute oxygen consumption/m^2 for each between sample period, and finally for each year.

The annual population respiration and assimilation are shown in Table 1. The overwinter respiratory cost to the population has been cut down in several ways. a) whole worms comprise most of the overwintering population and the adult respiration rate is lower than that for fragments b) active individuals become passive when temperature drops in winter and the passive respiration rate is much lower than the active rate c) there is no acclimatisation to low temperatures which means that the respiration rate is lower than if the worms were low temperature adapted.

Nevertheless the production efficiencies $\frac{\text{Production} \times 100}{\text{assimilation}}$ are only

17.2 for 1968/69 and 14.1 for 1969/70. These are much lower than predicted for short lived poikilotherms by McNeill and Lawton (1970) and may be because the energy cost to production is greatly reduced by its method of reproducing by fragmentation.

It is suggested that reproducing by fragmentation cuts down the energy cost to production and lack of acclimatisation to low temperatures reduces the overall respiratory cost and that therefore C. sphagnetorum is well adapted to live under Moor House conditions.

Table 1 The annual population production and respiration for C. sphagnetorum, calorific equivalent 1.034 Kcals/gm live weight. Oxycalorific equivalent 4.775 Kcals/litre oxygen

Year	Production (P) g/m^2	Production (P) $Kcals/m^2$	Respiration (R) CO_2/m^2	Respiration (R) $Kcals/m^2$	Assimilation (P + R) $Kcals/m^2$	$\frac{P \times 100}{A}$
1968-1969	12.44	12.86	12.98	61.98	74.84	17.2
1969-1970	10.05	10.39	13.27	63.36	73.75	14.1

Table 2 Standing crop, turnover and net production of C. sphagnetorum

Category	Av. segment number	Av. weight (mg)	1968-1969 Annual turnover no/m^2	1968-1969 Annual turnover biomass (g)	1968-1969 Av. standing crop no/m^2	1968-1969 Av. standing crop biomass (g)	1969-1970 Annual turnover no/m^2	1969-1970 Annual turnover biomass (g)	1969-1970 Av. standing crop no/m^2	1969-1970 Av. standing crop biomass (g)
small	32	0.19	10,457	1.987	14,736	2.799	8,884	1.688	17,487	3.322
Large	49	0.41	27,655	11.338	18,242	7.479	15,043	0.168	22,365	9.169
Head	22	0.11	1,633	0.180	11,524	0.127	9,499	1.045	837	0.092
Middle	17	0.08	168	0.013	6,809	0.054	3,736	0.299	534	0.043
Tail	25	0.13	2,771	0.360	2,478	0.322	2,070	0.261	2,036	0.265
				13.878		10.781		9.461		12.891

	Standing Crop	Difference
April 1968	9.61 g	
April 1969	8.17 g	- 1.44 g
March 1970	3.75 g	+ 0.58 g

Production = Annual turnover + difference in standing crop

1968-1969 = 13.378 + (-1.44) = 12.44 g
1969-1970 = 9.461 + 0.58 = 10.04 g

m) Feeding Studies on Enchytraeidae - Project 2/06 (Pamela M. Latter and Gillian Howson, Merlewood)

The experimental work on the food eaten by the Enchytraeid worm; Cognettia sphagnetorum, (1970 Annual Report) has now been completed. The observations on gut contents, faeces and microbial content of foods is now being carried out. The method of culturing worms in the perspex slides with a sample of food in a shallow depth of bog pool water has proved successful and worms have remained alive for over one year. Preliminary results show the tested foods to support growth of non-sterile worms as follows:

Good growth (up to 130% increase in segment number in 8 weeks) - Calluna, Eriophorum and Rubus litters.

Moderate growth (approx. 30-60% increase) - Sphagnum, Cladonia, peat particles.

Poor growth (below 30% increase) - peat expressate, bacteria expressed from peat with antibiotics added.

No growth or death - bacteria expressed from peat, fungal mycelium, filter paper.

Calluna litter inoculated with various fungi gave similar growth to untreated control litter. Growth occurred in a few sterile worms maintained on irradiated (sterile) Calluna litter.

The worms move up the centre of Calluna litter, Eriophorum leaves and Cladonia thallus and feed on and remove the internal tissues leaving a cylinder of outer tissues. On Rubus leaves the softer tissues between the veins is eaten. Finely divided faecal material accumulating in the cultures varied in quantity with different substrates. Where solid food was not present, particles or bacteria in suspension were sucked in. The worms were not observed to re-ingest faecal deposits.

Under the culture conditions used, i.e. with chopped food, material which would be present in the standing dead and surface litter seems acceptable as food. In the field, numbers are lower on this type of litter and worms were not observed on the marked decomposing litters in the first year (see litter decomposition project). It is presumably unavailable in the field because worms are unable to penetrate the harder external tissues unless they are broken, and the lack of satisfactory moist conditions makes the material unacceptable. Numbers of worms increased in the 2 and 3 year old litter but were reduced on 4 to 5 year old litter.

The results suggest that C. sphagnetorum which constitutes 60% of the fauna biomass in the peat sites, is responsible for comminution and digestion of partially decomposed dead plant litter. Micro-organisms do not seem to provide an acceptable food source. This would place the worms in the secondary decomposer pathway of the food chain.

n) The Influence of Soil Fauna on the Decomposition of Blanket Bog Litters - Project 2/18 (V. Standen, University of Durham)

The objectives of this research are:

(1) to measure the growth and production of Cognettia sphagnetorum in the field to test the validity of production

(2) to show the influence of different population densities of enchytraeids and tipulids on (a) the rate of decomposition of different types of litter, (b) the rate of respiration of decomposing litter and (c) on nutrient release.

The experimental set-up uses nylon mesh bags (aperture 45 microns diameter) with weighed quantities of litter of different types. Known numbers of C. sphagnetorum were added to the bags before they were returned to the field. The number added was either 14 or 5 animals equivalent to approximately 35,000/m^2 and 12,000/m^2 respectively. After three months (June-September) the bags were retrieved and the changes in physical and chemical composition of the litter, the dry weight loss and the growth of the animals are being measured. Microbial activity is being measured as the respiration of the undisturbed litter in Dixon respirometer flasks - the contribution made by animals in the litter is calculated from the known rate of respiration of these animals measured in a previous study using a Cartesian Diver. The experimental site is on blanket bog at Sike Hill where temperature is being monitored by a Grant recorder.

The first of these experiments, which used different densities of C. sphagnetorum only, is complete and the results are being analysed. In the second experiment the tipulid Molophilus ater is included.

The results obtained show the rates of oxygen uptake of undisturbed litter to be similar for Eriophorum and Calluna which are greater than the rate for Sphagnum. After three hours in the respirometer the average rate of respiration at 10°C of the litter with a high density of enchytraeids is:

Calluna	213 µl oxygen/gm oven dry wt. litter/hour
Eriophorum	264 µl oxygen/gm oven dry wt. litter/hour
Shagnum	51 µl oxygen/gm oven dry wt. litter/hour

Measurement of respiration rate with Sphagnum litter has not been satisfactory and the average figure given above may include some results which are too low owing to the release of oxygen and methane in the respirometer.

The rate of respiration of Eriophorum litter with a high density of enchytraeids is twice the rate found for the same litter with no enchytraeids. The data for the other litter types are not yet analysed.

The loss in dry weight of Eriophorum litter with a high density of enchytraeids is about 20% of the original weight after three months compared with 5.5% of Eriophorum without enchytraeids; for Sphagnum with a high density of enchytraeids the loss is 8.7% as against 4.8% for the same litter without enchytraeids.

The animals are recovered from the litter and then their segments are counted before they are killed and oven dried prior to weighing. The weighing has not yet been carried out but from the segment counts it seems that there has been a proportionally greater increase in the standing crop within the litter bags containing the low numbers of C. sphagnetorum compared with the bags containing the high numbers.

In addition the carbon dioxide output on the site is being measured using the conductimetric method described by Chapman (Oikos, in press). Readings have been taken at noon on three different occasions this year, but a more complete record of the carbon dioxide output through the day will be obtained in 1972.

None of the results quoted is final. Six replicates on the sites will give standard deviation of the mean.

o) Decomposition of Plant Remains - Project 2/07 (O. W. Heal and P. M. Latter, Merlewood)

The aims of this study are:

a. To estimate the rates of decay of the main components of the blanket bog vegetation and to relate these to the chemical quality of the organic matter and to habitat variables.

b. To calculate from primary production data and decay rates, the rates of accumulation of organic matter.

Long term decomposition

The dry weight loss and changes in chemical composition of the main vegetation types are being recorded for up to ten years, on samples laid down in 1966 (Calluna, Eriophorum) and 1967 (Rubus chamaemorus). Samples are enclosed in nylon mesh bags with the exception of Calluna stems which are tied directly to the label.

The % dry weight loss from the four types of litter are given in Table 1. The exponential trend in all litters has continued in the sampling made in September 1971.

Table 1 % dry weight loss ± SE

	1 yr	2 yr	3 yr	4 yr	5 yr*
Calluna stems	7.6 ± 0.6	15.2 ± 2.0	16.1 ± 1.0	24.1 ± 1.3	23.3
Calluna shoots	14.8 ± 1.4	29.3 ± 2.5	24.5 ± 2.2	40.2 ± 1.4	53.6
Eriophorum leaves	26.4 ± 2.1	36.5 ± 2.4	46.7 ± 2.1	65.1 ± 5.1	54.0
Rubus leaves	38.1 ± 1.6	53.8 ± 2.0	62.3 ± 3.8	69.7*	

* approximate results only

The wood of some of the Calluna stems is softened in parts but the samples are still complete, apart from some loss of bark. The condition of the leaf samples is very variable, some are largely disintegrated to faecal material while others are still recognisable remains or complete

leaves or shoots. Penetration of the samples by rootlets continues and some central cylinders of Calluna and Eriophorum leaves and shoots are now filled by roots. The Calluna and Eriophorum samples now five years in the field, are mostly lying on, or just into the brown horizon (mean depth 3-4 cm).

The condition of the retrieved remains now makes sorting very difficult. It is doubtful whether any further dry weight loss measurements can be made, except in the case of Calluna stems. The results were discussed at a British Ecological Society Meeting in March 1971.

Variation in decomposition rates

In late 1970 a series of experiments were set out by Mr. G. Smith. These used the litter bag technique and were designed to examine a number of sources of variation. Samples will be collected in October-December 1971.

The experiments containing at least 10 replicates for each treatment were distributed as follows in randomised block designs.

Between year variation: Rubus chamaemorus leaves on Bog Hill, to repeat the earlier experiment. A further set of nets were laid down in September 1971.

Between litter variation: 15 types of litter from 10 species on Sike Hill.

Between microhabitat: Rubus chamaemorus leaves in three habitats - Calluna, Eriophorum and Sphagnum - on Sike Hill.

Between depths: 3 litters including, Eriophorum vaginatum roots and Calluna below ground stems, at 5 depths on Sike Hill.

Between sites: Rubus chamaemorus leaves and cotton strips on 9 blanket bog sites.

Cellulose decomposition

In the above experiments cotton strips inserted vertically into the profile are being used to compare decay rates on different sites. The strips are left in position for up to one year and the tensile strength of sections of the strip is measured as an index of decay.

Cotton strips have been provided for parallel IBP studies in Kevo (Finland); Signy Island (Antarctica), Glenamoy (Ireland), Hardangervidda (Norway) and Abisko (Sweden). Samples from the first three sites have just been analysed but results are not yet available. In addition to wood pulp cellulose preparation, which is being used as a standard in all Tundra IBP sites, has been set out at Moor House.

In a separate study Mr. G. Spragg, a sandwich student from Bath Polytechnic examined the relationship between dry weight loss, cellulose loss and tensile strength. There was a difference in the relationship for two soils tested, and it may be necessary to do a simple soil test for any new site. The results are being analysed and will be written up in a paper on the method.

Decomposition in relation to burning

At Hard Hill, Rubus chamaemorus leaves obtained from the unburnt plot, showed 43.3% dry weight loss in one year (1967-68) when decomposed on the burnt plots (A/SF) compared to 34.7% on the unburnt plot (A/NF). The difference, which was significant at 5% level may be due to increased moisture content and more faunal activity on the burnt plot. This work is being prepared for publication with P. J. A. Howard.

Tolypocladium, gen. nov.

The fungus referred to in Latter, Cragg and Heal (1967) as unidentified white sporing species, and which is common in the peat sites, has now been named by W. Gams as follows:

Species A = Tolypocladium geodes

Species B = T. cylindrosporum

Type specimens of Moor House cultures, are held at Centraal Bureau Schimmelcultures, Baarn, and a full taxonomic description is given in Gams, W. (1971), Persoonia 6, 185-191.

The paper "A preliminary study of the growth of fungi and bacteria from temperate and antarctic soils in relation to temperature", which includes work on fungi and bacteria isolated from Moor House peat, is shortly to appear in Soil Biology and Biochemistry.

p i) Study of Anaerobic and Facultative Bacteria in Peat - Project 2/08 (Vera G. Collins and Barbara T. D'Sylva, Freshwater Biological Association)

The numbers of heterotrophic aerobic and facultative anaerobic bacteria and the numbers of selected physiological groups of bacteria were studied at different depths in the peat profile. Pure cultures of these bacteria were identified and tested for their ability to perform various biochemical activities. The techniques for enumeration and isolation of the bacteria can be found in previous Annual Reports (1967-70). Tables I, II and III summarise the characteristics of the peat profile and the numbers of the different groups of organisms present at various depths in the peat.

The results indicate that there are bacteria present in peat capable of carrying out various biochemical activities. They occur in rather low numbers, but these are indicative of their 'potential' activity in the soil. The numbers of heterotrophic bacteria are in the same range as those for some arable soils, and the aerobes and facultative anaerobes follow a similar pattern with depth in the profile (Table I). Tests done on representative cultures showed that the isolates demonstrate an oxygen tolerance range from 3% to 90% saturation, indicating a truly facultative population present at all depths.

Biochemical groups

The numbers of bacteria that could grow on a medium with chitin as the main carbon source ranged from 10-170 x 10^3 (Table II) but very few of them could decompose chitin to its final stage of N-acetyl-β-glucosamine. It is likely therefore, that bacteria initiate the breakdown of chitin in association with fungi; the latter completing the lysis.

A similar association with fungi probably takes place in the breakdown of cellulose; high numbers of cellulose decomposers were observed in the 'litter' horizon (Table III).

Sulphate reduction was greatest in the 'green' horizon; a strong odour of hydrogen sulphide was noticed in this zone, and the 'green' colour turned to black upon exposure to air. Sulphate reduction is higher under waterlogged, anaerobic conditions; Urquhart (1969) found a drop in redox potential around 20 cm and this corresponded to maximum sulphide deposition on silver plates.

The thiosulphate oxidisers were high in the litter layers. Tests with pure culture isolates showed the presence of high numbers of Thiobacillus denitrificans in the 'green' zone indicating the facultatively anaerobic metabolism of this organism.

Highest numbers of denitrifying bacteria occurred in the 'litter' horizon and the numbers decreased with depth. This demonstrates the ability of the facultative population to utilise available nutrients under the site conditions, since it is likely that more nitrate is present at the surface than in the lower layers.

All the biochemical groups tested are present in blanket peat, but all are in much lower numbers than in arable soils. It is known that decomposition rates in peat are low, and although bacteria capable of breaking down the components are present, their ability may be restricted by low pH and resistant organic matter. Reduced oxygen conditions also reduce populations despite the increased numbers of facultative anaerobes and although populations may be high their rate of carbon breakdown is low.

p ii) Studies on Nitrogen Fixation in Peat - Project 2/16 (Vera G. Collins, and Barbara T. D'Sylva, Freshwater Biological Association)

Investigations have continued to determine the amount of N_2 fixed/m^2/year and to try and relate the amount of N_2 fixed with the numbers of nitrogen-fixing bacteria.

The numbers of nitrogen-fixing bacteria were estimated by a dilution count on Biggins and Postgate's mineral salts medium containing a small amount of nitrogen (20 µg/l). The results given in Table IV are the mean values for three samples taken at each sampling treatment. Details of the depths of the four horizons are given in the preceeding report.

The highest numbers of bacteria capable of growing on the selective medium for estimating their nitrogen fixing capacity occurred in February for three of the four horizons. For the 'green' horizon counts were slightly higher in October than in February. Aerobic and anaerobic counts appear to be closely related (Table IV) for each sampling. Maximum numbers occurred in the litter zone.

The amount of nitrogen fixed in situ is estimated by the acetylene reduction technique. The quantity of ethylene produced from acetylene is analysed on a gas chromatograph. (Details of method in Moor House Annual Report, 1969-1970). Preliminary results indicated that the amounts of ethylene produced varies between 1 and 40 n. moles C_2H_4/g dry weight/hr.

Between site variation and between depth variation are being studied on five sites, (Bog End, Sike Hill, Cottage Hill (2 sites) and Green Burn), and seasonal variation studies continue on the Bog End site.

Table I Characteristics of the Peat Profile at Bog End

Horizon	Range of depth at which horizon commences cm (42 samples)	Range of thickness of horizon cm (42 samples)	Munsell Soil chart colour (12 samples)	pH range in dist. water (40 samples)	pH range in 1M KCl (18 samples)	Moisture content Range % dry wt. (40 samples)
Litter	0	2-15	-	3.1-3.9	2.6-3.4	614-1900
Black brown	2-15	3-10	5YR 2/2	3.2-4.0	2.5-3.4	809-1900
Green	5-20	3-24	5Y 2/2	3.0-3.7	2.4-3.1	733-2400
Red brown	15-36	9-36	5YR 3/2	3.1-4.6	2.4-3.0	669-1150

Table II Plate counts of heterotrophic and chitinolytic bacteria at Bog End

Horizon	No. of heterotrophic bacteria/g dry wt. Aerobic Range x 10^5 (2 samples)	Facultative Range x 10^5 (8 samples)	No. of chitinolytic bacteria/g dry wt. Aerobic x 10^3 (4 samples)	Facultative x 10^3 (4 samples)
Litter	9-150	3- 77	10	170
Black brown	5- 62	23-138	10	25
Green	10-490	10-380	20	30
Red brown	16-230	27-210	10	19

Table III Physiological groups of bacteria. Numbers/g dry weight estimated by Most Probable Number Method

Horizon	Cellulose decomposers (1 sample)	Sulphate reducers (1 sample)	Thiosulphate oxidisers (4 samples)	Denitrifiers (3 samples)
Litter	21×10^2	2.4×10^3	5×10^3	16×10^3
Black brown	32×10^1	4.6×10^3	3×10^2	17×10^3
Green	83×10^1	1.6×10^3	2×10^1	11×10^2
Red brown	8×10^1	1.6×10^3	2×10^2	11×10^2

Table IV Numbers of Nitrogen-fixing bacteria/g dry wt. x 10^4 at Bog End

Horizon	September 1970		October 1970		February 1971		April 1971		June 1971	
	Aerobic	Anaerobic	Aerobic	Anaerobic	Aerobic	Anaerobic	Aerobic	Anaerobic	Aerobic	Anaerobic
Litter	251	26	286	434	898	1225	372	194	567	532
Black/ Brown	91	44	145	127	642	677	395	543	262	180
Green	13	18	496	639	437	359	260	318	115	153
Red/ Brown	1	8	85	95	251	349	3	3	197	168

q) The Influence of Microflora on the Cycling of Inorganic Ions in Moor House Soils - Project 2/19 (Ernestine McEvoy and A. J. Holding, University of Edinburgh)

The overall object is to demonstrate the influence of inorganic ion availability in peat on microbial activity. Under certain circumstances small concentrations of calcium added to peat stimulate microbial activity and it is important to know how the peat ion exchange capacity influences this response to Ca. Therefore investigations on the influence of cation exchange capacity are being undertaken in simple model systems using ion exchange resins. The results obtained will be related to the peat system.

Experiments were therefore devised to show whether Ca bound on a resin stimulated or reduced the growth of bacteria compared with an equivalent amount of Ca in solution. Zeocarb 216 was selected for the studies since it was the resin with ion exchange characteristics closely resembling those of the peat. It is weakly cationic and contains -OH and -COOH groups. A gram-negative rod-shaped organism isolated from peat was used for the investigations. The organism was cultured in a minimal nutritional medium (MN) containing K_2HPO_4, KH_2PO_4, $MgSO_4$, $NaNO_3$ and glucose. The growth rate of the organism increased in the presence of added Ca.

Preliminary investigations revealed several problems associated with the use of resins. Percolation through a resin column was unsatisfactory both due to the bacteria not adhering to the resin and due to difficulty in obtaining a stable Ca concentrations on different sections of the resin column. Both the initial toxicity of the resin and sterilization problems were overcome by extensive washing with IN HCl. Growth inhibition was also overcome by using unexpectedly high concentrations of phosphate buffer. Since the cations associated with the buffer were throught to affect the system, an alternative non-metabolizable buffer of pyromellitic acid and tri-ethanolamine was used subsequently.

Using shaken flasks, with and without both Ca and the resin, it can be seen (Table 1) that the presence of the resin markedly increases the growth of the organism at the lower Ca concentration (27 mg/ml) but at the highest concentration (135 mg/ml) there appears to be slight inhibition of growth particularly in the absence of the resin. Experiments to confirm and clarify some of the unexpected results are continuing.

Table 1 Effect of Ca and resin on bacterial growth

Minimal medium plus		Optical Density Readings		
Ca (mg/ml)	Resin (g)	After 17 hrs.	20 hrs.	22 hrs.
-	-	6	18	34
27	-	6	10	21
27	0.25	35	70	88
135	-	17	53	80
135	1.25	25	65	87

Factorial Analysis Experiment

In the experiment, the biochemical characteristics of 100 randomly selected bacterial strains from several Tundra Biome sites are being compared to show functional differences between the populations. This

computer study is being undertaken at Uppsala, Sweden. The 100 isolates obtained from a Moor House sample for this purpose comprised approximately 95% Bacillus sp. and the remainder Gram-negative non-sporeforming organisms.

r) Incidence of V.A. Mycorrhiza at Moor House - Project 2/20
(B. Mosse and D. S. Hayman, Roathamsted Experimental Station, Harpenden)

Vesicular-arbuscular mycorrhiza may have important functions in the phosphorus nutrition of natural vegetation (Hayman and Mosse, New Phytol., 1971, 70, 19-27; Mosse and Hayman, New Phytol., 1971, 70, 29-34). A survey is being made of their occurrence in IBP sites at Moor House, Meathop Wood, Banchory, and Wareham.

Samples were collected in April as blocks (6" cubes approx.) and kept in the greenhouse in wire baskets stood in saucers with water. Roots or particular plant species were teased out from these blocks and examined for mycorrhizal infection in July. Wet sievings from the peat blocks were examined for presence of Endogone spores and mycelium. Plant species examined were Juncus squarrosus, Eriophorum vaginatum, Rubus chamaemorus and Nardus stricta.

Root infection

Juncus sample 1	No Endogone infection
Juncus sample 2	No Endogone infection
Rubus sample 1 (Collected in November)	No Endogone infection
Rubus sample 2 (Collected in April)	No Endogone infection
Eriophorum	No Endogone infection with the possible exception of one root
Nardus sample 1	No Endogone infection
Nardus sample 2	Approx. 10% of roots had typical V.A. mycorrhiza with arbuscules, vesicles and small amounts of fine external mycelium.

Wet sievings from peat

From most of the samples small amounts of hyphae were recovered. Mostly these were brown and septate. From the Eriophorum sample a thick, colourless ribbon-like mycelium was recovered attached to a fragment of a fruit body that could have belonged to Endogone sphagnophila. From the Nardus sample 2 a small amount of Endogone mycelium was recovered.

Conclusions

Samples collected in April and examined in July showed minimal amounts of mycorrhizal infection. It might be worthwhile to re-examine material collected in September when V.A. infection generally reaches its maximum. Present indications are that V.A. mycorrhiza would be of very little significance at the Moor House site in contrast with Meathop Wood where they are very common and at Wareham where they are also quite widespread.

s) Climate - Project 2/13 (O. W. Heal, Merlewood)

The Meteorological summary from the Moor House Met. Station for the year January-December 1970 is given on p. 18

Solar radiation The problems with the Lintronic equipment have continued, particularly condensation in the lead, and problems association with the temperature and radiation sensitivity characteristics. As a result of discussions with the Meteorological Office it was decided to replace the Lintronic solarimeter with a Kipp, but to continue to use the Lintronic integrating counter and print-out. This was done in September 1971.

Temperature The Grant recorder has continued to work satisfactorily and data are still being collected from the air and soil profiles on the blanket bog and Juncus squarrosus grassland at Sike Hill. The data for 1968 and 1969 have been summarised and some preliminary Fourier Analysis carried out using weekly means. This has increased the possibility of predicting soil temperatures and preliminary trials have proved satisfactory. Therefore it has been decided to concentrate on this approach and to discontinue further translation and analysis of 1970 and 1971 data particularly because of shortage of staff. Selected data may be extracted for specific purposes. The field recording will probably be stopped in January 1972 although the recorder will be available to obtain data for specific experiments