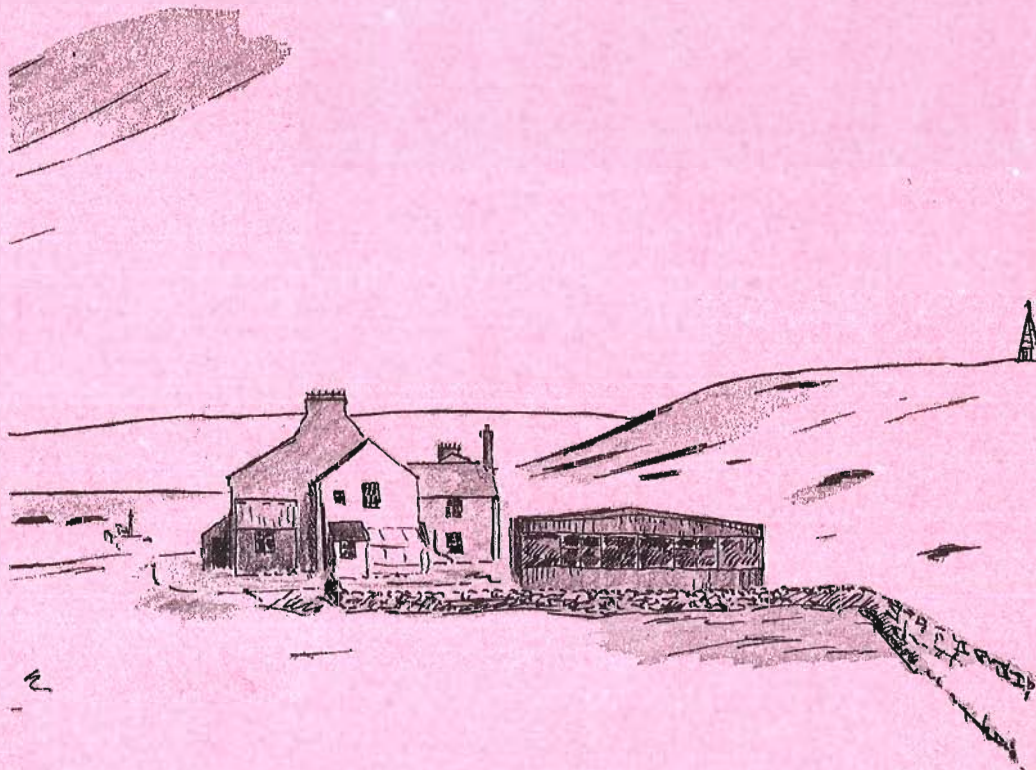


Aspects of the Ecology of The Northern Pennines

Occasional Papers

No. 6



MOOR HOUSE

"Aspects of the Ecology of Northern Pennine Moorland is a series of informal review and discussion papers for the reader with a general interest in the subject. They are not official publications of the Nature Conservancy and do not necessarily reflect the Conservancy's official views."

Aspects of the Ecology of the northern Pennines

6. The Ecology of the Red Grouse

by

P. Taylor and M. Rawes

March, 1974

1. Introduction

This account is the first attempt at describing the ecology of grouse at Moor House. We deal briefly, because the subject is so large, with a wide range of topics. History (more particularly of local shooting), biology, behaviour and management are mentioned as background to a discussion of recent population studies and of some aspects of moorland management for wildlife. It is surprising that so little scientific attention has been given to any aspect of grouse ecology on the Reserve considering that grouse are the major vertebrate herbivore of the most widespread habitat, heather dominated blanket bog. The data are exceedingly scanty, not least in local history, so we particularly welcome further information on this aspect; it can be incorporated in future revisions and additions to this paper.

For information of the biology and behaviour of the grouse we have based much of our discussion on the findings of the Grouse Research Unit, at Banchory, in north-east Scotland. However, extrapolation of results has its dangers. Moorland conditions are variable, the high-level country of the Reserve is both cold and wet, whilst the best grouse shooting moors are in eastern Britain, where rainfall is less than 50 ins (two thirds that of Moor House) a year.

Is bird behaviour the same under extreme conditions? Is survival, especially of chicks, similar? Is the same management prescription of rotational heather burning suitable for both situations? What is the effect of a no-shooting policy? These are some of the questions we raise and discuss in management proposals, which use present day knowledge of the blanket bog and its chief plant components, heather (Calluna), Cotton Grass (Eriophorum) and Sphagnum moss.

Our interest is not in the productivity of grouse for economic exploitation, but in the conservation of both habitat and species. However, grouse moors are, in their own right, habitats of conservation interest and it is possible that high grouse productivity is compatible with conservation.

The situation at Moor House is in some ways unique, it is a grouse moor that after 100 years of keeping and management for grouse shooting has been unshot for more than 30 years. Keeping since 1952 has been confined to controlling foxes and the occasional carrion crow, and to irregular burning of small areas of heather. There has been no effort either to encourage or in any way influence the number and habitats of the resident grouse.

2. History

The Red Grouse (Lagopus lagopus scoticus) is indigenous to the moors of northern Britain. Its status prior to the 19th century is not well known, but it has been suggested that on the northern Pennines Black Game (Lyrurus tetrix), a bird more associated with woodland conditions, was more common than grouse. Nicholson and Burn (1774) in their History of Cumberland said of the Pennines "These mountains also produce plenty of grouse or moor-game, which are nourished in like manner chiefly by ling".

Snaring, netting and shooting of grouse by the local populace was not uncommon and at one time the military were sent to Alston Moor in an endeavour to catch the culprits. However, shooting as a sport became fashionable in Victorian times, especially when the breech loading shot-gun was introduced. Landowners were quick to exploit the new situation and moorlands became socially desirable to the wealthy industrialist, who was able to enhance his status by the acquisition of a country estate. Later as the popularity of shooting spread and the cost of upkeep increased it became economically necessary to let grouse moors. It was to this end that efforts were made to increase the value of the grouse shooting by keeping, and thus managing the moors to favour grouse. This resulted in a large increase in grouse numbers, which was followed by a serious outbreak of "grouse disease" in 1872-73. Since then management has attempted to prevent further outbreaks, and led to the first scientific investigations into the biology of the bird, culminating in the production in 1911 of a manual "The Red Grouse in Health and Disease".

Tenets of good management as set out by Lord Lovat in this book, aimed at the provision of nutritious feed and the control of predators. Regular burning of the moor was suggested so that ample young heather of good food value was available. Grit, essential to the digestion, should be provided and was especially necessary where rock outcrops and metalled tracks were few. All vermin, species that prey on adult birds, chicks and eggs, should be killed. The grouse population was to be kept within limits and the shooting of driven birds from a line of butts, not only provided "better sport" than "walking up" with dogs but was more effective in reducing the stock of surplus birds and thus preventing disease.

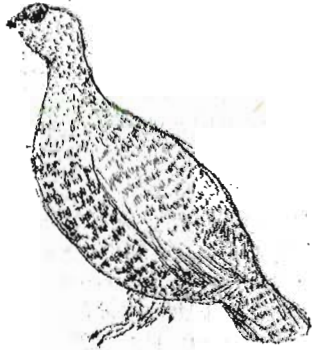
Grouse numbers, however, never returned to the large figures of the 19th century and in 1956, a team to investigate the question of grouse decline was set up in Scotland, it has continued since then for most of its time as a unit of the Nature Conservancy, to study the biology and management of grouse. Thus the red grouse can truly be said to have received much scientific attention as the number of scientific papers and the numerous articles produced by this Unit testify.

3. Biology of Grouse

Scottish research with tagged birds and population surveys has shown that grouse are short-lived birds, because of their social behaviour rather than their physiological make up. Only a very small number live beyond 3 years. The majority die in their first winter, whether there is shooting or not. This has been found to be the case at Moor House, and this section is based on studies at Moor House.

The first nests are occupied in April, but May is the usual month, with hatching occurring towards the end of the month and in early June. In a good year there will be an average of 8 eggs per hen and in a bad year 6 eggs. Nests are made in long heather, and usually they are lined with heather, cotton grass and moss and have a canopy of tall heather.

Around 90% of the eggs hatch and survival thereafter is usually good, but is dependent on predation and weather, although on the best grouse moors the latter is not considered as important a factor as on the wet and less productive moors.



RED GROUSE
(LAGOPUS LAGOPUS SCOTICUS)

Until August the young birds remain with their parents, mainly staying in the nesting territory. Growth is fast and in most years adult weight is reached in August. After hatching, it is thought that they feed on insects, such as Crane-fly (Tipulidae), which have been recovered from chicks. However, the importance of insect food at

this time is not known. Heather is probably, even in the first 3 weeks, the main diet and insects supplement it. Later there is no doubt that heather is the preferred food, and grouse have been shown in experiments by the Banchory workers to select plants, and parts of plants, of highest nutrition. It is interesting to note that fresh green shoots of young heather may not contain the quality of poor looking plants selected by the grouse. Also selected are Cotton Grass (Eriophorum spp.), Blaeberry berries (Vaccinium myrtillus) and the seeds of the Moor Rush (Juncus squarrosus). They will eventually eat around 55 g of dry food a day. They require water and will be taken daily by the parent birds to drink the running water of becks and sikes, this being preferred to pool water. In view of the fibrous nature of the diet an ample supply of grit is required, but this can be retained in the gizzard for several weeks. Grit is normally readily available from tracks, erosion channels and becks, although keepers used to supply bought grit and this is still done on neighbouring moors.

It is in August that the social behaviour of the grouse changes, the old cocks showing aggressive attitudes and striking an early claim to dominance. In September and October the family groups are broken up, fighting among the cocks takes place and the most aggressive are successful in claiming a territory, and later, a hen. Pairing often does not take place until after winter, the cock defending his territory against the surplus and neighbouring territorial cocks throughout this time. Territory size is related to the nature of the ground, broken ground being preferred with heather offering good feed value and cover. However, the aggression of the cock will determine the eventual size of the territory, which on a well stocked moor may be about 5 acres. The surplus birds, often in packs, are harried from one part of the moor to another. According to Scottish research many of them will leave the moor in autumn, others will remain, but the majority in both cases will die before they are eleven months old. Only if a territorial bird dies, from predation or accident, and this is rare, will a surplus bird succeed in taking his place. Annual mortality of the whole population averages 65%.

The effect of predators, foxes and hawks, has been shown in Scotland to be less important than previously thought. Predators certainly kill birds and may disrupt a shoot, but the breeding birds are little affected, it is the surplus birds that are going to die anyway that fall victim to the predator. Nesting birds, eggs and chicks are vulnerable but even so, losses in general are low. The position of the crow, and locally the black-headed gull, as predators, however, is more doubtful and there are instances where considerable damage has been done at nesting time.

The grouse population varies considerably throughout the year, but populations also vary from year to year, due it is thought to food quality and climate, for it is well known that there are regionally good, and bad years for grouse.

Differences between moors are related mainly to heather growth, which, in general, is of better quality and quantity on dry rather than wet moors, but the geology and soil of the moor has been shown in Scotland to be all-important. The less acidic the soil, as when overlying limestone, the more nutritious is the heather and consequently the larger the grouse population.

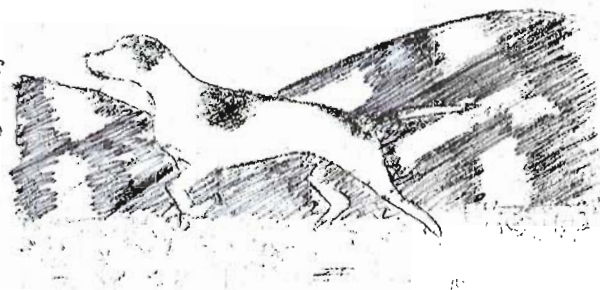
4. Principles of Management

Firstly one must recognise that no two moors are the same, indeed the range of conditions in which grouse breed and are shot is very great. Nevertheless, management, which must take into consideration the biology of the bird, will aim to provide food and habitat conditions that are best for the grouse stock. There can be no argument that young heather has a higher chemical content than old, nor that burning is usually the most suitable method of providing young heather. The frequency of burning will depend on the climate, but generally it is unwise to burn more frequently than every 10 years. Machine cutting is now employed on some moors and, where it is reasonably dry and accessible, and the relief undulating rather than steep, it has much to commend it, especially where the cut heather can be baled in summer and fed to grouse in winter.

Bearing in mind the need for each territory, say 5 - 10 acres in extent to have cover (long heather) and good feed quality (short heather) it is important to restrict burns to narrow strips, not wider than 35 yards. Chicks will then always be near cover. Burning may take place in autumn or spring, before 1st April in England. To burn later would risk the destruction of many nesting birds.

As the total grouse population fluctuates considerably throughout the year the best time to count the stock is in spring, before nesting, when the breeding population will be recorded, and again in late July - early August, when the maximum number of birds are present. Counting is usually done with the help of dogs to flush the grouse. Only by knowing the size of the grouse stock can a moor be properly managed for shooting and wildlife conservation.

POINTER WITH STRIP BURNT
MOORLAND BEHIND



Apart, possibly from foxes, carrion crows and black-headed gulls the need to destroy all predators is unproven and will, if carried out ruthlessly, have an adverse effect on the ecology of the moor. The need to control the exceptions should only arise from time to time and not as a regular feature of management.

5. Moor House - its development as a grouse moor

Records are extremely scarce. Although sheep, which had grazed the fell for centuries, remained an important influence on the moorland ecology, it was lead mining that dominated the scene in the late 18th and the 19th centuries. Not only did buildings, tracks and mines themselves make an obvious impression, but the widespread draining of the bog to provide water power had a considerable effect in drying the habitat, at least temporarily.

We know little of the shooting in the 19th century beyond the story passed down by Mason, Keeper of Birkdale, the neighbouring moor, about the wild folk, who lived at Old Moor House, possibly early in the century. Old Moor House, now a ruin, lies a mile up Moss Burn from Moor House. Apparently there were disputes over shooting and the men from Old Moor House were said on occasion to have shot the pointers (kept for putting up grouse) of Birkdale with muzzle loading guns. However, it was not until 1842 that a written account (Bell, 1843) mentioned shooting. In this year a Teesdale miner, Binks by name, and a fine field botanist, found the rare saxifrage (Saxifraga hirculus) at Nether Hurth, near where the Earl of Thanet had recently erected a shooting lodge (Moor House itself). This was adjacent to an old mine shop, possibly used as a drover's "stance" or stopping place, in the early 18th century (Raistrick, pers comm.) In the 19th century the fell was part of the Appleby Castle Estate, owned by the Hothfield family, and two keepers, living in the cottages provided, looked after the moor. It was from this Estate that the Nature Conservancy purchased the property, then 10,000 acres, in 1952.

We know that the moor was shot by the Hothfields on occasions, but usually it was let (Table 1) and the most complete records are those kindly loaned by Mr. John Harris, of Brackenburgh, whose father Mr. Joseph Harris, rented the shooting for 20 years, early in the century. Fascimiles of the game book for this period are kept in the Moor House Reserve Record. At that time the moor was shot 2-3 times a year, sometimes in conjunction with the adjacent Tynehead Fell. House parties of 8-10 shooters stayed in the shooting lodge for a fortnight and more at a time.

Table 1	Tenants and Keepers	
Shooting Tenants	Keepers	Underkeepers
J. Harris, Brackenburg, (1898-1917)	J. Hinds (1863-1900)	
Collins (1918-1925)	W.M. Pearson (1900-1917) T.W. Pearson (1917-1930)	T.W. Pearson C. Dowson Wm. Armstrong
Chapman (1926-1934)	Wm. Armstrong (1930-1947)	McVey
R.W. Collins (1935)		Makepeace
F.W. Cooke (1936-1940)		Robson
R.W. Collins (1941-1942)		Brown
Unlet (1943-1949)		
H.T. Haggas (1950)	H. Earnshaw (1947-1951)	

The duties of the head keeper, who received support from other estate staff for routine work, such as repairing roads, bridges, shooting butts etc. was to plan the shoots, control vermin, burn heather and put out grit. He had the right to keep a flock of hill sheep and usually had a pony, one or two house cows (a byre stood just to the south of the present-day Met. Station until 1955), some pigs and hens.

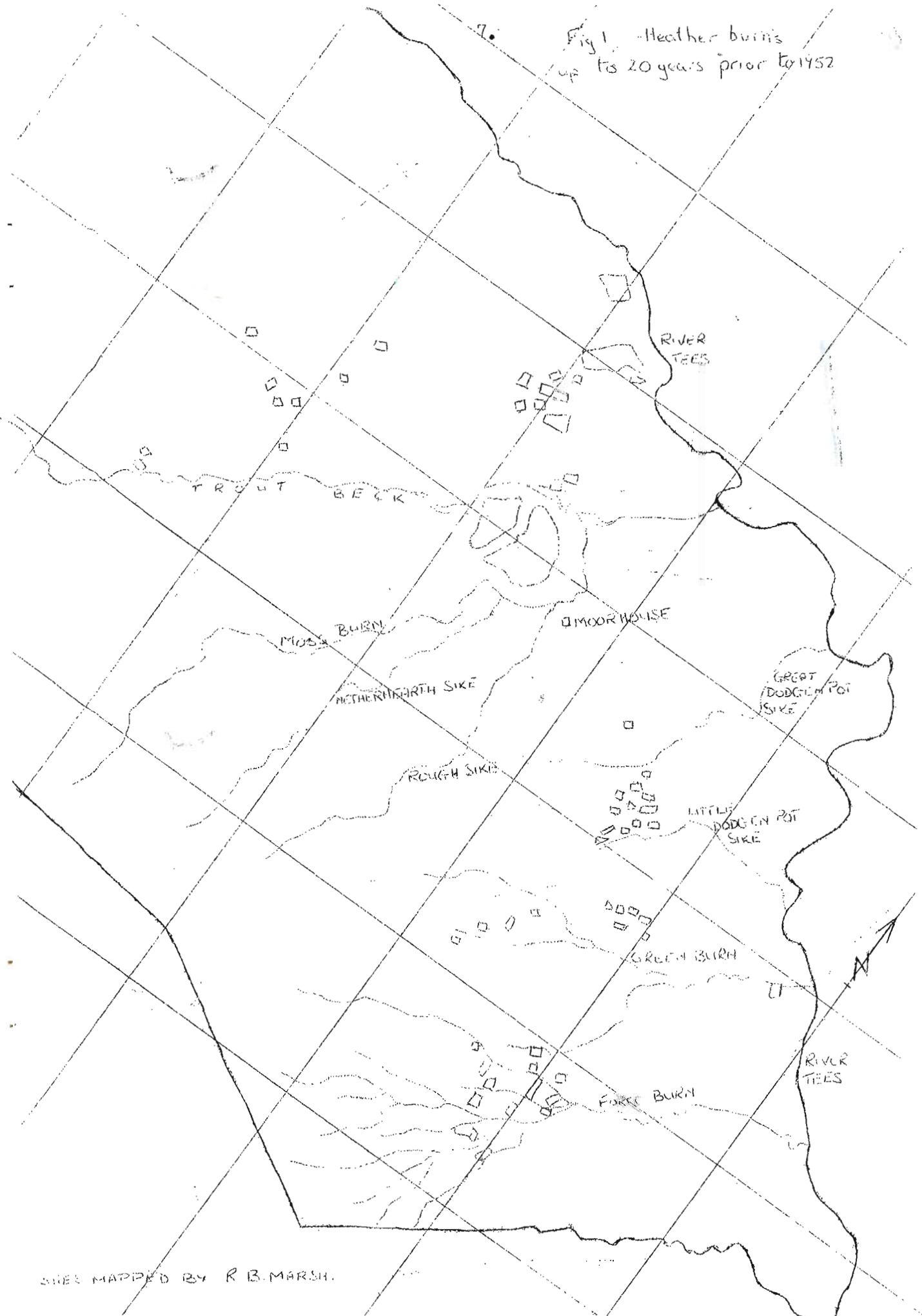
The history of moor burning is unknown, but it is apparent that certain areas received more attention from the keepers than others. Burnt Hill for instance, reasonably close to the house, clearly earned its name from frequent burning, and the present infrequency of Sphagnum moss on this hill is evidence of this.

In W. Pearson's time the average burn per year was said by his son J. Pearson, to be 250 acres but in some years, as now, it was not possible to burn at all. So in good years up to 500 acres might be burnt. There was one particularly large fire around 1900 which got out of control and burnt a very large area. Generally the fires then were large rather than small. Even so, J. Pearson, remembered the moor as being much as it was in 1966, with the heather similar in length.

Air photography enables burns to be identified for up to 20 years after the event and an examination (Fig 1.) of photographs taken in 1956, 1969 and 1971 show that in the time of the last two keepers, most of the fires were small and a serious effort was being made to improve the moor in the approved manner. However, the air photographs are not of sufficient quality to enable us to date the individual burns.

When Moor House was for sale it was advertised as offering at least two full day's shooting without covering the same ground twice, 8 drives could be shot and one drive could be taken twice. Whilst many of the butts have long since fallen into disrepair others are still in good condition. Most were constructed of peat turves but a few were built of stone. The various types of construction are being recorded and the actual sites of many butts have been obtained from ground observation, air photography and records. They are shown in Fig 2 together with the names by which they were known and the direction of the drives. As our search continues more and presumably older butts come to light. The most recent butts

Fig 1. Heather burns
up to 20 years prior to 1952

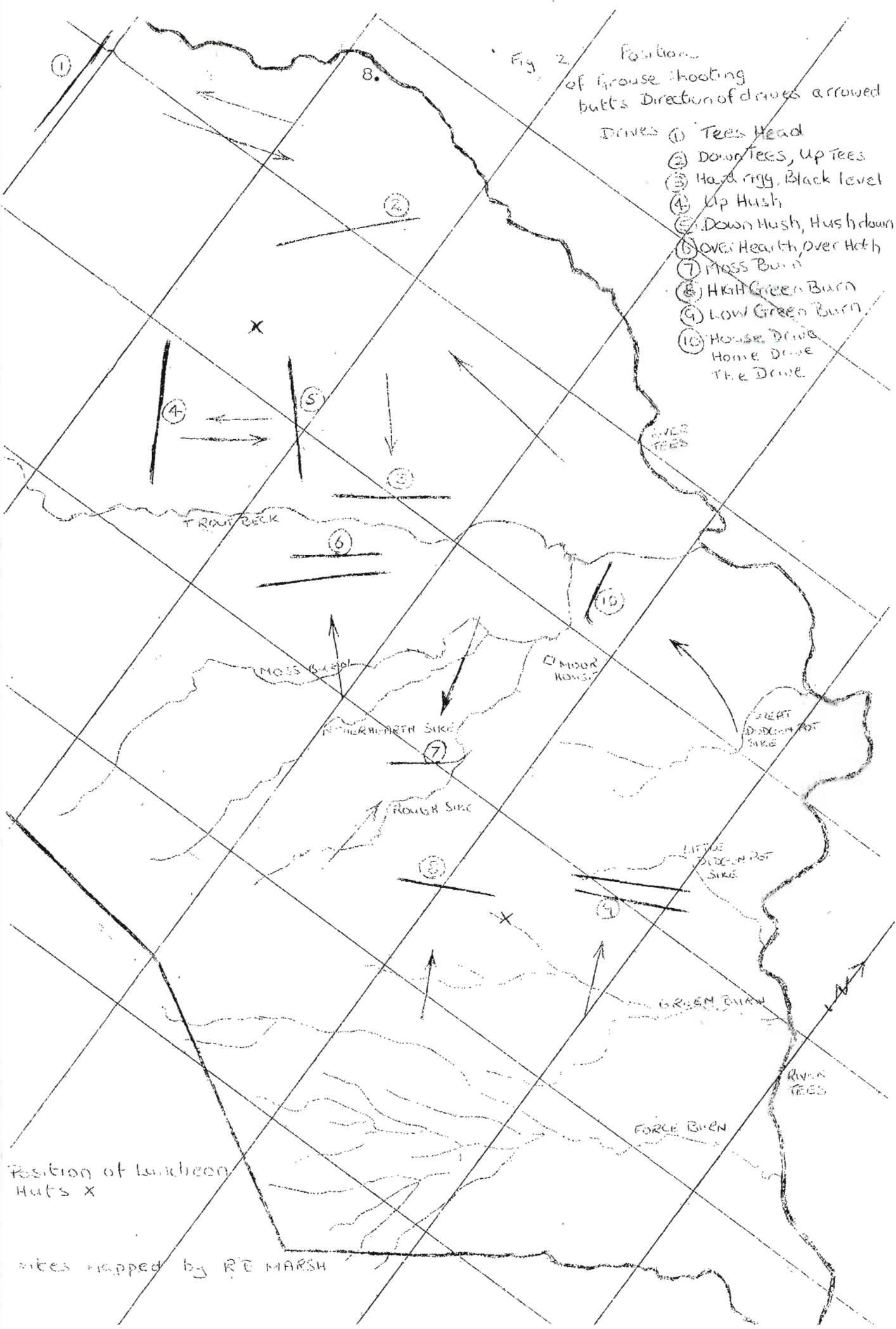


SINES MAPPED BY R. B. MARSH.

Fig. 2

Positions of grouse shooting butts Direction of drives arrowed

- Drives
- ① Tees Head
 - ② Down Tees, up Tees
 - ③ Hard rigg, Black level
 - ④ Up Hush
 - ⑤ Down Hush, Hush down
 - ⑥ Over Heath, over Heth
 - ⑦ Moss Burn
 - ⑧ High Green Burn
 - ⑨ Low Green Burn
 - ⑩ House Drive, Home Drive, The Drive



Position of Luchean Huts X

sites mapped by R.E. MARSH

were placed 9 in each row and three drives had double rows. But the position is far from simple, names of apparently similar drives differ, drives themselves varied with different keepers, and in some cases butts were not used and the shooters stood in broken ground among peat hagsgs or along the line of a hush or sike.

SHOOTING BUTTS



Many of the drives, the beaters covering up to 1 mile in line, were long. The Green Burn drive started from Mattorgill and as in all such cases there was from time to time friction with the neighbouring moor. On one such occasion Lord Hothfield had to mediate between Moor House and Birkdale. In the thirties the beaters, from Garrigill and Harwood mainly, arrived on the Sunday before shooting. There were usually 20. They stayed in Nether Hurth and the annex next to the house. One of us (M.R.) has heard it said that grouse were sometimes driven down from above Higher Green Burn and Moss Burn and "heafed" the night before a shoot, but we have not had this verified.

The routine when Armstrong was keeper was for the Green Burn drives to be shot on Monday morning. Lunch was then taken, the seated hut was used by the shooters and the unlined hut by the beaters. In the afternoon Over Hoth and Home were driven. On Tuesday, Hardrigg, Hardrigg up (Tees up) and Hush were shot. This programme, repeated on Wednesday and Thursday, was given to us by A. Bell (Alston).

Shooting usually started on 12 August. Fig 3 shows the size of the bags, with the best years being 1909-1912. The most frequently shot drives were Hardrigg, and Moss Burn in the early years. Hardrigg and then Lower Green Burn produced the largest total bags but Green Burn was on average the best drive.

During this time large numbers of vermin were killed by the Keepers. It is not possible to say whether these numbers relate solely to Moor House, but even so they are enormous by present day standards.

Between 1900 and 1928 the following were killed:-

Foxes	379	Buzzards	23
Moles	871	Carrion Crows	92
Otters	5	Hérons	6
Rats	217	Kestrels	68
Stoats	561	Merlins	66
Water Voles	304	Peregrines	14
Weasels	601	Ravens	296
		Seagulls	6

NUMBER OF GROUSE SHOT

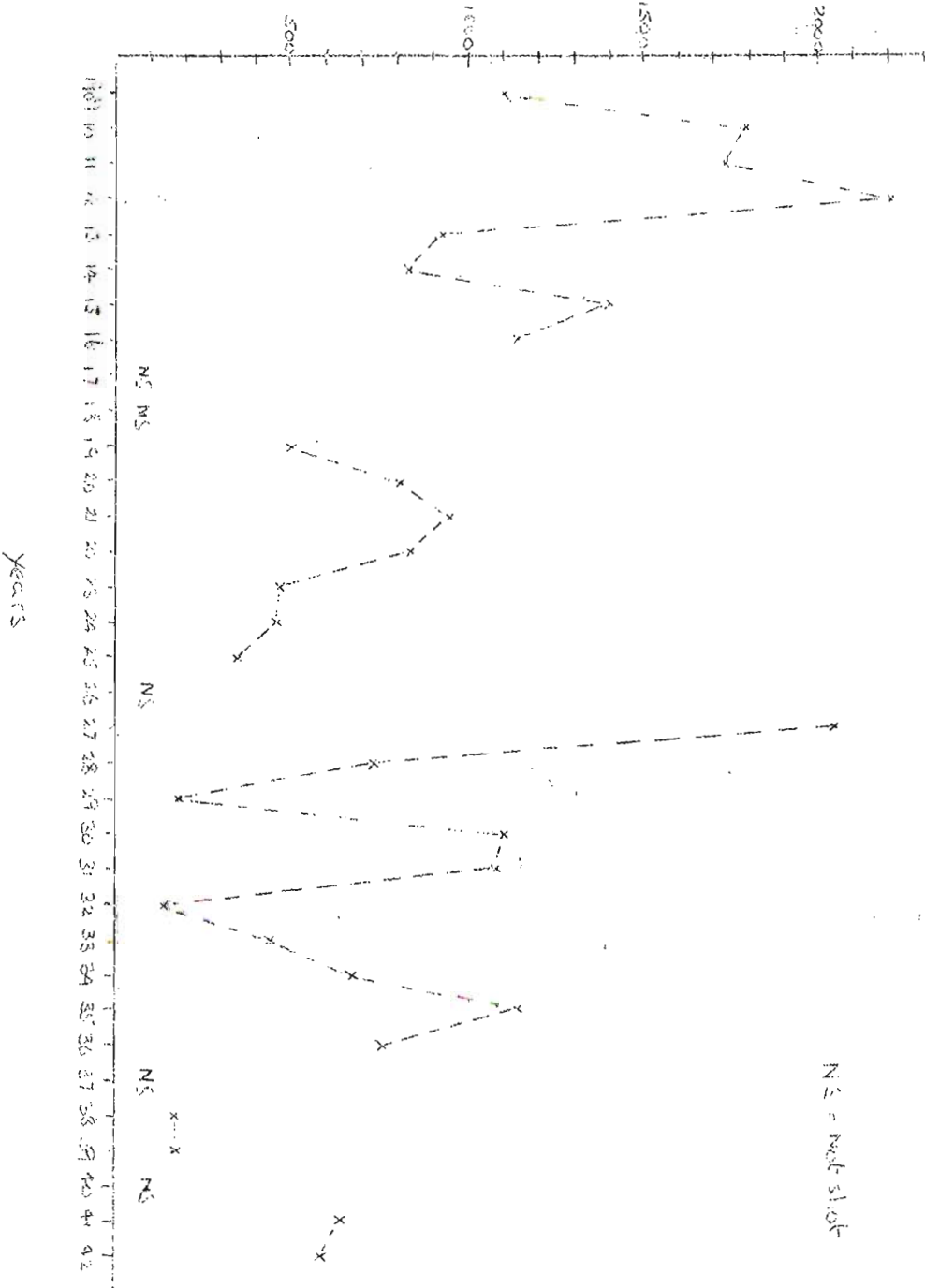


Fig 3 Numbers of Grouse Shot, 1909-1942

6. Moor House since 1952

ε.) General

Staff resources have never been sufficient to employ a scientist full time to work on the ecology of grouse, and it is unlikely that this situation will change. A number of small studies and surveys have been, and continue to be, carried out, and a great deal of knowledge related to grouse, concerning the vegetation and the moorland habitat exists. Management, which includes an examination of heather burning, is an important aspect of study.

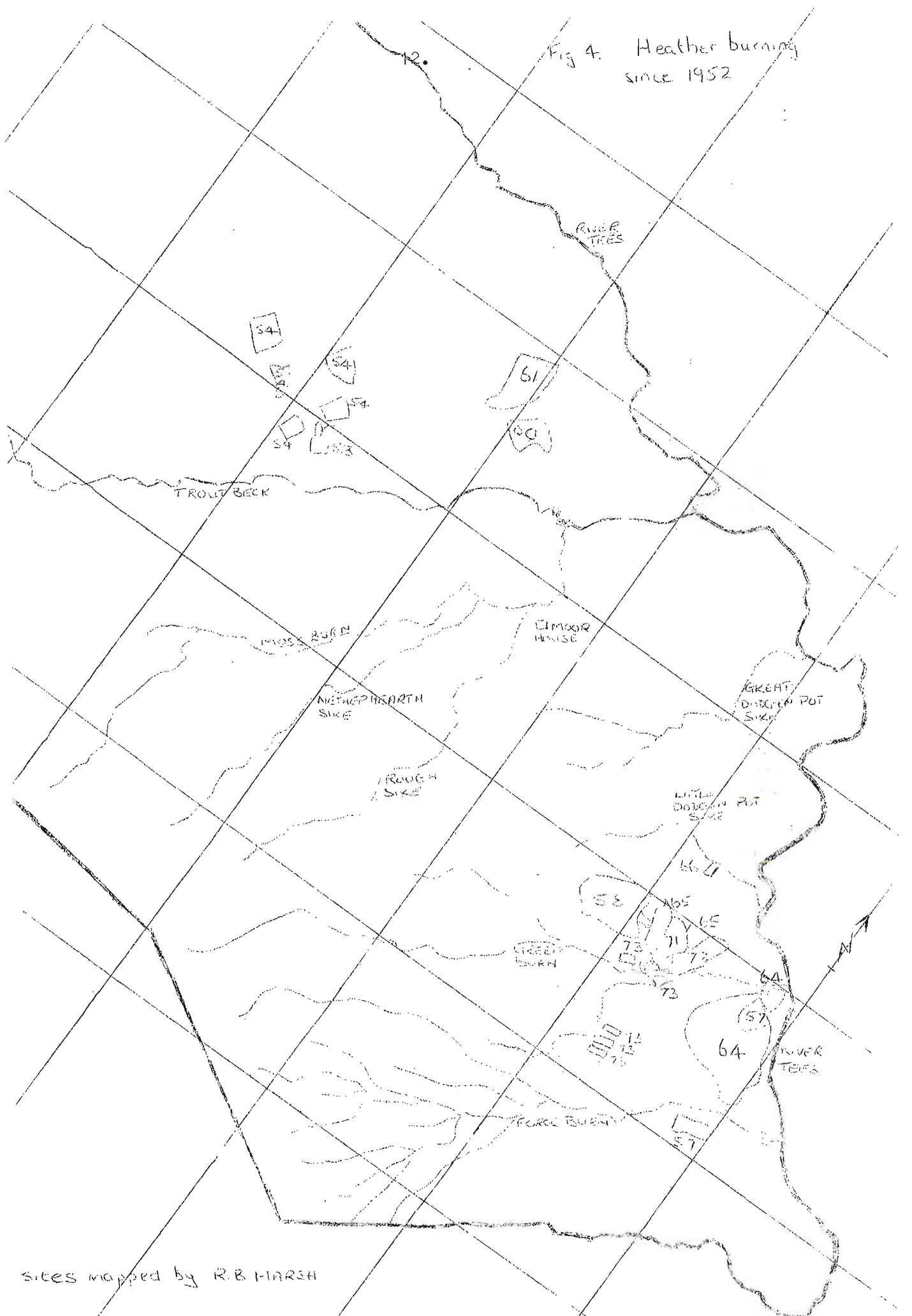
Between 1952 and the present time sheep grazing has continued at much the same intensity and in the same manner as before. Burning has been restricted (Fig 4) and no more than 260 acres have been burnt, ranging in yearly extent from 58 acres to less than an acre, whilst in seven years no burning was done at all. Thus most of the heather moor has been unburnt for 30 years, but as will be shown later the actual age of the live heather is very much younger than this. Control of predators has been restricted but the numbers present are less than 50 years ago. On average 10 foxes are killed each year, and a number of carrion crows are shot. Neighbouring fells are kept, and, in some years, attempts have been made to control the number of black-headed gulls. No grouse shooting has taken place on Moor House itself, but the moors surrounding the Reserve are regularly shot. The area, or at least part of it, is probably more disturbed by people, research workers, than would previously have been the case.

The surveys of grouse have varied in effectiveness. They have attempted to estimate numbers, and later to determine to what extent, if at all, the biology and movement of these grouse differ from published findings. Between 1966 and 1972 population estimates received some stimulus from the International Biological Programme, Moor House being a recognised main site in this programme of investigations into terrestrial productivity. However, only in 1971 and 1972 was there continuity in this population work and the following account takes the investigation by P. Taylor as the mainstay, whilst previous information, especially that of B.P. Springett in 1966 and 1967, is used where possible. More recent surveys and counts have been continued since 1972 by P. Holms (Moor House Annual Report No. 13) and are included.

b) Estimation of grouse numbers

Counting is usually done with the aid of trained dogs putting up the grouse and systematically working a census area. A number of repeat counts are necessary before a true census can be obtained. Some surveys have been done without dogs, using people or a 50 foot line dragged between two observers, but in general, these methods have not been satisfactory. There are three occasions in the year when counts are made; spring, to record the breeding population and any surplus non-territorial birds; autumn, to record the maximum adult stock and the assessment of breeding success; and winter to record territories and the fate of the surplus birds.

Fig 4. Heather burning since 1952



sites mapped by R.B. MARSH

The spring count is done in late March and early April, before nesting is general. The count of the breeding birds can be confirmed by a nest count later. Taylor relies on a nest count in 1971 and 1972 (Table 2) whilst the 1973 figures of Holms were obtained from bird counts and verified by nest counts. The same census areas are used late in July and August, to assess the autumn population which is the moor's potential stock for shooting and next year's breeding. These counts will show the success or otherwise of the season and great importance is attached to the young to adult bird ratio. A ratio of 1.5 : 1 on a well stocked moor has been found to provide, catastrophes excepted, the certainty of birds for breeding next season with a surplus for shooting.

Winter counts are more difficult to make as the surplus non-territorial birds are unsettled and large areas are required if counts are to be meaningful. These counts however, are of less importance, though they do enable movement to be observed and indicate whether the surplus population is leaving the fell or dying on the moor.

By using the young to old bird ratio, the autumn population can be estimated, basing the calculation on the adult density in spring. But these estimates are unreliable because they fail to account for mortality of adults, particularly through predation. These losses are discussed later.

There were no counts in two years in the 11 year period, 1962-1973, as shown in Table 2. The poorest spring was 1965 when less than one breeding bird to 10 acres was recorded, although breeding success was marginally better than 1967, which was recognised as having been a poor season with a very wet May when many grouse nests were lost. 1966 was possibly an average year, but the ratio of young to old birds (2.0 : 1) was better than usual. 1971 and 1972 were undoubtedly the best years for a very long time.

Table 2 Average grouse numbers. Counts in spring and autumn, and young to old ratio.

	Spring - breeding birds		Autumn - population		Ratios Young : Old
	April/May		August		
	birds/acre	birds/ha	birds/acre	birds/ha	
1962	0.50	1.20	0.50 ¹	1.20	-
1963	0.22	0.53	-	-	-
1964	0.20	0.48	0.15 ²	0.39	-
1965	0.09	0.22	0.21	0.50	1.3 : 1
1966	0.13	0.31	0.39	0.93	2.0 : 1
1967	0.10	0.24	0.21	0.50	1.1 : 1
1970	0.28	0.67	-	-	-
1971	0.47	1.14	2.02	4.85	3.3 : 1
1972	0.77	1.85	2.31	5.55	2.0 : 1
1973	0.46	1.14	1.01	2.42	2.9 : 1

¹ October counts

² November counts

Thus the numbers given in Table 2 indicate a population fluctuation, although the numbers may be subject to some distortion due to the difference in method employed. Nevertheless it is apparent that the breeding population has shown trends, first of decline and then of increase, over the period of study. This finding agrees with those of the Scottish research workers.

c) Variation within the Reserve

In a good breeding year, such as 1971, the variation in breeding success between sites is not great, but the numbers of birds in different parts of the fell still differ. Data are insufficient, but observations indicate that some parts of the fell are consistently better than others; the Troutbeck side of Hård Rigg, for example, seems usually to have a good stock of birds, whilst Green Burn to the east is poor despite being lower ground and having had more burning in the recent past.

Table 3 compares three sites in four years, in each of which, one, Bog End, always had the largest number of breeding birds and autumn population, yet not the best young to old bird ratio.

Table 3 Site variation in numbers of birds/acre and young to old ratios for 3 sites (see Fig 5)

		The Drive (1)	Burnt Hill (2)	Bog End (3)
1967	Spring	0.06	-	0.06
	Autumn	0.07	-	0.10
	Ratio	0.7 : 1	-	0.6 : 1
1971	Spring	0.45	0.45	0.57
	Autumn	2.10	1.80	2.34
	Ratio	3.6 : 1	3.0 : 1	3.1 : 1
1972	Spring	0.82	0.61	0.98
	Autumn	2.05	2.13	2.46
	Ratio	1.5 : 1	2.5 : 1	1.55 : 1
1973	Spring	0.40	0.56	0.64
	Autumn	0.92	1.11	1.28
	Ratio	3.40 : 1	3.18 : 1	2.7 : 1

Inter-site variation is probably greatest in a poor season, such as 1967, but it would not be unreasonable to suggest that a density dependent factor governs the size of the population. For example, in 1972 the breeding population on Burnt Hill was two thirds that of Bog End but the number of young birds raised per adult was 70% higher.

d) Comparison with pre-1942 Records

It is well known that shooting will rarely be so hard as materially to reduce the number of breeding birds. This is shown on Moor House with the run of large bags in 1909-1912.

Less than half the Reserve, about 4000 acres (1670 ha) was shot, the remainder being predominantly grassland or land too high to support grouse regularly. The number of grouse estimated to have been on this area between 1965 and 1973 is shown in Table 4, with figures for six of the years. These estimates can be compared with earlier shooting records.

Table 4 The estimated autumn grouse population on Moor House

1965	840	1971	8080
1966	1560	1972	9240
1967	840	1973	4040

In order to provide an exceptionally large number, 3000 brace, of surplus birds for shooting the moor would need some 2000 breeding birds. Where this was achieved in 1971 and 1972, it is rare and, as on neighbouring moors, there is much fluctuation in numbers. It would be interesting to know the total stock in 1912 when 2400 brace were shot.

Shooting records may indicate the size of the grouse population, but on the higher moors, where conditions can be more difficult during the shooting season, less reliance can be placed on them than usual. Records from Moor House show (Fig 3) much annual variation although they do include some very large bags. It is noticeable that there was site variation, certain drives being habitually better than others.

e) Nesting

Nesting usually starts in the period mid-April to early May, the earliest nest being found on 8 April and the average date being 22 April. In most cases, the nests are in clumps of heather, which is usually 20-35 cm in height. The ground is typical, wet blanket bog, often with a ground layer of Sphagnum moss, but normally not liable to flooding. The vegetation of upland blanket bog is in structure markedly different from the drier heather-dominant moors found on the east side of the country. Tussocks of cotton grass, open heather with stems of varying size, covering a wet surface in a climate where rain occurs, on average, on 280 days each year make for differences that will be discussed later. Often the nests are close to paths or trods. A pool or running water is always found within 50 m of the nest, but this is likely to be the case on most parts of the fell. There tend to be more nests in areas of broken ground where territories are smaller. Usually the nest site provides a good view of the surrounding terrain, being on a peat hagg, tussock or hillside, but the nest itself is nevertheless normally hidden, in particular from the air, by a canopy of heather. The nesting material is confined mostly to cotton grass (Eriophorum vaginatum), but heather, crowberry (Empetrum nigrum), lichen, moss and feathers may also be used.

In the last three years clutches have been examined (see Table 5) and some measurements made. In 1971, 33 clutches were found. The largest clutch had 12 eggs. 51 clutches were visited in 1972, one was of 15 eggs and the smallest of 4 eggs. In 1973, the largest clutch was of 11 eggs and the smallest of 5. In north-east Scotland the average clutch sizes of a grouse moor (Kerloch) examined by the grouse unit (Jenkins et al 1967) was 6.4, 7.7, 7.7, and 8.1 for four years, 1962-1965.

Table 5 Average number of eggs in a clutch and egg size with 95% confidence limits of 1971 results.

	1971	1972	1973
Clutch size	8.82 ± 0.52	8.02	7.6
Egg weight (gms.)	24.4 ± 0.67	-	-
Egg size (Length in cm. x Breadth ²)	45.8 ± 0.91	-	-

There can be a significant difference in the number of eggs in different parts of the moor (Table 6) and in 1971 and 1972 it was apparent that the area with the smallest breeding population (Burnt Hill) had the largest clutch size.

Table 6 Variation in clutch size

The Drive		Burnt Hill		Bog End	
1971	1972	1971	1972	1971	1972
7.7 ± 1.2	7.1 ± 0.77	8.9 ± 1.2	9.46 ± 0.67	7.8 ± 1.5	7.82 ± 1.7

Only in 1971 was egg weight and size measured. The average then was greater than the four year average of Jenkins *et al* (1967) in Scotland.

The average period of incubation in 1971 was 21 days and the average hatching date, 25 May. The last fortnight in May was the most common time for hatching in 1972 but weather is a deciding factor. Hatching success in 1971 and 1972 was high (Table 7) but an examination of unhatched eggs in 1971 showed that many were fertile and contained fully formed chicks. Jenkins *et al* (1965) has shown that egg fertility and chick viability are undoubtedly related to the condition of the breeding birds and therefore to the quality of the food (heather) available over the preceding months.

Table 7 Hatching success

	The Drive	Burnt Hill	Bog End	Whole Area
1971	98.1%	90.1%	92.3%	94.5%
1972	95.3%	92.7%	94.2%	94.1%

The differences shown in Table 7 appear to be correlated with clutch size for both years, the smaller clutch having the greatest hatchability. This reinforces the previous suggestion of a density dependent factor

operating within the population. The order of magnitude in hatching success over the whole area is similar to Jenkins et al (1967).

A number of nests are for various reasons either deserted or robbed. Second clutches may be laid when the first has failed. Desertions may be due to 1) the predation of the hen bird, particularly by a fox, 2) accident to the adult whilst off the nest, 3) weather, such as a heavy rainstorm, affecting a badly sited nest, and 4) disturbance by man, dog or other factor. Of 54 nests examined in 1971 five were deserted, in two cases the hen bird being killed by a fox. In 1973 even more nests were deserted (14.5%). This is a higher percentage of desertions than recorded on Kerloch, but there the number of eggs robbed was much higher, ranging from 6 - 30% in four years, whilst at Moor House it was 3.7 - 10.9%. The most common predator of eggs on Moor House is probably the black-headed gull, whereas in Scotland crows are mainly responsible. When nests are robbed by gulls all eggs are taken and the shells scattered around the nest, each with a characteristic hole in the side. Robbery of single eggs by stoats, weasels or rats was only recorded on three occasions.

f) Chicks

On hatching the average weight in 1971 of a chick was 17.9 g. After an initial loss in the first two days rapid growth was made and live weight doubled in the second week. Thus rate of growth increases in the succeeding weeks, but is dependent on food and weather. In 1971, the chicks grew particularly well and most reached adult size by 12 August, when they averaged 600g.

In 1971 the crops of a number of chicks were examined in May, June and early July. Springett also looked at chick feeding in 1967 but his results are not yet available.

In all the crops examined heather was found and in no case did it form less than 50% of the total volume of crop content. Chicks always took green shoots or flower buds. The capsules of the moss, Polytrichum commune, commonly found especially on the less wet parts of the moor, were next in frequency and in one case 49 capsules were found in a chick. Chemical analysis of the capsules show that they have two to three times the amount of nitrogen, potassium and phosphorus as heather shoots taken at the same time of year. The capsules are most frequent when the chicks are 2-3 weeks old. A few berries of blaeberry (Vaccinium myrtillus) were found in the older chicks. It has been suspected that insects formed an important supplement to the chick diet at Moor House and this may be so. Unfortunately 1971 was a poor year for Cranefly (Tipulidae) which otherwise are the most obvious moorland food and only in chicks taken from grassy places were many found. In other crops one or two insects, usually a small species of cranefly or large species of Collembola were found. Grit was always found in chicks over one week in age, but before then, where the territory was away from sources of grit, such as on Burnt Hill and The Drive, none was found in the gizzard.

Chicks and adults together were estimated to consume only 3-4% of the annual shoot production of heather in both 1971 and 1972. Therefore unless grouse are even more selective than is at present thought, food quantity is unlikely to be a limiting factor.

Observations in 1971 showed that the chicks remained in the nest until they were dry, then, after a few exploratory excursions they leave with the hen. Where they go now depends on the food and cover available. Territorial boundaries soon break down and hens with chicks are frequently found near an incubating hen, the cock no longer taking aggressive action. Even so the broods are usually found within 2 - 300 metres of the old nest and rarely move more than 600 metres away. Only in the case of chicks from Burnt Hill or The Drive were they found further afield, usually by the river Tees or Trout Beck, where they obtained grit before returning after a few days to the nesting area.

The most vulnerable time for the chick is in the first few hours after hatching, and, in 1971 most mortality was found during this time. Death may be due to a number of causes; late hatching may result in some chicks failing to follow the hen off the nest and thereby dying of exposure; rainstorms may cause heavy losses; and natural hazards such as holes claim a number of chicks. Whilst a few days old chick has been observed to swim like a duckling, death from drowning is not infrequent. Foxes and other predators claimed a few chicks in 1971, but mortality (1.9%) on the nest was low. However, although few chicks were found dead later, the total mortality of the juvenile birds in their first four months of life might have been as high as 20%. 1972 however, was very wet during the latter part of May (over 6 ins (153 mm) of rain fell in the last week of the month), and losses were high. One brood of 10 chicks was lost and mortality on or around the nest was 7.5%.

Tape worms and trichostrongyle worms were both found, but there was no evidence of any chick deaths due to these burdens. Only one chick (alive) was observed with a tapeworm and the trichostrongyle worms were only observed in 1972 in the faeces of two hens that were late in laying.

g) Social behaviour

Observations of grouse behaviour at Moor House generally agree with the programme of events described by the Scottish workers. Aggressive postures by the old cocks are observed in August, packs of surplus birds are seen and territories become established with an increasing number of dead birds being found as the winter progresses. The two stage decrease in surplus birds, however, has not been found, nor has immigration and movement to lower ground. Survival of marked territorial birds has been found to be good, but the results of the ringing of 450 chicks in 1971 has been very disappointing. The object of this ringing was to record information on the movement of grouse, to see especially whether surplus birds took up territories elsewhere than on Moor House and whether mass migration, suggested by some gamekeepers, might take place in this year when the population was so high. A dozen rings have been recovered. In the first year two birds were shot on Calvert End (Tynehead), and one on Harwood, the remainder being recovered from Moor House. In 1972 two were shot on Birkdale, near Cow Green Reservoir and one on Tynehead. These birds had probably been territorial grouse. The greatest distance of recovery was 2 miles from the nest.

7. Discussion and Conclusions

a) Comparisons

Moor House compares well with most local grouse moors. The grouse stocks in 1971 - 1973 were as good and probably better than most. Croglin Fell, to the north-west is a good moor, on which exceptionally high ratios of young to old birds were counted in 1971 (4.04 : 1) and 1972 (3 : 1). In the same years the Moor House figures were 3.3 : 1 and 2.0 : 1 respectively. The number of grouse shot (Fig 6) on an estate 25 miles south-east of the Reserve and at a much lower altitude (600-1200 ft O.D.) show an annual fluctuation due to a large number of reasons, which might include the frequency of shooting, manner of shooting, weather, skill and number of shooters, and many other factors apart from the birds themselves, their breeding success, effect of weather, nutrition, predation etc. The Moor House bags can be expected to show even greater fluctuation, and this they do (Fig 3), because all factors, especially those of grouse survival, are likely to be even more marked under the more adverse conditions of a high-level moor (1600 - 2500 ft O.D.). Nevertheless despite the situation clutch size (8.8), egg size (45.8 x 0.91 cm), hatching success (94.5%) and chick weight on hatching (17.9 g) in 1971 were all greater than the figures recorded by the Grouse Unit at Banchory during the period 1962-1965.

b) Migration

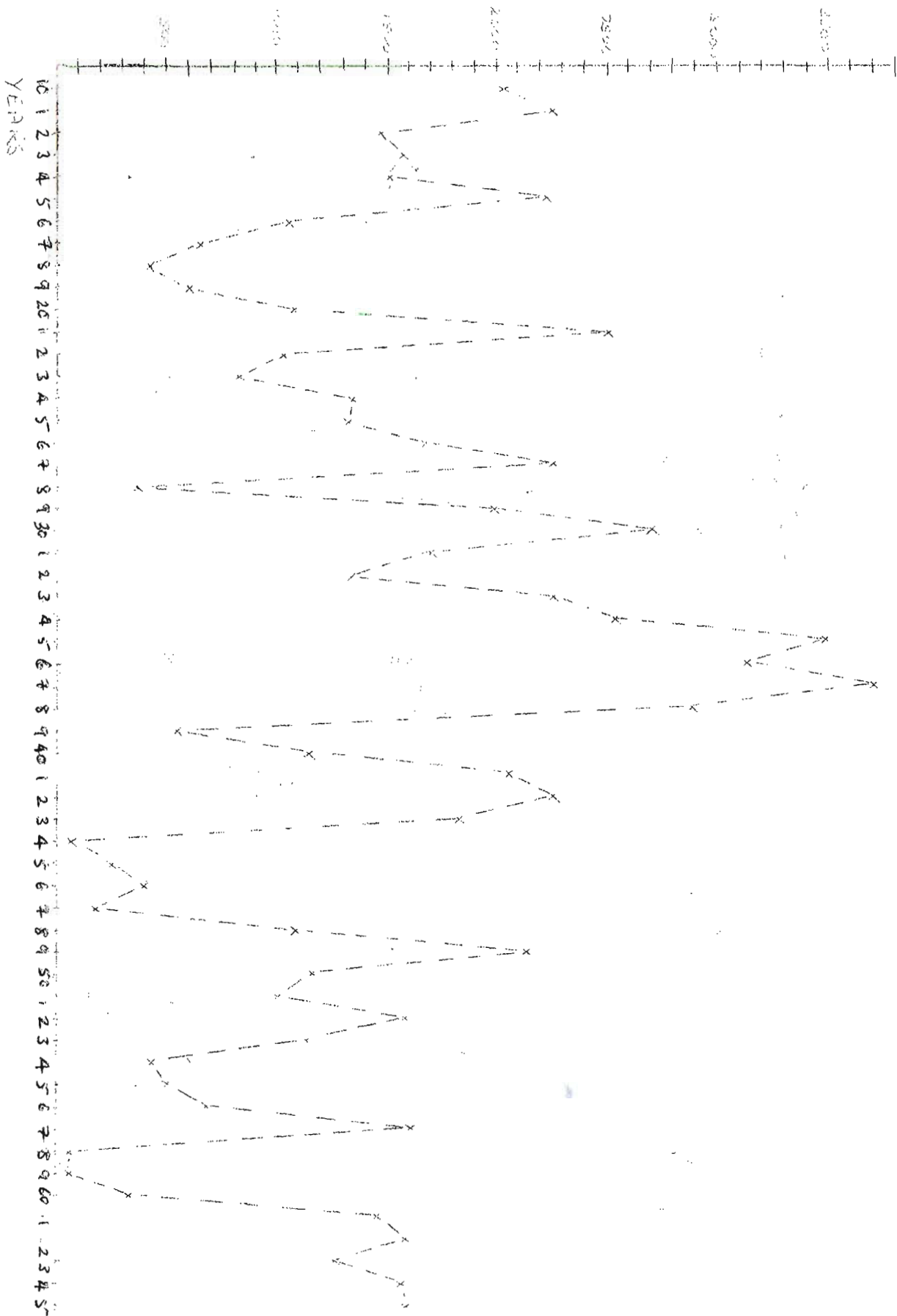
Our observations on territorial behaviour and the fate of the surplus birds agree with the Scottish findings except that we have no proof of widespread movement of the surplus birds to lower country. This is possibly due to 1) neighbouring ground being at similar, if slightly lower altitude 2) the large amount of heather on the Reserve compared with adjacent moors, and 3) the absence of neighbouring corn fields. Marked birds have generally been recovered close to their place of tagging. Grouse may leave the fell temporarily in times of winter storm and local pack movement but there is no evidence of wholesale grouse migration. This has been suggested, but we believe it is a myth.

c) Disease

Death in grouse is commonly ascribed to disease, which may be due to malnutrition and social stress. Jenkins *et al* (1963) found various species of bacteria associated with pneumonia and peritonitis, Coccidia, tapeworms and intestinal nematodes were the common internal parasites, Coccidia occurring in 25% of the adults examined. Two thirds of the adults had tapeworms (*Davainea urogalli* and *Hymenolepis micropa*), but the most frequent and numerous parasite was the nematode *Trichostrongylus tenuis*. Few grouse had no trichostrongyles, many had thousands, but provided the feed available is of sufficient nutritive value worm burden does not become a problem to the breeding population. Surplus birds, often in a poor condition, are prone to die with heavy parasite burdens.

Dead birds have been examined at Moor House. In 1970, seven out of 13 birds were found to have Trichostrongylosis, single birds had coccidiosis, tapeworm with trichostrongyles, catarrhal enteritis, aspergillosis, environmental stress and predator damage. In 1963 a grouse in poor condition, weighing only 440 g in November was found to be heavily infested with lice (*Lagopoecus affinus*) and trichostrongyles.

Fig. 5. Numbers of Grackle shot on a game preserve North of Chicago from 1910-1942.



In January 1964 a cock bird not only had numerous nematode worms but was suffering from aspergillosis and its lungs were infected with Pasteurella aviseptica, the causative organism of fowl cholera - a rare occurrence. Remarkably enough this bird had a full crop with 530 bits of heather in it.

The majority of birds die in spring and early summer. Jenkins et al (1963) found these to be surplus birds that made no difference to the breeding stock. Dead birds are often picked up in areas between territories, where large numbers of parasites may be expected. Poor breeding success can however, be attributed to nutritional deficiencies and disease, but Jenkins et al consider that parasitic disease and consequent mortality are not fundamentally important in controlling the size of the over-wintering and breeding populations.

At Moor House then, despite the recording of large numbers of dead birds, there has in 20 years been no evidence of an outbreak of "disease".

d) Weather

Grouse are extremely hardy birds but they are affected by weather. Territorial birds will stay in their territories in storm and snow, unless the heather remains covered for long periods, when, with the surplus birds, they may leave the fell temporarily. This occurred in 1963. During a snow storm birds will rest in the heather and allow the snow to cover them. Grouse snow holes are a common feature on Moor House in winter.

Indirectly grouse may be affected by late frosts destroying the heather shoots. A short and cold summer will also result in poor heather growth, although insufficient quantity of available feed is probably rare at Moor House.

It is in the summer that the obvious effects of snow, rain and cold are found. Hens may desert the nest in heavy snow and rainfall; chicks are very vulnerable in the first two days to exposure from rain, wet vegetation and cold temperatures, and many are drowned.

e) Predators

It is nearly always the surplus bird that falls foul of a predator; predation of breeding stock, when it occurs, is mainly restricted to nesting hens, eggs and chicks.

Work in Scotland has shown that predation on most moors is not important. However, where there are a large number of crows destruction of eggs can be considerable and may have a significant effect on the stock of birds for shooting.

The main predator of adult birds on Moor House is the fox, whilst black-headed gulls have been found to destroy eggs. In 1971, of 54 nests studied 2 were robbed with the shells of the whole clutch scattered around and each egg with a characteristic hole in the side. Robbery of single eggs by stoats occurred on 3 occasions. In 1973 Holms reported that a number of nests were robbed by gulls but in every case the hen relaid. The percentage of nests robbed was as high as 10.9%.

Compared with the list of predators killed by the keepers in the first 28 years of the century, numbers on the Reserve are now very small. An estimate by T.L. Hodgson suggests there to be 2-3 fox pairs, on average ten foxes are killed each year, whilst 2 pairs of kestrels, 1 pair of buzzards and 20 pairs of black-headed gulls include the Reserve in their range. Stoats and Weasels are estimated to be uncommon. Crows are not a significant factor.

f) Shooting

An accepted principle of grouse moor management is to shoot as many birds surplus to breeding requirements as possible, as a large stock of grouse over-wintering may lead to a disease problem and affect the following year's production. This has not been found to be the case at Moor House after many years without shooting. There are possibly a number of reasons for this.

1. Severe weather conditions may control numbers so that few surplus birds survive a winter.
2. The immediately adjoining moors, although poorer in heather, are supplied with birds.
3. The food quantity and quality has been good enough to support a breeding grouse population in health.

It is often said that not to shoot will result in a population of old birds, with old aggressive cocks maintaining territories but having poor virility, resulting in low fertility, small clutches and poor birds. This is not the case, as the intensive studies at Banchory have shown and have been supported by our own observations both of marked birds and the population. Productivity at Moor House bears comparison with any shot moor. The fact is, of course, that few cocks survive to breed a second year.

It cannot therefore be said that shooting is always necessary to maintain a healthy stock. On the other hand shooting will have no detrimental affect on the population unless it is so selective as to crop the most aggressive (territorial) birds. So the work at Moor House, where the grouse are largely unmanaged, has provided a valuable ecological study, the population size being found to be regulated naturally.

g) Burning

The Grouse Unit in Scotland have found that bird numbers increase after burning and they recommend regular burning of small strips of moor so that the greater part of the moor is burnt in 10 years. They have also noted that severe sheep and cattle grazing, in rotation with periods of rest, can produce as good a result in terms of grouse numbers as burning.

Burning of heather is normally done to produce young, and supposedly more nutritious, feed than does old heather. In the short term heather may become tall, rank and decadent. Burning prevents this. It is also done to propagate a heather dominant vegetation, for on many relatively dry moors, birch and pine would quickly colonise the ungrazed ground if burning was stopped. The management of a grouse heather moor, an artificial habitat, is therefore a form of monoculture. The habitat is nevertheless of conservation interest and one we would wish to see perpetuated.

The distribution pattern of grouse requires to be understood if burning is to be effective in these conditions. A grouse territory may vary from 5 - 10 or more acres in size, so burns must be widespread to give variety in the age stands available to the whole breeding population.

Too severe and frequent a burning regime leads to losses of minerals in run-off and also elements in the smoke, apart from the physical damage, erosion and destruction of all vegetation, that can follow poor management. Severe burning followed by grazing may also result in bracken invasion.

What has been our experience at Moor House? We have had high stocks of grouse yet our management has been negligible and burning, on average, has been less than 12 acres a year out of a possible 4000 acres.

The Grouse Unit say that grouse stocks over the whole country have increased greatly during the last few years. This has been the case locally, and, of course, at Moor House. It is undoubtedly due to the mild winters and the good conditions of the moors. The Unit say that even where management of heather burning is bad, and has been bad for a long time, there are now abundant grouse, but that stocks would have been higher if burning had been "correct". However, we have found that on the one area of the Reserve, Green Burn and Force Burn, where burning has been concentrated (see Fig 4) grouse numbers have been the lowest. Prior to counting census plots in this area our experience had been that there were fewer grouse in this part of the moor than elsewhere. During the period of maximum grouse numbers, 1909-1912, the management was "bad", large fires of 250 acres were the order. Before the war small burns were concentrated in certain areas (see Fig 1) yet stocks were equally good in the upper Tees and Moss Burn parts where no burning appears to have been carried out.

Is the management of a wet high-level moor therefore different from the relatively dry heather moor of lower country? We think it is; we are dealing with an entirely different habitat, one that is semi-aquatic, a vegetation of heather, cotton grass and Sphagnum moss on deep wet peat, 3 feet and more in depth. This peat supports bog communities not heathlands, and the plants, even heather, grow and react to treatment in a different manner.

Unburnt and lightly grazed bog has a thick carpet of moss among which the heather and other flowering plants grow. In this medium heather branches spread horizontally, encouraged by wind and snow cover, and much is covered by moss. Propagation is by layering (seedlings are not frequent) rootlets grow from these layered stems and the whole becomes a complex in which individual plants lose their identity. It is often impossible to demarcate a single heather plant. When these emerging stems (we may call them heather plants) are sampled for age estimation one finds the moor consists of a whole range of age groups, from 1 to 26 years, with the majority of "plants" falling between 3 and 16 years. This is not the case on a dry moor, the age range there being related to the dates of burning, regeneration having been mainly from seed. Thus the unburnt bog provides a good range in age structure, which cannot be improved by burning. Burning indeed may be detrimental as it removes areas from food production, for grouse, for at least 7 years, recovery of heather under these conditions being very slow.

Moreover the effect of burning cannot be dissociated from sheep grazing, which is widespread on Pennine moors. Trials at Moor House in which different burning regimes and grazing intensities are being tested show that burning, even when only a minimal amount of grazing is permitted, can be detrimental to the bog surface (Rawes & Williams, 1973). Sphagnum cover is much reduced and bare peat lies exposed on the surface. It is a poor and unstable habitat for plants, other than cotton grass, and heather recovery is slow, often taking 15 to 20 years to return to its former condition. Meanwhile, if sheep grazing pressure is increased it is unlikely that heather will ever again become dominant. Indeed there is evidence for the Pennines generally that heather is steadily becoming less frequent. One trial in which light grazing, without burning, had been tested for four years showed that heather shoot production was stimulated by this treatment, but in this case the grazing was strictly controlled. Nevertheless, it is possible that this sort of treatment would be a more suitable management than burning for this type of land.

h) Future work

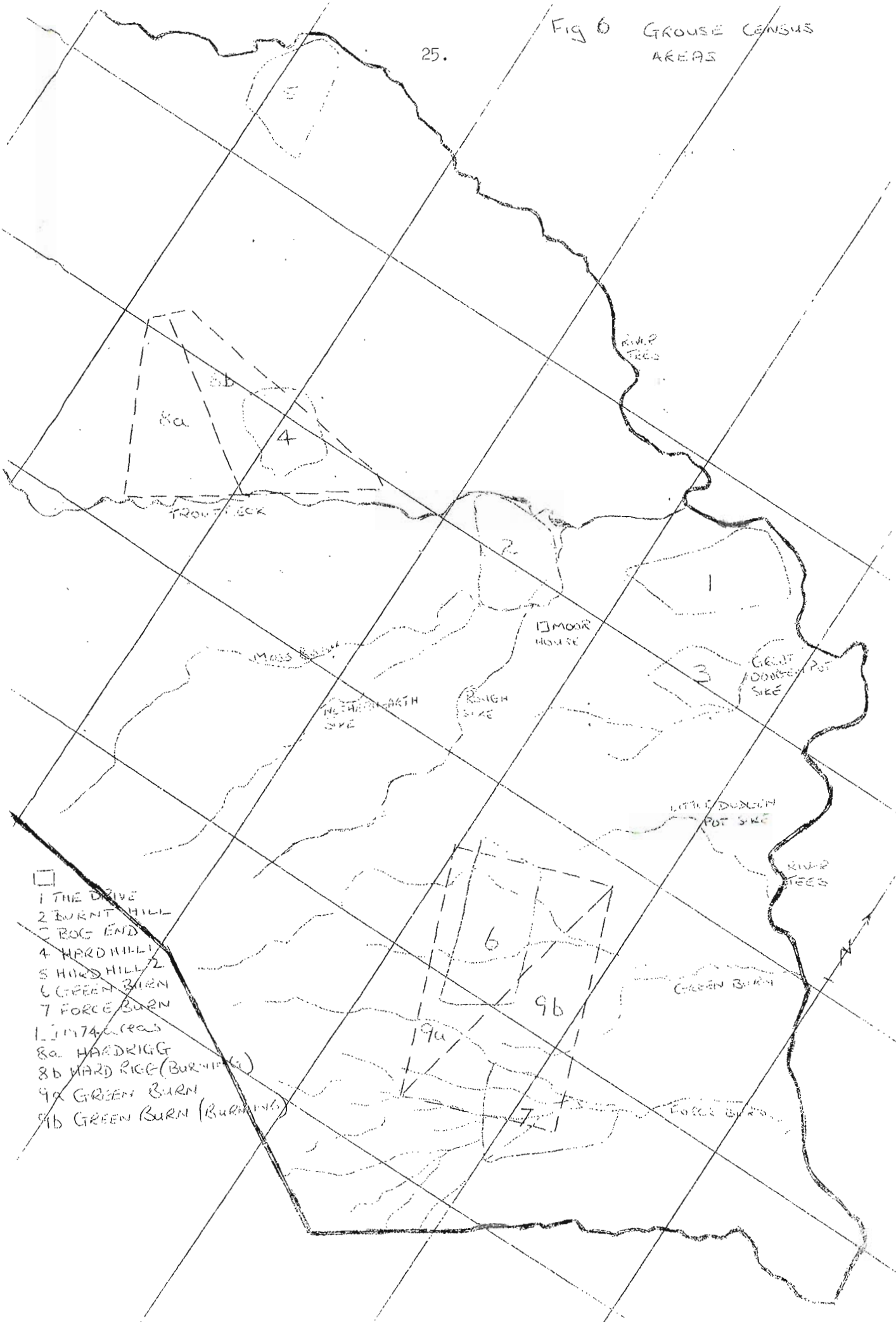
Grouse are important because 1) they are the main indigenous animal of many moorlands in northern England and Scotland, 2) more often than not they provide revenue to proprietors in excess of that obtained from sheep farming, and 3) moorlands are often areas of wilderness with little economic value but high aesthetic and conservation interest. Thus at Moor House we intend to continue studies to further our information on grouse and the moorland habitat. Management is clearly important in these studies. The effects of sheep grazing and its removal, of burning, draining, fertilising, tree planting and recolonisation of eroded peat areas are all aspects that have received some attention and will continue to do so. More academic projects, undertaken where management has altered the original habitat, are encouraged. To establish the optimum management for all interests is the station's objective, but with grouse we still have much to learn.

It has become clear from work in Scotland that nutrition, soil status and food quality, are of prime importance in grouse productivity. Moors on soils less acidic than others have higher grouse stocks. It has also recently been shown that grouse are as selective in their grazing as sheep and will select heather shoots of highest nutritive quality, which may not be the green shoots that we think are good for the birds.

At Moor House we have noted that grouse numbers are greater in the Hard Rigg than the Green Burn area. Are the areas different nutritionally or in the territories they provide? Limestone outcrops on Hardrigg at 2200 ft O.D. There is no limestone influencing the Green Burn area. These two areas (Fig 6) will be surveyed, their vegetation, habitat variation (streams, aspect, broken ground etc.) recorded, water, soil and vegetation chemically analysed, and the grouse surveyed yearly. To continue our investigations into the effect of heather burning each area will be divided into two equal parts of 200 acres and one part will be subjected to an intensive burning regime of numerous small fires. The results, in about 10 years, should, if the areas are shown to be nutritionally different, show 1) consistently larger numbers on Hard Rigg, and 2) will answer the question of the effectiveness of burning in the short term in two parts of the Reserve.

Fig 6 GROUSE CENSUS AREAS

25.



- 1 THE DRIVE
- 2 BURNT HILL
- 3 BOG END
- 4 HARD HILL
- 5 HARD HILL 2
- 6 GREEN BURN
- 7 FORCE BURN
- 1 in 74 areas
- 8a HARDRIGG
- 8b HARD RICE (BURNING)
- 9a GREEN BURN
- 9b GREEN BURN (BURNING)

The annual survey of grouse - breeding numbers, nesting success and autumn stock will continue, with counts in the previously selected census areas.

Acknowledgements

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