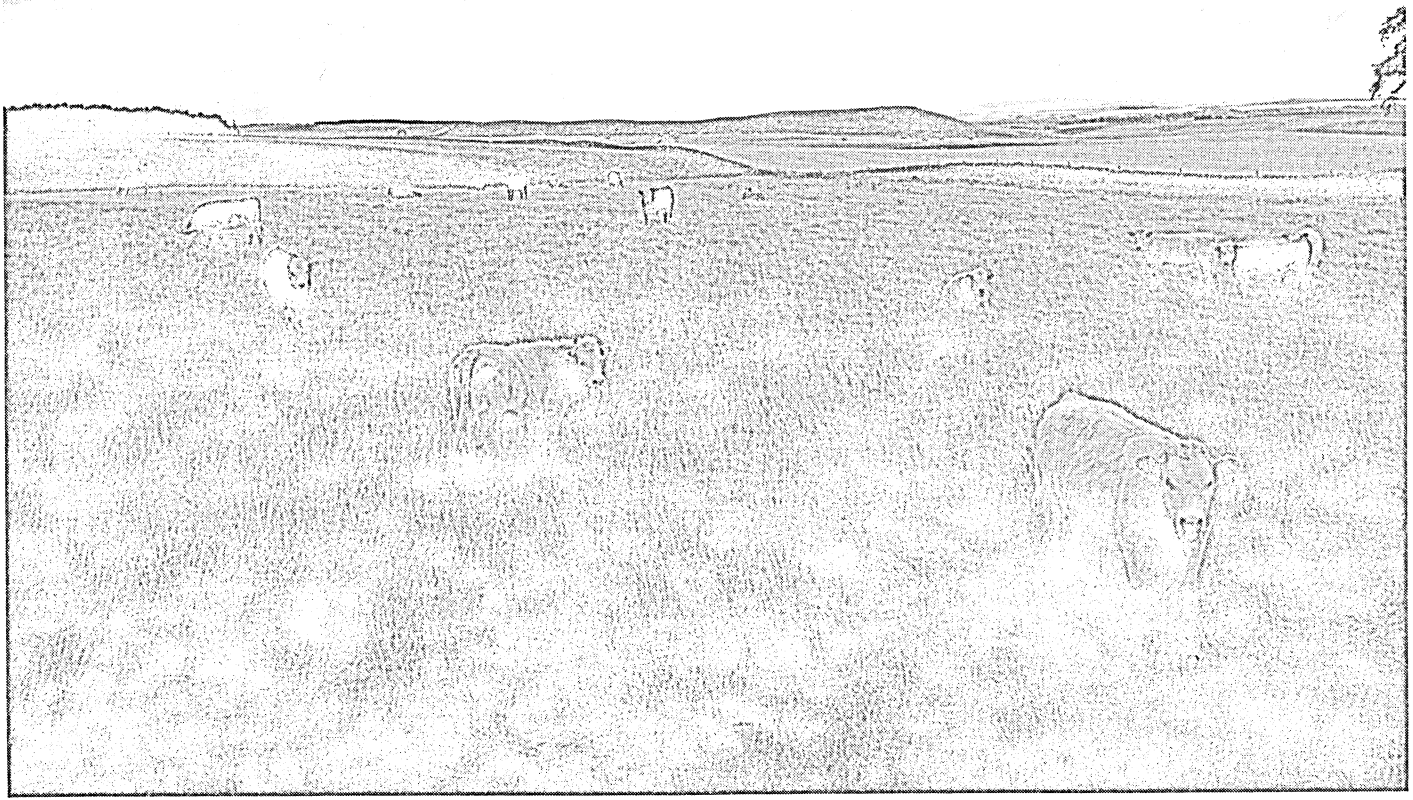
ESCA

THE GRASSLAND OF EAST SCOTLAND —A SURVEY 1976-78

BULLETIN No. 29 Price £1.00 JUNE 1983



The East of Scotland College of Agriculture
Agricultural Research Council Unit of Statistics

The Grassland of East Scotland — A Survey 1976-78

by

G Swift, J. C. Holmes, A. T. Cleland and D. Fortune
Crop Production Advisory and Development Department

J. Wood
A.R.C. Unit of Statistics

With grateful acknowledgement to the many colleagues who assisted with this survey, especially R. J. F. Morris and R. B. Speirs who made the soil survey, and A. D. Mann who processed the data.

Bulletin No. 29

June 1983

Copies can be obtained from:
The East of Scotland College of Agriculture
Edinburgh School of Agriculture
West Mains Road
Edinburgh EH9 3JG

Crop Production Advisory
and Development Department
Bush Estate
Penicuik
Midlothian

ISSN 0306 8668

CONTENTS

SUMMARY

A survey was made in 1976-1978 to obtain information on the grassland of East Scotland, in order to identify factors limiting output from grass and to provide advisory and development priorities. A total of 5,300 ha of enclosed rotational and permanent grass was surveyed on 89 stock rearing farms, whose main outputs were store cattle, fat and store lambs and barley.

Nearly two-thirds of the grass was under 7 years (rotational grass); 30 per cent was 10 years and over. Few fields of rotational grass, but just over half of the permanent grass, had less than 65 per cent of 'sown' species, on a herbage cover basis which excluded bare ground. Half of all fields surveyed had under 15 per cent of white clover. A quarter of the fields in rotational grass were below pH 6.0 or very low in phosphate and potash. One third of the fields used mainly for hay or silage were very low in potash. Forty per cent of the permanent grass fields were below pH 6.0 or very low in phosphate. 'Sown' species content increased up to a soil pH in the range 6.0 - 6.4 and in soils up to a moderate P status (6 - 10 mg/kg). At this soil P status, permanent grass averaged 77 per cent 'sown' species.

Grazed rotational grass was given an average of 104 kg N/ha (range 0 - 312 kg N). Phosphate and potash averaged just over 20 kg/ha. Most hay and silage crops received recommended rates of fertiliser, but only a quarter of the farmers applied a compound fertiliser to the aftermaths to replace the phosphate and potash removed in the hay and silage crop. Permanent grass was mostly grazed and was given on average 63 kg N and 15 - 18 kg P_2O_5 and K_20 per hectare.

There were few physical limitations of topography or drainage to the reseeding of permanent grass low in 'sown' species content. It was estimated that 20 per cent of the permanent grass, which had less than 45 per cent of 'sown' species including a low content of white clover, could benefit from reseeding. A further 20 per cent would benefit from the use of more lime and phosphate.

The average stocking rate on grass and forage crops was 1.7 livestock units (LU) per hectare (range 0.8 - 3.5 LU). Forty per cent of farms carried less than 1.5 LU/ha but most of these used less than the average 100 kg N/ha on the grazed grass. The only factor clearly affecting stocking rate was input of fertiliser N on the grazed grass. This input was used as the best available guide to total fertiliser N usage on the grass. The farmer's knowledge of grass had a small but significant influence on stock carry. Together these accounted for 34 per cent of the variation in stocking rate between farms, in a multiple regression analysis. High output was also obtained where swards were young and/or high in 'sown' species content and where soil pH, P and K levels were satisfactory. Some low stocking rates and generally low fertiliser N usage, together with a two-fold range in stocking rate within similar N inputs, suggest considerable scope for intensifying stocking rates.

INTRODUCTION

Scotland's agricultural land totals 6.8 M ha, of which 5.0 M ha is rough grazings, 1.0 M ha is in grassland and 0.8 M ha in crops. Grassland in the East of Scotland College area amounts to nearly 0.3 M ha. With forage crops this supports a livestock population giving an annual output of £200M.

The aims of this survey were to obtain information on the quality of the grassland, field and soil characteristics and grassland management practices on stock rearing farms in the East College area; and then to identify from this information the main problems or barriers to improved productivity. This would be used to provide advisory and development priorities.

THE FARMS

FARM TYPE

The survey was carried out on 'rearing with arable' farms. These are defined by the Department of Agriculture and Fisheries for Scotland (DAFS) as "farms having a smaller proportion of permanent grass and rough grazings than upland farms, and with crops which may account for up to 55 per cent of the total man-days, but with the proportion of cash crops below 25 per cent." They are found on the fringes of hill and upland areas and in lowground situations. They share many of the characteristics of upland farms, but climate and soil allow more cropping and more intensive stocking. Main outputs are store cattle, fat and store lambs and barley.

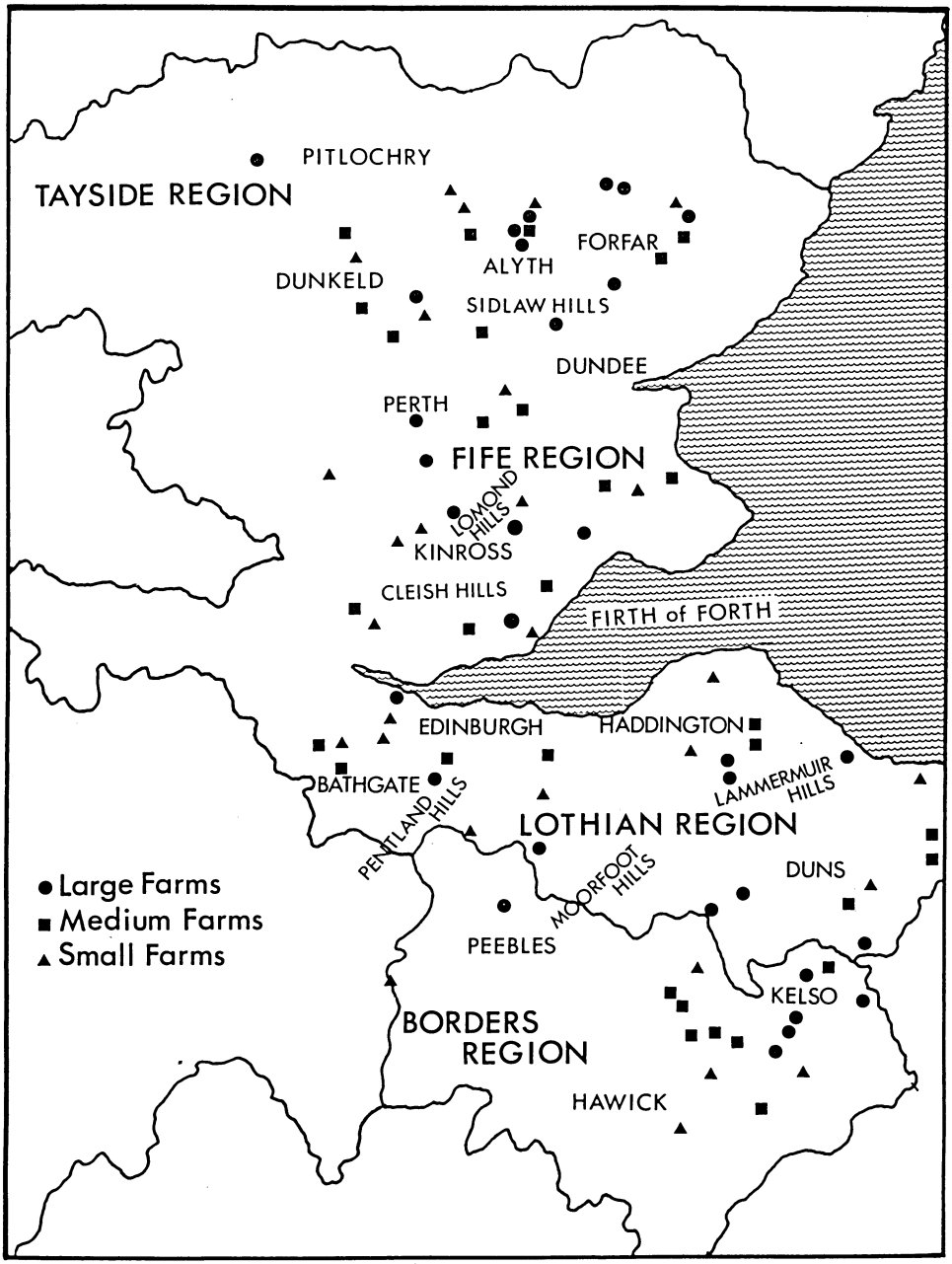
SELECTION OF FARMS

The farms were stratified by enterprise size, into small, medium and large (250 - 599, 600 - 1199 and 1200 + standard man-days) and by location, north of the Forth, in the regions of Tayside and Fife, and south of the Forth in the Lothian and Border regions. Thirty farms within each farm size, divided equally north and south of the Forth, were selected at random to give a total of 90 farms. Thirty were surveyed in each of the three years 1976 - 78. One changed hands during the survey and was withdrawn.

LOCATION OF FARMS

The distribution of the farms is shown in Figure 1. Half of the farms lay between 100 m and 200 m altitude, a quarter below 100 m and a quarter between 200 m and 300 m. The twenty or so at the higher altitudes were mainly farms in hilly regions of Angus and around Blairgowrie, in the Border hills south of Melrose, and the Lammermuirs.

FIGURE 1. Distribution of Farms



DATA COLLECTION AND ANALYSIS

Data were collected from three sources. Grassland specialists in the Crop Production A and D Department surveyed the grassland and obtained information on each field; the Soil Science Department collected soil and topographic data, while agricultural advisers completed questionnaire forms. The data were prepared for computer analysis and processed by the ARC Unit of Statistics in Edinburgh.

THE GRASSLAND SURVEY

After the farmer had provided information on the size, age, intended duration, past management and other details of each field, sward composition was assessed. The method involved random sampling using a 30 cm x 30 cm subdivided quadrat. Per cent herbage cover of the various species was estimated for each of 10 samples per field. The following species or group of species were recorded:—

'Sown'	'Unsown'
Italian ryegrass	Annual meadow grass
Perennial ryegrass	Rough-stalked meadow grass
Cocksfoot	Yorkshire fog
Timothy	Bent species
Other sown grasses	Fine-leaved fescues
Red clover	Other grasses
White clover	Broad-leaved weeds
Other sown legumes	

The level of infestation of particular weeds—creeping/spear thistle, ragwort, dock and rush—was estimated separately.

Bare ground was graded as 0 - 10%, 10 - 20%, 20 - 50% and over 50% for the whole fields. The coding used for herbage cover and weed infestation is based on the England and Wales survey (Forbes *et al* 1980) and is given in Appendix 1.

The survey was carried out from May to October. Since clover and broad-leaved weeds are less prominent early in the season, an adjustment was made for fields surveyed in May: where the clover or broad-leaved weed content came near the top of a category, the next higher code was recorded.

THE SOIL SURVEY

The soil survey began with an assessment of the physical features of the fields—average slope, relief and aspect. Soil restrictions to ploughing were also noted, along with natural drainage, topsoil and

subsoil texture and the dominant soil series. Soil data were completed for only 68 farms, but the soil series were obtained for seven other farms from soil survey maps. Ordnance survey maps were used to estimate field altitude.

THE QUESTIONNAIRE

The greater part of the questionnaire dealt with the grassland policy of the farm to supplement the field data. Information was sought by interview, on cropping and livestock enterprises, seed mixtures, grassland management, conservation methods, manuring and annual livestock numbers from June and December statutory returns. Other questions covered the wintering of stock, housing and turn-out dates, and time of top dressing in the spring for grazing, silage and hay.

DESCRIPTION OF FARMS

FARM SIZE

Average farm size within each size group, and the proportion in crops, grass and rough grazings, are compared with all 'rearing with arable' farms in East Scotland (Agricultural Statistics for Scotland 1978) in Table 1.

TABLE 1: Average farm size and proportion of sample and total farms in crops, grass and rough grazings.

	Sample farms			All farms		
	Small	Medium	Large	Small	Medium	Large
No. of farms	29	30	30	164	209	286
			Hectares per farm			
Average farm size*	72	127	269	95	152	327
Crops	20	37	63	15	35	82
Grass	33	46	99	34	54	122
Rough grazings	18	37	96	44	59	110
			% of farm†			
Crops	28	29	25	16	24	26
Grass	47	39	38	36	36	39
Rough grazings	25	32	37	48	40	35

* Including woodland, roads, yards and buildings

† Excluding woodland, roads, yards and buildings

The sample farms were smaller than the average for all farms in each size group. The difference lay mainly in a smaller area of rough grazings. This may be attributed partly to the lowground situation of many of the sample farms, thirty having no rough grazings. The average sample farm had 40 per cent in grass, 28 per cent in crop and 32 per cent in rough grazings.

RAINFALL

Mean annual rainfall was 820 mm for the north farms and 760 mm for those in the south. The mean rainfall ranged from 655 mm to just over 1000 mm.

SOIL TYPE

Almost half of the 75 farms soil surveyed were on soils represented by eight major soil series, Hobkirk, Sourhope, Whitsome, Macmerry, Kedslie, Caprington, Winton and Strichen. These are imperfectly or freely drained sandy loams or loams overlying sandy loam/loam or sandy clay loam/clay loam subsoils.

Land use capability was classified as grade 3 for 70 per cent of the farms. This is described as land of good fertility with moderate limitations to agricultural use.

CROPPING

The main cropping enterprises of the surveyed farms, and the average area in rotational and permanent grass, are shown in Table 2.

TABLE 2: Area in crops and grass

	Farm size		
	Small	Medium	Large
	Hectares per farm		
Crops			
Barley	12	26	42
Oats	4	3	7
Roots	1	4	6
Potatoes	1	1	3
Other crops	2	1	3
Total crops	20	37*	63*
Grass			
Rotational	23	31	55
Permanent	10	15	44
Total Crops and Grass	53	83	162

* Includes wheat

Barley averaged 40 per cent of total crops and grass. Oats featured on 44 of the farms but only 5 grew wheat. Other crops were mainly rape and kale.

A third of the sown grassland on the small and medium farms was permanent grass; on the large farms it was 44 per cent. Permanent grassland is defined here, and in the DAFS agricultural statistics for 1978, as grass aged 7 years and over.

LIVESTOCK ENTERPRISES

The main livestock enterprises are given in Table 3.

TABLE 3: Frequency of livestock enterprises

	North farms	South farms	Total
		No. of farms	
Sheep	31	39	70
Suckler cows	36	26	62
Bought-in beef	15	33	48
Other beef	5	3	8

Three quarters of the farms had sheep, 70% had sucklers whilst half bought in beef cattle.

Two thirds of the farms with lambs from breeding flocks sold fat. Around two thirds of the suckled calves, and half the bought-in cattle, went store.

FIELD CHARACTERISTICS

The physical features of the fields are summarised in Appendix 2.

ALTITUDE

Just over a quarter of the fields in either rotational or permanent grass lay below 100 m with a similar proportion between 200 m and 300 m.

GRADIENT

Forty per cent of the fields for which the average gradient was recorded (630) had an average slope between 1° and 6°; a further 45 per cent ranged from 7° to 11° average slope. Only 9 per cent were moderately steep, with average slopes between 12° and 15°, although the proportion increased to 14 per cent for fields in permanent grass. Few fields were on slopes steeper than 15°. Steepness of field thus appeared not to be a major deterrent to reseeding.

RELIEF AND ASPECT

Nearly three-quarters of the fields were described as either "subdued" or "gently rolling." A further 18 per cent were lower or upper hill slopes. Aspect was generally favourable, being mainly variable, level or south facing.

SUBSOIL TEXTURE

Virtually all the fields soil surveyed had a sandy loam or loam topsoil overlying the same soil type in half the fields, clay loam subsoils (39%) or loamy sands (10%).

SOIL DRAINAGE

Half the fields were imperfectly drained and a third freely drained. Only 5 per cent were poorly drained.

SOIL RESTRICTIONS TO PLOUGHING

Nine per cent of both the rotational and the permanent grass fields were very stony, whilst slightly fewer had surface boulders or rocks down to plough depth. Thus 17 per cent of the fields were either difficult to plough or unploughable.

WATER SUPPLY

Just over 80 per cent of the fields were well supplied with water, 40 per cent with ample piped water. One field in 10 had no drinking water, or an unreliable supply.

THE GRASSLAND— GENERAL INFORMATION

Over 5,300 hectares were surveyed, 10% of the grass on all 'rearing with arable' farms and 2 per cent of the total grass in East Scotland.

AGE STRUCTURE

Nearly two thirds of the grass was under 7 years (rotational grass), while 30 per cent was 10 years and over. South of the Forth one field in five was over 20 years.

INTENDED DURATION

One third of the fields were intended to be down for as long as they remained productive. The next most common duration was 5 - 6 years. Most of those over 20 years were expected to remain in grass. Very few fields were in short-term leys.

ESTABLISHMENT

From information obtained on 1 - 3 year old fields, three quarters of the grass was sown under barley and 15 per cent under oats. Ten per cent was direct sown, but this was more widely practised in the North region than in the South. The direct sow-outs were mainly spring sown in the North, and August or September sowings in the South.

Broadcasting was slightly more popular than drilling, but few fields of 1 - 3 year old grass had been established by broadcasting on to a ring-rolled seed bed.

FIRST YEAR MANAGEMENT

Half the fields of 1 - 4 year old grass had been grazed in the first year and a third cut for hay. But there was a marked contrast between the North and South farms. North of the Forth, where cattle predominated, only a third of the fields were grazed in the first year compared with two thirds in the sheep rearing area of the South.

SEED MIXTURES

Cockle-Park type seed mixtures of perennial ryegrass, cocksfoot, timothy and clover were used for 70 per cent of the medium and longer term leys. Most of these mixtures contained a small quantity of Italian ryegrass, while red clover featured in over half.

Most farmers appeared to have particular reasons for choice of seed mixture. Among the main ones given were "to suit the farm system and management requirements," "suits the land" and "satisfactory performance." Other reasons included a recommendation by a seed merchant or the College. Some farmers expressed a special desire to include or exclude cocksfoot.

USE OF HERBICIDES FOR ESTABLISHMENT

On undersown cereals, two thirds of the farms used herbicide formulations based on MCPB and other chemicals least harmful to clover. Less than a third frequently used MCPA; the few remainder used no herbicide.

Of the thirty farms with direct reseeds, 17 used no herbicides. The others often or occasionally used MCPA- or MCPB-based formulations.

GRAZING SYSTEMS

Over half the suckler herds were set stocked, but in the North rotational grazing of fields was slightly more popular than set stocking. Three quarters of the beef cattle were set stocked. Two of the North farms zero grazed these cattle. Most of the sheep flocks were set stocked.

On farms with sheep and cattle mixed grazing predominated in the South and separate grazing in the North. Only three farms were practising the East College's "clean grazing" system, although others were considering it.

WINTERING OF STOCK

Two thirds of the suckler herds were in-wintered, most being housed from late November and turned out in April or early May. Most of the beef cattle were housed in October and turned out late April or early May. Sheep were mainly wintered (from New Year to lambing) on some of the grass fields, with or without access to forage crops. Nearly 20 per cent of the flocks wintered on all the grass fields.

CONSERVATION

Hay was the main winter feed on over 70 per cent of the farms. Most other farms made clamp silage, mainly the large farms. Twenty five farms made both hay and silage. The majority of farmers aimed for a compromise between bulk and quality of both hay and silage.

THE GRASSLAND— BOTANICAL QUALITY

As high productivity is usually associated with swards containing a high proportion of 'sown' or 'preferred' species, botanical quality in this Bulletin is used in the context of sward composition; the higher the content of 'sown' species the better the quality. Sward composition is defined as the relative contribution of each species to **total herbage cover.** It excludes bare ground, which was assessed separately to overcome differences in utilisation among fields over the season. It should be noted that, because of the prostrate habit of growth and low dry matter content of white clover, a herbage cover of 20 per cent clover is equivalent to a dry matter contribution of only around 5 per cent.

AGE OF SWARD AND AVERAGE COMPOSITION

Table 4 shows the average composition of the fields in six age groups.

TABLE 4: Age of sward and average composition

	Age (years)						Weighted mean
	1-2*	3-4	5-6	7-9	10-20	>20	
No. of fields	198	191	103	70	121	135	
	% herbage cover						
Italian ryegrass	6	2	<1	<1	<1	<1	2
Perennial ryegrass	51	47	47	44	40	30	44
Cocksfoot	10	13	12	8	9	6	10
Timothy	9	7	6	5	2	1	5
Red clover	2	1	<1	0	0	0	1
White clover	14	16	17	16	15	12	15
'Unsown' grasses	5	11	14	22	28	43	19
Broad-leaved weeds	2	3	3	4	6	8	4
'Sown' species†	93	86	83	74	66	49	77
'Unsown' species	7	14	17	26	34	51	23

* Excluding 1-2 year leys

† Including a negligible content of "other sown grasses and legumes."

Fields under seven years fell steadily in quality with age but still had over 80 per cent of 'sown' species, including 47 per cent of perennial ryegrass. 'Sown' species continued to fall with time in older fields, down to an average of 49 per cent in the oldest grass. 'Sown' species content was highly correlated with age of sward ($r = -0.66$).

The highest average content of cocksfoot was 13 per cent, in 3 - 4 year old grass. Timothy was highest in the first two years, but the content averaged only 9 per cent. White clover appeared to reach a slight peak, at 17 per cent herbage cover, in years 5 and 6, but otherwise there was no clear relationship with age.

VARIATION IN SWARD COMPOSITION

The quality of the average field, although high, masks the wide variation between fields within older age groups (Table 5).

TABLE 5: Age of sward and range in content of 'sown' species

	Age (years)					Weighted mean
	1-4	5-6	7-9	10-20	>20	
No of fields	389	103	70	121	135	
'Sown' species (%)	% of fields					
5-25	0	1	0	8	24	5
25-45	2	5	10	18	30	10
45-65	3	5	19	19	26	10
65-85	17	31	38	24	17	22
85-100	78	58	33	31	3	53
	100	100	100	100	100	100

While few fields under 7 years had less than 65 per cent of 'sown' species, the proportion increased to 29 per cent for 7 - 9 year old swards, and to 80 per cent for the oldest fields.

Nearly three quarters of the fields had less than 15 per cent of cocksfoot and less than 5 per cent of timothy. Cocksfoot, however, was probably not sown in about 15 per cent of the fields.

White clover content varied widely, from 0 - 45 per cent within each age group (Table 6). Half of the fields had under 15 per cent of white clover.

TABLE 6: Age of sward and range in content of white clover

	Age (years)					Weighted mean
	1-4	5-6	7-9	10-20	>20	
No. of fields	389	103	70	121	135	
White clover (%)	% of fields					
0	2	2	2	3	1	2
1-15	54	42	38	50	73	53
15-25	26	25	39	35	23	28
25-45	16	30	21	12	3	16
45-65	2	1	0	0	0	1
	100	100	100	100	100	100

AGE OF SWARD AND CONTENT OF 'UNSOWN' GRASSES

Annual meadow grass (*Poa annua*) was the most common 'unsown' grass in 1 - 4 year old swards, Yorkshire fog (*Holcus lanatus*) and bent (*Agrostis* spp) in older swards (Table 7). Yorkshire fog and bent increased together to a mean of around 20 per cent in fields 10 years and over.

TABLE 7: Age of sward and content of 'unsown' grasses

	Age (years)					Weighted mean
	1-4	5-6	7-9	10-20	>20	
No. of fields	382	102	67	117	134	
	% herbage cover					
Annual meadow grass	3	2	2	1	2	2
Rough stalked meadow grass	1	2	2	3	3	2
Yorkshire fog	2	4	6	7	13	5
Bent spp	1	3	7	11	10	5
Fine-leaved fescues	<1	<1	1	2	5	2
Other grasses*	1	3	4	5	10	4
Total	8	14	22	29	43	20

* Mainly crested dogstail, sweet vernal and smooth stalked meadow grass

AGE OF SWARD AND CONTENT OF BROAD-LEAVED WEEDS

Creeping thistle (*Cirsium arvense*) and spear thistle (*C. vulgare*), along with creeping buttercup (*Ranunculus repens*), to a lesser extent, were the only important broad-leaved weeds. Table 8 shows that the infestation of thistles increased rapidly in the permanent grass with age of sward, half those 10 years and over being heavily infested (>1 plant per 16 m^2).

TABLE 8: Age of sward and infestation of thistles

Level of infestation	Age (years)					Weighted mean
	1-4	5-6	7-9	10-20	>20	
No. of fields	395	98	57	94	115	
	% of fields					
None or light	64	43	37	35	24	49
Moderate	23	23	35	16	25	24
Heavy*	13	34	28	49	51	27
	100	100	100	100	100	100

* > 1 plant/16 m^2

Buttercups increased steadily with age of sward such that a third of the fields 10 years and older had a "heavy" infestation (>5% herbage cover). Fields with a "heavy" infestation of docks (*Rumex obtusifolius*) and ragwort (*Senecio jacobea*)(>1 plant/16 m^2) amounted to only 5 per cent and 1 per cent, respectively.

Low growing broad-leaved weeds, mainly daisy (*Bellis perennis*), mouse-ear chickweed (*Cerastium arvense*) and hawkweeds (*Hieracium* spp) were present in two thirds of the fields. Collectively they increased rapidly after the sixth year and half the fields of permanent grass had a "heavy" infestation (>5% herbage cover).

SOWING METHOD AND SWARD COMPOSITION

Fields which were 1 - 3 years old were compared for possible effects of sowing method on sward composition. Broadcasting after flat rolling, and drilling, gave swards of similar composition, although perennial ryegrass was higher in drilled swards and white clover slightly lower. Too few swards were established by broadcasting on to a ring-rolled seed bed for a valid comparison of this method. Drilled fields had the most open swards.

FIRST YEAR MANAGEMENT AND SWARD COMPOSITION

Fields of two-four years' grass were compared for possible effects of first year management on sward composition (Table 9).

TABLE 9: First year management and average composition of 2-4 year old swards

	First year management		
	Grazed	Cut for hay	Cut for silage
No. of fields	145	116	61
		% herbage cover	
Italian ryegrass	1	4	8
Perennial ryegrass	51	44	53
Cocksfoot	11	17	9
Timothy	5	9	10
Red clover	<1	1	1
White clover	19	15	13
'Unsown' grasses	10	8	4
Broad-leaved weeds	3	2	2

Compared with fields grazed in the first year, fields cut for hay had more Italian ryegrass, cocksfoot and timothy and less perennial ryegrass, white clover and 'unsown' species. The fewer fields cut for silage in the first year had least clover and 'unsown' species.

SWARD COMPOSITION OF CUTTING AND GRAZING FIELDS

The average composition of fields cut at least once in their lifetime (or within the past 10 years, if over 10 years old) differed in many respects from fields used only for grazing (Table 10).

TABLE 10: Average composition of fields cut and grazed or grazed only

	Management	
	Cut and grazed	Grazed
No. of fields	416	400
	% herbage cover	
Italian ryegrass	3	2
Perennial ryegrass	47	40
Cocksfoot	13	7
Timothy	8	3
Red clover	1	<1
White clover	15	15
'Unsown' grasses	10	28
Broad-leaved weeds	3	6
'Sown' species*	87	66
'Unsown' species	13	34

* Including a negligible content of "other sown grasses and legumes"

Fields which had been cut for hay or silage had slighty more ryegrass than grazing fields, twice as much cocksfoot and timothy and appreciably fewer weeds. The white clover content was similar under both managements. However, a comparison of the rotational grass fields showed the content to be lowest in the cutting fields.

TYPE OF GRAZING STOCK AND SWARD COMPOSITION

The survey confirmed the preferential grazing by sheep of timothy and the relative avoidance of cocksfoot. Thus timothy content was lowest, and cocksfoot highest, in fields grazed mainly by sheep. White clover content was highest in fields mixed grazed.

ALTITUDE AND SWARD COMPOSITION

Altitude had no effect on the average quality of the rotational grass fields, but the highest fields of permanent grass had the lowest average content of perennial ryegrass and the highest content of 'unsown' grasses and broad-leaved weeds.

SOIL TEXTURE AND SWARD COMPOSITION

There was no difference in composition between fields with sandy loam/loam subsoils and a smaller number with clay loam subsoils. The few fields (10%) with loamy sand subsoils had marginally the most perennial ryegrass and cocksfoot and the least timothy.

DRAINAGE AND SWARD COMPOSITION

Imperfectly drained and freely drained fields had a higher content of 'sown' species than the much smaller number of fields with poor or variable drainage. Cocksfoot content was highest in freely drained fields (average content 12%) and lowest (4%) in poorly drained fields. No other grass showed any consistent trend, nor did white clover.

SOIL FERTILITY

Soil samples were taken from all the fields except for a few which had been ploughed. The samples were taken in the autumn to a depth of 15 cm for pH, P and K analyses. Exchangeable P and K were extracted using a modified Morgan extracting solution (ammonium acetate-acetic acid).

SOIL ANALYSIS

Table 11 shows the proportion of the fields of rotational and permanent grass within six categories of soil pH, P and K.

TABLE 11: Distribution of fields by soil pH, P and K

	Soil pH					
	4.5-4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	7.0-7.4
	% of fields					
Rotational grass	<1	5	22	44	25	3
Permanent grass	<1	8	32	43	14	2
	Soil P (mg/kg)					
	0.0-1.5	1.6-3.0	3.1-6.0	6.1-10.0	10.1-25.0	25.1-75.0
	% of fields					
Rotational grass	25	33	30	9	2	<1
Permanent grass	42	27	23	7	1	0
	Soil K (mg/kg)					
	0-60	61-90	91-120	121-170	171-270	271-500
	% of fields					
Rotational grass	30	30	20	13	6	1
Permanent grass	13	24	24	17	17	5

A quarter of the fields in rotational grass were below pH 6.0 and a similar proportion very low in P and K. Forty per cent of the permanent grass fields were below pH 6.0 or very low in P.

SOIL POTASSIUM AND GRASSLAND UTILISATION

Whereas utilisation of the rotational grass by cutting or grazing had no effect on soil P status, grazing fields differed markedly in soil K status from those cut and grazed. Only 18 per cent of the grazing fields were very low in K compared with a third of the cutting fields.

SOIL FERTILITY AND SWARD COMPOSITION

There was an increase in 'sown' species content with increasing soil pH and soil P, but not soil K (Table 12).

TABLE 12: Soil fertility and content of 'sown' species

	Soil pH					
	4.5-4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	7.0-7.4
	% 'sown' species					
Rotational grass	41	77	83	90	92	95
Permanent grass	38	46	58	63	63	66
	Soil P (mg/kg)					
	0.0-1.5	1.6-3.0	3.1-6.0	6.1-10.0	10.1-25.0	25.1-75.0
	% 'sown' species					
Rotational grass	82	89	91	91	87	93
Permanent grass	51	63	68	77	78	—
	Soil K (mg/kg)					
	0-60	61-90	91-120	121-170	171-270	271-500
	% 'sown' species					
Rotational grass	88	90	85	88	88	88
Permanent grass	63	63	55	62	60	63

'Sown' species content increased up to pH 6.0-6.4 and up to a moderate P soil status with 6.1-10.0 mg/kg of phosphorus. At this level of soil P, permanent grass had on average 77 per cent of 'sown' species.

FERTILISER USE AND PRACTICES

AVERAGE FERTILISER USE

Average rates of fertiliser nitrogen, phosphate and potash applied annually to the rotational and permanent grass are given in Table 13.

TABLE 13: Average fertiliser use

	North farms			South farms			All farms		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
	kg/ha/ann								
Rotational grass									
Grazing	114	29	26	94	18	17	104	23	21
Hay	96	36	44	88	27	31	93	32	37
Silage, 1st cut	110	29	49	137	21	26	124	29	39
Silage, 2nd cut	87	33	45	105	22	36	96	28	41
Aftermaths	41	6	7	34	9	8	37	8	8
Permanent grass									
Grazing	73	23	20	53	13	11	63	18	15

Grazed rotational grass received an average of 104 kg N/ha (83 units N/ac) but the rate ranged from nil (eight farms) to over 300 kg N/ha or 240 units/ac (two farms). Phosphate and potash averaged just over 20 kg/ha (16 units/ac). Approximately the recommended rates of fertiliser were used for hay or silage, but only a quarter of the farmers applied a compound fertiliser to the aftermaths to replace the phosphate and potash removed in the hay and silage crop.

Most of the permanent grass was grazed and received just over half the average rate of fertiliser N applied to the rotational grass. A third of the farmers used no compound fertiliser on the permanent grass and few applied basic slag or other phosphatic fertilisers.

General manuring policy with regard to the use of phosphates revealed that half the farmers used basic slag on the grass or for the turnip break. Eight others used Gafsa rock phosphate. The phosphatic fertilisers were mostly applied to the seed bed or on the young grass in the autumn.

Relatively little grass received farmyard manure, most of which went on the turnip ground or to stubbles. Only six farms used slurry.

TIME OF FERTILISER APPLICATION IN THE SPRING

Grazing fields. A third of the farmers claimed to topdress in spring for an "early bite" (and a third for late bite in the autumn). Time of application ranged from late February to early May, although the late applications were on lambing fields. Most farmers applied the fertiliser in early April (30%), late March (20%) or mid March (14%). Early April was the most common time in the North region and mid or late March in the South. Twelve farmers used no spring fertiliser.

Hay and silage fields. Two thirds of the farmers regularly grazed the conservation fields in the spring and this influenced the time of topdressing. The hay ground was fertilised in early April by a third of the farmers, in mid or late April by another quarter, whilst 20 per cent topdressed in May. Only four of the latter split the dressings, into March and May applications.

Silage fields were mostly topdressed in late March-early April.

FARM ANALYSIS

This section deals entirely with whole farm data, the object being to examine which factors were related to stocking rates and to the 'sown' species and white clover content of the farm. The relationships were studied by multiple regression and correlation analyses. Four of the 89 farms were excluded from these analyses, two because of very low cow numbers due to brucellosis; one an atypical lowground farm with no suckler cows or sheep and a winter fattening enterprise based on silage from one-year leys; and one with grass lets.

STOCKING RATES

The June and December statutory returns were used to calculate the stocking rate per forage hectare from the total adjusted area (grass, fodder crops and one third or one sixth of rough grazings) and total livestock units. The livestock unit (LU) used for each class of stock is given in Appendix 3. Each livestock unit is based on the land requirement of that particular enterprise relative to an autumn calving suckler cow and calf. The unit is apportioned according to summer and winter keep requirements.

Stocking rates and other farm data for the farms surveyed in 1976, 1977 and 1978 are listed in Appendix 4, 5 and 6, respectively.

The average and range of stocking rates found within the three farm sizes are given in Table 14.

TABLE 14: Average and range of stocking rates within each farm size

		Average LU/ha	Range of LU/ha
North farms	Small	1.4	0.8 - 2.2
	Medium	2.0	0.9 - 3.5
	Large	1.6	1.0 - 3.0
South farms	Small	1.7	0.9 - 2.6
	Medium	1.6	1.0 - 2.9
	Large	1.8	1.2 - 2.7
All farms	Small	1.6	0.8 - 2.6
	Medium	1.8	0.9 - 3.5
	Large	1.7	1.0 - 3.0

The overall mean stocking rate was 1.7 livestock units per hectare, with a range from 0.8 to 3.5 LU per hectare, and a 3 - 4 fold variation within each farm size. There was no clear distinction between region or farm size.

FACTORS AFFECTING STOCKING RATE

Multiple Regression Analysis

From the many interrelated variables which might affect stocking rate, a basic set was selected containing those expected to have most effect (Table 15). Regression on this basic model accounted for 35 per cent of the variation in stocking rate between farms*. The relative contribution of each basic variable to the model was measured by omitting it from the model and testing whether the difference was statistically significant. Other variables were also tested by addition to the basic model — rainfall, soil drainage, subsoil texture, land use capability and age group of the farmer. All were found to be non-significant individually.

Dropping a single significant variable from the model can give a non-significant result when a variable with which it is correlated remains in. All pairs of correlated non-significant variables were therefore tested for their combined effect. All were non-significant. Significant levels for the basic variables are in Table 15.

TABLE 15: The significance of the effect of a range of farm variables on stocking rate

Basic farm variables	Significance level
Fertiliser N for grazing	5%
Fertiliser N for conservation	N.S.
'Sown' species content	N.S.
Age of sward	N.S.
Soil fertility index	N.S.
Altitude	N.S.
Farmer interest	10%

N.S. = not significant

* Regressions were done using the GENSTAT program in which "per cent variation accounted for" is calculated from the mean squares in the analysis of variance table, rather than from the sums of squares as in the more familiar statistic R^2. The method makes allowance for the number of degrees of freedom due to the regression and "per cent variation accounted for" in the multiple regression is less than given by R^2.

The only factor clearly associated with stocking rate was the rate of fertiliser nitrogen used for grazing. A special interest of the farmer in grass, based on a knowledge of the crop, had a small but significant influence. When assessed together in a two factor model, fertiliser N and farmer interest accounted for 34 per cent of the variation in stocking rate between farms. This increased to 38 per cent with the addition of 'sown' species content.

Fertiliser nitrogen and stocking rate

The input of fertiliser N on the grazed grass was used as the best available guide to total fertiliser N usage on the grass. Table 16 shows an increase in stocking rate with increasing increments of 60 kg/ha, with the exception of a group of only three farms.

TABLE 16: Fertiliser nitrogen for grazing and stocking rate

Fertiliser N (kg/ha)	0-60	61-120	121-180	181-240	>240
No. of farms	34	28	14	3	6
Stocking rate (LU/ha)	1.4	1.7	1.9	1.7	2.6
Top third	2.1	2.1	2.3	1.9	3.1
Bottom third	1.0	1.1	1.5	1.5	2.2

There was a wide variation in stocking rate within each range of fertiliser N usage. The top third of the farms carried up to twice the number of stock per hectare as the bottom third. The relationship between individual farm stocking rates and input of fertiliser N is shown in Figure 2 (see page 27). Most of the high stocking rate/low N farms had bought-in beef cattle, relatively young swards with a farm average of over 80 per cent 'sown' species, and a medium or high soil fertility rating.

Correlation Analysis

The correlation coefficients between eight farm variables are shown in Appendix 7. The correlations are unadjusted for the inter-relationships among these variables.

'Sown' species content and stocking rate

Table 17 shows the mean stocking rages over a range of 'sown' species contents.

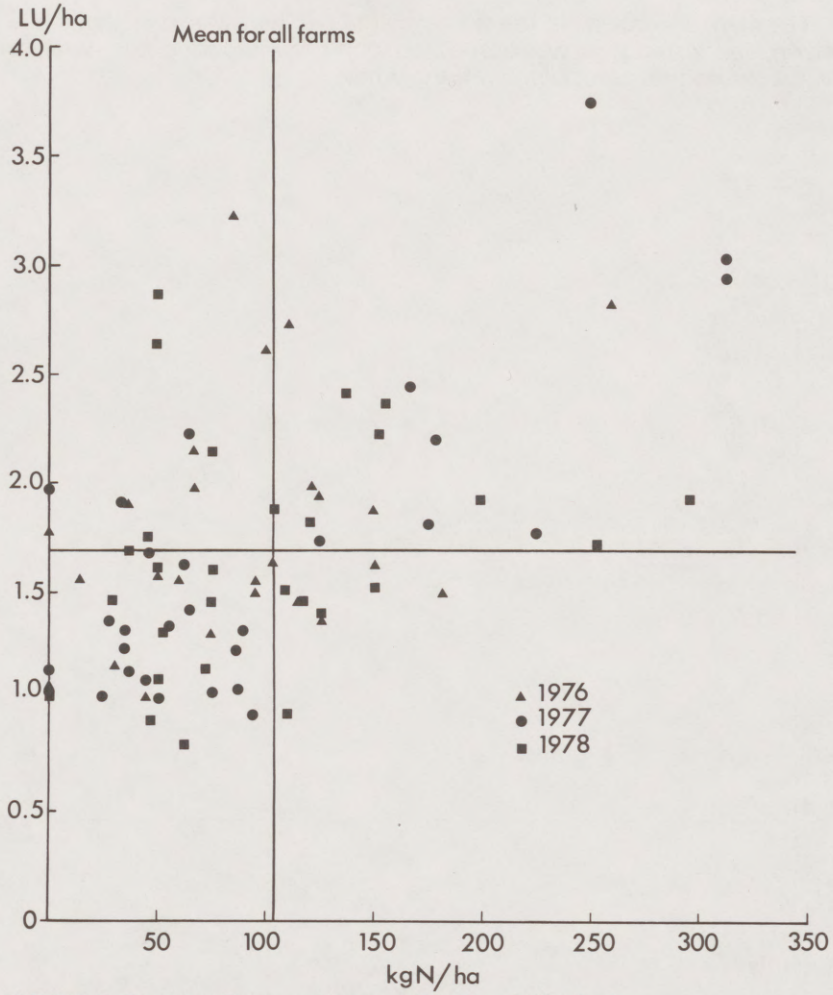


FIGURE 2 Stocking Rates and Input of Fertiliser N for Grazing

TABLE 17: 'Sown' species content and stocking rate

'Sown' species content (%)	41-50	51-60	51-70	71-80	81-90	91-100
No. of farms	3	4	14	23	27	14
Stocking rate (LU/ha)	1.2	1.4	1.6	1.5	1.8	2.1

The triangular outline of the scatter diagram (Figure 3) shows that a low 'sown' species content was associated with a low stocking rate, while a high content was associated with the whole range of stocking rates.

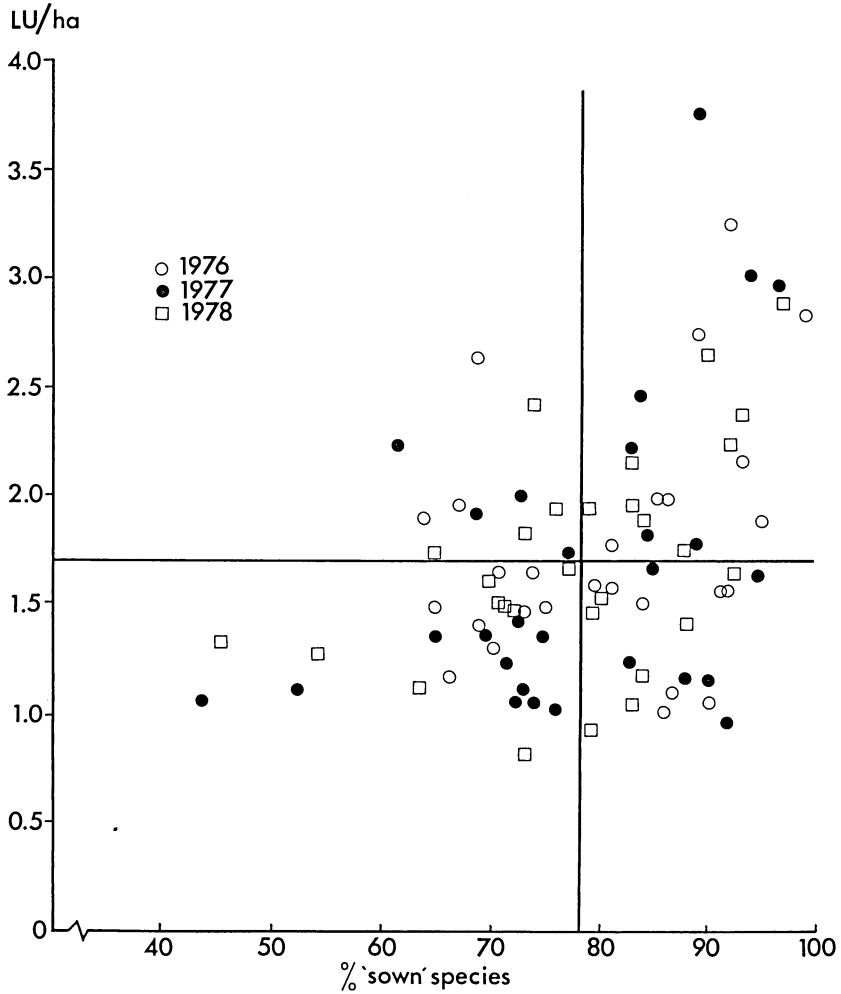


FIGURE 3 Stocking Rates and Content of 'Sown' Species

When uncorrected for fertiliser N use and other factors, stocking rate was positively correlated ($r = 0.39$) with the average 'sown' species content of the farm. The correlation was higher when white clover was excluded from the 'sown' species, a reflection of the reduction in clover by applied nitrogen.

Soil fertility and stocking rate

A soil fertility index for each farm was obtained by rating various combinations of 'low' and 'high' P and K levels. Farms with the lowest index had the lowest stocking rate (Table 18). The correlation between stocking rate and soil fertility index was highly significant ($r = 0.34$), when no allowance was made for the influence of fertiliser N or other factors.

TABLE 18: Soil fertility index and stocking rate

Soil fertility index	0.1-2.0	2.1-4.0	4.1-6.0	6.1-8.0
No. of farms	3	29	39	14
Stocking rate (LU/ha)	1.5	1.5	1.7	2.0

Age of fields and stocking rate

Farms with the youngest swards tended to be the heaviest stocked, whereas a high proportion of permanent grass was generally but not always associated with low stocking rates (Table 19). The correlation between mean age of fields and stocking rate was just significant ($r = 0.25$).

TABLE 19: Age of fields and stocking rate

Age of fields (years)	1-3	4-6	7-9	10-12	13-15	16-19	>20
No. of farms	14	23	17	20	6	3	2
Stocking rate (LU/ha)	2.2	1.5	1.7	1.6	1.4	1.8	1.2

FACTORS AFFECTING 'SOWN' SPECIES CONTENT

Regression on the basic model accounted for 67 per cent of the variation in content of 'sown' species between farms. The significant variables were age of sward ($P < 0.001$), soil fertility index ($P < 0.01$) and farm altitude ($P < 0.01$). 'Sown' species content showed a high negative correlation with age of sward ($r = -0.66$) and a positive correlation with soil fertility index ($r = 0.51$) (Appendix 7). This was to be expected in view of their influence on the botanical quality of the individual fields. A non-significant effect of fertiliser N on 'sown' species content became

significant ($P < 0.05$) when white clover was excluded from 'sown' species. A reduction in clover by fertiliser N was evidently offset by an increase in 'sown' grass, mainly perennial ryegrass.

FACTORS AFFECTING WHITE CLOVER CONTENT

The basic regression model for assessing factors affecting white clover content accounted for only 27 per cent of the variation between farms. The white clover content was significantly related to fertiliser N ($P < 0.01$) and to age of sward ($P < 0.05$). There were no significant relationships with soil fertility, altitude or rainfall. The relationship between white clover content and fertiliser N used for grazing is shown in Table 20.

TABLE 20: Fertiliser nitrogen for grazing and white clover content

Fertiliser N (kg/ha)	0-60	61-120	121-180	181-240	>240
No. of farms	33	28	14	3	6
White clover (%)					
Range	8-24	14	11	9	9
Mean	18	6-20	1-27	2-15	3-13

The 33 farms using less than 60 kg N/ha for grazing had a mean clover content of 18 per cent, compared with 12 per cent on farms applying 60-180 kg N and 9 per cent on the few farms using more than 180 kg N/ha.

DISCUSSION AND CONCLUSIONS

BOTANICAL QUALITY

The generally high botanical quality of the rotational grass indicates good management aided by a favourable environment for grassland—soils mainly of freely drained, medium texture, and a temperate climate with an average annual rainfall of 800 mm. This accords with the findings of the England and Wales survey, where a higher mean content of 'preferred' species was associated with better drained and more manageable land and with drier environments.

There were clear examples of permanent pasture of long standing that had a high percentage of perennial ryegrass, and there would seem to be no reason why most permanent pasture could not be in this state if higher inputs of lime and phosphate were used, along with suitable management. There would also seem to be little physical restriction of topography or drainage to the reseeding of permanent grass deficient in productive species. It is estimated that 20 per cent of the permanent grass which had less than 45 per cent of 'sown' species, including a low content of clover, could with benefit be reseeded, and another 20 per cent would benefit from higher inputs of lime and phosphate.

No obvious reasons for the low content of white clover in the pastures, such as soil fertility or drainage, were apparent. A possible reason could be the degree of undergrazing noted in a third of the grazing fields and this could partly account for the lowest content of clover in the oldest permanent grass. Other possible causes, such as the incidence of clover rot (*Sclerotinia trifoliorum*) and pest attack require investigation before the full potential of white clover can be realised.

FERTILISER USE

It is significant to note that the average levels of phosphate and potash applied to the grazed rotational grass, at 20 kg/ha, is well below the 50 kg/ha recommended for soils of moderate P and K status. Inputs of potash on the cutting fields fell below maintenance requirements on a third of the fields.

A problem common to many of the farms was lateness of spring grass. This appeared to be aggravated by late nitrogen applications, a third top dressing in early April and only 14 per cent in mid-March. Trials carried out on 12 of the farms over 1979 and 1980 indicated that more farmers should top dress in mid-March, and only in early April on the highest farms, or in a very late year. From these trials a guideline has been developed for timing the spring N dressing based on daily accumulated 10 cm soil temperatures above 0°C, from 1 February, to a total of 80°. Nitrogen applied at 'T 80°' has given 20 - 30 per cent more early grass than more normal, later dressings. A number of farmers are now adopting earlier spring fertiliser N applications.

As two thirds of the farmers grazed the conservation fields in the spring, and as few applied split dressings of fertiliser to these fields, valuable grazing and hay production is being lost.

STOCKING RATES

The survey shows that the highest output from grassland, in terms of stocking rate, was obtained where the swards were young and/or high in 'sown' species content, the soil pH, phosphate and potash were satisfactory, higher than average fertiliser N rates were used and where the manager was knowledgeable about grass. The two most important ingredients of high output were N rate and the farmer's knowledge or interest in the grassland.

In a survey it is not possible to separate the effects on stocking rate of the different factors and many of them are correlated. Thus, although stocking rate was correlated with both N rate and 'soil fertility index,' dropping soil fertility index from the basic regression model had no significant effect on the amount of stocking rate variation explained. This is because of a significant correlation between N rate and soil fertility index. There are also likely to be strong correlations between farmer knowledge, N rate used, the quality of the pasture and stocking rates.

With regard to the calculated stocking rates, these must be treated with some reserve as they do not take account of any sales or purchases between the six-monthly returns, nor do they take account of the amount of cereals and concentrates, or other feeds, being fed. From the records available, it appeared that, on average, the highest stocked farms fed more cereals and/or concentrates than the lowest stocked farms. This difference was equivalent to around 0.5 livestock units/ha. With these reservations in mind, the average stocking rate of 1.7 LU/ha/annum, with an average application of 100 kg N/ha for grazing, is a reasonable stocking rate on mainly rotational grass. This compares with a mean stocking rate on suckler beef farms in the England and Wales survey of 1.2 LU/ha at a mean fertiliser N input of 42 kg/ha, on mainly permanent pasture. Clearly some farms in our survey did considerably better than the average — 12 per cent carried more than 2.5 LU/ha, but some of these farms used more than the average N rate. Forty four per cent had less than 1.5 LU/ha; most of these used less than 100 kg N/ha. It is interesting to note that the average fertiliser N usage per livestock unit was 50 kg N on the lowest stocked farms and 65 kg N on the highest stocked farms. These values correspond to approximately 10 - 12 kg N/100 kg liveweight (1 LU = 500 kg).

Low stocking rates on some farms and a generally low N usage, together with a two-fold range in stocking rate found within similar fertiliser N rates, suggest considerable scope for intensifying stocking rates by higher N inputs or by better management of the same stock numbers. This assumes that the improvements can be made to pay in the particular farm situation.

ADVISORY INPUTS REQUIRED

The results of this survey suggest certain areas of advisory input on grassland in the east of Scotland:

1. Reseeding and maintenance of permanent pasture.
2. Phosphate and potash requirements of cut and grazed grassland.
3. Optimal use of fertiliser N in spring for early grass e.g. "T-80°".
4. Management and utilisation of white clover.
5. Encouragement of "clean" grazing.
6. Stocking rates and grassland management systems, e.g. "buffer grazing."

REFERENCES

DEPARTMENT OF AGRICULTURE AND FISHERIES FOR SCOTLAND, (1980)

Agricultural Statistics 1978, Scotland.

FORBES, T. J.; DIBB, C.; GREEN, J. O.; HOPKINS, A. and PEEL, S. (1980)

Factors affecting the productivity of permanent grassland. A National Farm Study. GRI-ADAS Joint Permanent Pasture Group, Hurley, Maidenhead, Berkshire.

GENSTAT (1980)

Lawes Agricultural Trust, Rothamsted Experimental Station.

APPENDIX 1. Coding for herbage cover and weed infestation

Herbage cover

		Code
Less than	2%	0
	2 - 5%	+
	5 - 15%	1
	15 - 25%	2
	25 - 35%	3
	35 - 45%	4
	45 - 55%	5
	55 - 65%	6
	65 - 75%	7
	75 - 85%	8
	85 - 95%	9
	95 - 100%	X

Weed infestation

Weed well distributed and in the case of: thistles, docks, ragwort and rushes more than 1 plant per 4 m sq (16 m^2); buttercups and other low-growing broad-leaved weeds more than 5% of herbage cover.	1
Weed well distributed but less frequent than above.	+
Weed confined to one or two small areas	0

APPENDIX 2. Physical features of the fields

	Rotational grass		Permanent grass
		% of fields	
Altitude (850 fields)			
0-100 m	26		31
101-200 m	47		40
201-300 m	27		28
> 300 m	<1		1
Gradient (630 fields)			
0- 6°	44		37
7-11°	47		45
12-15°	6		14
16° +	3		4
Relief (850 fields)			
Subdued		29	
Gently rolling		41	
Strongly rolling		4	
Upper hill slope		6	
Lower hill slope		12	
Moundy		8	
Aspect (850 fields)			
North		16	
South		21	
East		7	
West		5	
Variable		30	
Level		21	
Subsoil texture (630 fields)			
Loamy sands		10	
Sandy loams/loams		50	
Clay loams		39	
Peat		1	
Soil drainage (630 fields)			
Free		31	
Moderate		3	
Imperfect		48	
Poor		5	
Variable		13	
Soil restrictions to ploughing (630 fields)			
Few stones	6		8
Moderately stony	68		68
Very stony	9		9
Gravel or clay	9		8
Boulders or rock	8		7
Water supply			
Ample piped		40	
Ample natural		42	
Unreliable/limited		10	
None		8	

APPENDIX 3. Class of stock and livestock units

Class of stock	Livestock units (LU)	Duration of period (months)
Suckler cow		
Autumn calving (+ calf)	1.00	12
Spring calving (+ calf)	0.80	12
Stores summered		
6-12 months	0.35	6
12-18 months	0.45	6
18-24 months	0.55	6
Stores wintered		
6-12 months	0.20	6
12-18 months	0.25	6
18-24 months	0.35	6
Lowground ewes (+ lambs)	0.25	12
Hill ewes (+ lambs)	0.15	12
Ewe hoggs	0.12	12
Stores—short keep	0.02	3
long keep	0.03	6
Tups	0.15	12

APPENDIX 4. Individual farm data, 1976 farms

Farm No.	Stocking rate	Fertiliser N for grazing	Age of fields	'Sown' species	White clover	Soil fertility*
	LU/ha	kg/ha	years	%	%	
1	1.4	115	12	73	20	M
2	2.6	100	3	64	11	L
3	1.6	102	9	69	13	M
4	1.5	94	13	74	12	L
6	1.2	30	10	70	24	M
7	1.5	182	3	88	2	L
8	1.9	37	9	68	8	H
9	3.2	85	3	90	12	M
10	2.8	260	2	98	13	H
11	1.5	14	4	95	19	M
12	1.6	151	18	60	9	M
14	1.5	0	6	75	22	L
15	1.0	0	4	79	18	M
16	1.6	50	4	83	15	M
17	1.1	0	3	84	15	M
18	1.9	150	14	93	14	M
19	1.5	95	11	91	6	M
20	1.0	45	6	88	14	H
21	2.1	67	4	92	19	H
22	2.0	122	9	87	15	L
23	1.8	0	5	83	22	M
25	2.7	110	10	91	18	M
26	1.9	125	17	72	7	H
27	1.4	125	15	60	10	M
28	2.0	67	10	84	12	M
29	1.3	74	20	65	9	H
30	1.5	59	5	85	15	M

* Very low (VL), low (L), moderate (M) or high (H)

APPENDIX 5. Individual farm data, 1977 farms

Farm No.	Stocking rate	Fertiliser N for grazing	Age of fields	'Sown' species	White clover	Soil fertility*
	LU/ha	kg/ha	years	%	%	
31	2.4	167	5	86	6	L
32	1.0	86	25	43	10	VL
33	1.4	65	10	78	15	H
34	1.4	27	9	71	24	L
35	1.9	34	11	63	13	L
36	1.9	0	7	77	23	L
37	1.0	0	6	55	17	L
38	1.0	50	10	73	18	L
39	1.7	125	14	78	14	M
40	1.6	62	3	95	19	M
41	1.0	75	11	74	12	M
42	2.2	64	7	61	13	VL
43	0.9	94	2	93	17	L
44	1.1	0	8	90	13	H
45	1.3	55	10	66	15	L
46	3.0	312	8	94	11	H
47	1.3	90	6	79	16	L
48	2.9	312	3	97	14	H
49	1.8	225	3	88	15	L
50	1.3	35	13	66	18	L
51	1.2	35	10	76	11	L
52	2.2	169	12	76	8	M
53	1.8	175	12	86	3	M
54	1.7	45	5	86	24	L
56	1.2	86	4	83	19	L
57	1.1	45	5	72	22	L
58	3.5	250	3	90	3	M
59	1.1	37	5	91	19	L
60	1.0	24	8	75	8	M

* Very low (VL), low (L), moderate (M), or high (H)

APPENDIX 6. Individual farm data, 1978 farms

Farm No.	Stocking rate	Fertiliser N for grazing	Age of fields	'Sown' species	White clover	Soil fertility*
	LU/ha	kg/ha	years	%	%	
61	1.9	295	2	81	5	L
62	1.6	50	2	94	10	M
64	1.3	52	11	45	21	VL
65	1.5	116	9	77	8	M
66	1.3	57	13	49	20	L
67	2.9	50	9	95	24	L
68	2.1	75	10	86	14	M
69	1.7	37	8	75	17	M
70	2.2	152	3	92	8	M
71	2.4	137	9	76	8	M
72	2.6	50	3	90	23	H
73	1.8	120	17	62	6	H
74	1.5	29	11	62	20	L
75	1.4	125	6	90	27	M
76	1.7	252	12	60	10	H
77	0.9	47	7	84	20	L
78	1.7	45	6	89	24	M
79	1.9	199	10	80	10	M
80	1.9	104	8	89	9	M
81	1.1	50	12	62	14	L
82	1.5	150	6	77	17	L
83	1.2	72	13	70	12	M
84	1.0	0	7	86	20	M
85	2.4	155	4	90	13	H
86	1.5	75	10	70	18	L
87	1.5	109	6	81	14	L
88	1.9	109	3	83	19	M
89	0.8	62	7	78	16	M
90	1.6	76	8	65	11	M

* Very low (VL), low (L), moderate (M), or high (H)

APPENDIX 7. Correlation coefficients between stocking rate and other variables

Stocking rate	1.00						
Fertiliser N for grazing	0.55	1.00					
'Sown' species	0.39	0.22	1.00				
'Sown' species excluding white clover	0.46	0.43	0.91	1.00			
White clover	−0.24	−0.53	0.02	−0.39	1.00		
Age of sward	−0.25	−0.06	−0.66	−0.54	−0.17	1.00	
Soil fertility index	0.34	0.32	0.51	0.54	−0.16	−0.15	1.00
Altitude	−0.09	−0.16	−0.17	−0.24	0.20	−0.06	−0.25

Degrees of freedom 81	Level of significance		
	$P < 0.05$	$P < 0.01$	$P < 0.001$
	0.216	0.288	0.355