Sheep - Cost of production

AGRICULTURAL ADJUSTMENT UNIT · UNIVERSITY OF NEWCASTLE UPON TYNE

Hill Sheep Farming Today and Tomorrow

A Workshop Report

13

THE AGRICULTURAL ADJUSTMENT UNIT
THE UNIVERSITY OF NEWCASTLE UPON TYNE

In recent years the forces of change have been reshaping the whole economy and, in the process, the economic framework of our society has been subject to pressures from which the agricultural sector of the economy is not insulated. The rate of technical advance and innovation in agriculture has increased, generating inescapable economic forces. The organisation of production and marketing, as well as the social structure, come inevitably under stress.

In February 1966 the Agricultural Adjustment Unit was established within the Department of Agricultural Economics at the University of Newcastle upon Tyne. This was facilitated by a grant from the W. K. Kellogg Foundation at Battle Creek, Michigan, U.S.A. The purpose of the Unit is to collect and disseminate information concerning the changing role of agriculture in the British and Irish economies, in the belief that a better understanding of the problems and processes of change can lead to a smoother, less painful and more efficient adaptation to new conditions.

Publications

To achieve its major aim of disseminating information the Unit will be publishing a series of pamphlets, bulletins and books covering various aspects of agricultural adjustment. These publications will arise in a number of ways. They may report on special studies carried out by individuals; they may be the result of joint studies; they may be the reproduction of papers prepared in a particular context, but thought to be of more general interest.

The Unit would welcome comments on its publications and suggestions for future work. The Unit would also welcome approaches from other organisations and groups interested in the subject of agricultural adjustment. All such enquiries should be addressed to the Director of the Unit.

Unit Staff

Director:	Professor J. Ashton, M.A., B.Litt, M.S.
Head of Unit:	S. J. Rogers, B.Sc. (*Econ*)
Administrative Officer:	B. H. Davey, B.Sc. (*Agric*), M.Econ.

The Agricultural Adjustment Unit,
Department of Agricultural Economics,
The University,
Newcastle upon Tyne NE1 7RU.
Tel: Newcastle 28511 *Ext.* 794.

HILL SHEEP FARMING TODAY AND TOMORROW

A WORKSHOP REPORT

Bulletin No. 13

AGRICULTURAL ADJUSTMENT UNIT
UNIVERSITY OF NEWCASTLE UPON TYNE

1970

PREFACE

The hills and uplands account for over one-third of the total agricultural land of Great Britain, but hill farming accounts for only about 5 per cent of the total gross output of agriculture. However, the contribution of hill farming to national sheep production is of importance, accounting for two-thirds of all breeding ewes in the United Kingdom.

The limitations imposed by environmental factors and farm structure on hill sheep farming have resulted in low levels of output and income. These, in turn, have militated against rapid technological change. In recognition of these aspects of hill farming, the Agricultural Adjustment Unit convened a Study Workshop to collate information on technical developments and possibilities for hill sheep farming.

It was recognised at the outset of this study that hill farming areas could be subject to substantial changes in policy should the U.K. become a member of the E.E.C. The nature of these policy changes resulting from such a development is not, however, in any way explicit within the existing policy framework of the E.E.C. It was therefore decided to confine the study to the existing policy framework within the U.K. The Workshop included a number of specialists who are specially concerned with the area of study, including experts from the Hill Farming Research Organisation, the Welsh Plant Breeding Station, government services and universities. This report is the joint product of the members of this group. The fact that it is a team effort, however, does not imply that individual members of the workshop have no personal reservations about some of the content. Furthermore, the views expressed in this bulletin do not necessarily reflect the views of the organisations from which members of the workshop are drawn. Membership of the workshop is given below:

Professor P. W. Arnold, B.Sc., M.A., Ph.D. (Department of Soil Science, University of Newcastle upon Tyne).
J. M. M. Cunningham, B.Sc., Ph.D. (Director, Hill Farming Research Organisation, Edinburgh).
J. Eadie, B.Sc. (Hill Farming Research Organisation, Edinburgh).
J. Harkins, B.Sc. (Edinburgh University).
P. D. Hebblethwaite, B.Sc., N.D.A. (Agricultural Adjustment Unit, University of Newcastle upon Tyne).
F. Hunter, B.Sc., F.R.I.C. (Department of Soil Science, University of Newcastle upon Tyne).
J. King, B.Sc., Ph.D. (Hill Farming Research Organisation, Edinburgh).
J. M. M. Munro, B.Sc., M.Agr.Sc., Dip.Agr. (Welsh Plant Breeding Station, Aberystwyth).

S. A. C. Oliver, N.D.D. (National Agricultural Advisory Service, North Region).
M. Roberts, B.Sc. (Director, Pwllpeirian E.H.F., M.A.F.F., Aberystwyth).
S. Robson, B.Sc. (Department of Agricultural Economics, University of Newcastle upon Tyne).
S. J. Rogers, B.Sc. (Econ.) (Agricultural Adjustment Unit, University of Newcastle upon Tyne).
G. D. Salmon, B.Sc. (National Agricultural Advisory Service, Northern Region).
E. D. Sargent, B.Sc. (Agricultural Adjustment Unit, University of Newcastle upon Tyne).

The Agricultural Adjustment Unit would like to express its gratitude to all the participants in the Workshop. They gave freely of their time and expert knowledge and many of them had to travel considerable distances to take part in meetings.

The workshop was an interesting co-operative attempt to achieve an understanding of the present situation and a consensus of opinion on future technical possibilities and opportunities for hill sheep farming. It is hoped that the report which follows will not only stimulate enough interest to encourage further research but will contribute to discussion of future policies for the industry.

J. Ashton.

July 1970.

HILL SHEEP FARMING TODAY AND TOMORROW

CONTENTS

INTRODUCTION

Farming in hill and upland regions is beset with many problems arising from natural, technical, economic and social forces. Hill land is not as naturally productive as the lowlands due to limitations imposed by climate, topography, soil and natural vegetation. Technical advances have been slow compared to other sectors of agriculture, partly due to the intractable nature of the problems faced and partly due to the low returns to additional capital investment resulting from the high price of inputs relative to the low levels of response—not only in terms of physical output but also in value. Compared to the rate of innovation in intensive livestock and cereal production in the lowlands over the past decade, developments in hill farming have been imperceptible.

Incomes and living conditions on hill farms compare unfavourably with those in the lowlands. To a large extent, this is due to the small business size of the average farm. Further constraints on output are imposed on farms with limited areas of improvable, inbye land and also on farms where the hills are subject to common or stinted grazing rights. In such cases, improvements in output are difficult to effect and maintain. Low output is a chronic condition in that it may generate profits which are too low to provide the additional capital which might enable improvements to be achieved.

Traditionally, output of the hills is mainly in the form of store stock sold for finishing or cast-for-age breeding stock sold for further breeding to the lowlands. This output is placed on an unpredictable market, during one short period of the year and it also results in relatively high working capital requirements for the system.

Remoteness from centres of population and career limitations in farming are factors which contribute to a drift of young people from hill farming areas and at the same time discourage new entrants.

Despite these difficulties, it is generally argued that it is desirable for hill farming to remain viable, albeit with Government investment to maintain production, because of its role as a reservoir of store stock. In addition it is a component of the social and physical structure of remote areas and may be a reservoir of productive land. It is argued that failure to maintain viability would result in the development of large tracts of unpopulated and unproductive wilderness and the run down of already accumulated capital, replacement of which would be even more expensive in the future.

This Bulletin begins with an examination of current statistics, policies, systems and economics of hill farming in Great Britain. Technical factors affecting the productivity of hill farming areas are then reviewed. A discussion of the economic implications of intensifying hill sheep farming is followed by a review of the

technological aspects of intensification. Finally, prospects for the future and some consideration of government policies are outlined and discussed.

The place and role of hill cattle have been largely ignored in this Bulletin as it was felt that hill cattle production is generally more suited to the better quality uplands and detailed consideration of this would broaden the scope of the Bulletin beyond limits of space and time. There are, of course, other possibilities for land use in remoter areas, including forestry, deer farming and recreation. Consideration of these alternatives was also outside the scope of this Bulletin but they should not be ignored.

I. HILL FARMING TODAY— STATISTICAL AND POLICY BACKGROUND

Statistical information specifically describing hill sheep farming is difficult to isolate from the body of official statistics. The following data are, at best, estimates and include upland farms on which cattle are raised. Because they are estimates, they must be treated with caution.

Over the years, various estimates of the area to be defined as hill land have been produced. This bulletin will use the estimate contained in the Report of the Land Use Study Group[1] which is that in Great Britain there are about 11 million acres of land on hill sheep farms and another 4½ million acres in upland stock rearing farms, a total of approximately 15½ million acres of hill and upland. This area of hill land is approximately 28 per cent of the total land area and 34 per cent of the agricultural land of Great Britain.

The number of holdings in England and Wales engaged in livestock Rearing and Fattening is shown in Table 1.

Not all livestock holdings are in hill farming areas or can be classed as hill farms. Hill farms are mainly devoted to sheep rearing and fattening, and examination of the category 'Livestock Rearing and Fattening: Mostly sheep' reveals that 73 per cent of all holdings in this category are in the Northern Region and Wales. Thus, the consideration of hill farming statistics for England and Wales will be limited to these areas. Table 2 gives a rough approximation of the structure of hill farming in Great Britain in 1967. There were approximately 11,580 hill and upland farms in Northern England and Wales, of which approximately 7,800 were in Wales and 3,800 in Northern England. Approximately 45 per cent of these were small farms of under 600 standard man days (smds). The holdings in Wales tended to be smaller on average than those in Northern England[2]. Of the 4,800 hill and upland farms in Scotland, approximately 52 per cent were under 600 smds. and most of the land was in rough grazing. They were therefore only moderate sized businesses[2]. These 16,380 hill and upland farms account for approximately 9·2 per cent of holdings over 275 smds. in Great Britain. If it is assumed that most of the above hill and upland holdings are farmed separately by an occupant farmer, there would be approximately 16,380 hill farmers.

Sample data[3] from 'Livestock, Mainly Sheep' and 'Livestock, Cattle and Sheep' farms in England and Wales show that in 1967 approximately 11,291 holdings employed 20,752 full time male workers, an average of 1·8 workers per holding. If it is assumed that all hill and upland farms in England and Wales employ a similar number of workers per holding, then the 11,580 holdings employ approximately 20,840 workers. In 1967 the 4,800 hill and upland farms in Scotland

TABLE 1

NUMBER OF HOLDINGS IN LIVESTOCK REARING AND FATTENING IN ENGLAND AND WALES BY TYPE OF FARMING AND MINISTRY REGIONS, 1967

Type of Farming	*M.A.F.F. REGIONS*								
	Eastern	*South Eastern*	*East Midlands*	*West Midlands*	*South Western*	*Yorks. and Lancs.*	*Northern*	*Wales*	*England and Wales*
Livestock Rearing and Fattening: Mostly Cattle*	194	504	378	369	659	204	285	252	2,845
Livestock Rearing and Fattening: Mostly Sheep†	20	307	102	195	356	329	795	2,716	4,820
Livestock Rearing and Fattening: Cattle and Sheep‡	100	697	1,113	2,174	3,068	772	2,982	5,099	16,011
Total	314	1,508	1,593	2,738	4,083	1,311	4,062	8,067	23,676

Source: 'Farm Classification in England and Wales, 1967'. H.M.S.O. p.6.

* Holdings with more than 50 per cent of total standard man-days in livestock rearing and fattening of which 75 per cent or more are in cattle.

† Holdings with more than 50 per cent of total standard man-days in livestock rearing and fattening of which 75 per cent or more are sheep.

‡ Other Holdings with more than 50 per cent in livestock rearing.

TABLE 2

SIZE DISTRIBUTION BY HOLDINGS AND OUTPUT, AND AVERAGE ACREAGE OF CROPS AND GRASS PER FARM—FARMS IN HILL AREAS OF GREAT BRITAIN, 1967

		BUSINESS SIZE GROUP (smds) 275–599	600–1199	1200 and over	Total
		Number of Holdings			
1. SIZE DISTRIBUTION					
(a) **England and Wales**					
(i) Livestock, Mainly Sheep in Hill Areas*	Nos.	1,500†	1,400†	600†	3,500†
	%	43†	40†	17†	100†
(ii) Livestock, Cattle and Sheep Holdings in Hill Areas	Nos.	4,100	2,981	1,000	8,081
	%	51	37	12	100
(b) **Scotland**					
(i) Hill Sheep Holdings	Nos.	552	447	315	1,314
	%	42	34	24	100
(ii) Upland Holdings	Nos.	1,949	940	592	3,481
	%	56	27	17	100

* Data for farms in the Northern Region and Wales.

† Estimated.

Source: England and Wales; Farm Classification in England and Wales. Scotland: Department of Agriculture and Fisheries for Scotland.

employed approximately 6,470 workers.[1] The estimated total of full time workers employed on hill and upland farms in Great Britain was therefore approximately 27,110 or approximately 9 per cent of the full time agricultural workers.

Table 3 gives a rough estimate of the gross output of hill and upland farms in Great Britain. It has been calculated by multiplying the output per farm for different farming types[4] [5] by the number of farms in each farming type (Table 2). In the case of 'Livestock, Sheep and Cattle' farms the average gross outputs per farm and the number of farms have been calculated using data from Wales and the Northern Region of England only. England and Wales contributed approximately £55 million and Scotland £26 million to give a total of approximately £81 million gross output in 1967. The livestock contribution of £73

[1] Department of Agriculture and Fisheries for Scotland.

TABLE 3

CONTRIBUTION OF THE HILLS AND UPLAND IN GREAT BRITAIN* IN TERMS OF GROSS OUTPUT AND NET FARM INCOME, 1967—£000's

	Crops	*Cattle*	*Sheep and Wool*	*Pigs Eggs Poultry and Other Revenue*	*Milk and Milk Products and Other Livestock†*	*Production Grants*	*Total*
England and Wales							
Hill Farms‡							
Gross Output	240	4,068	6,661	395	1,740	169	13,273
% of Total G.O.	2	31	50	3	13	1	100
Upland Farms§							
Gross Output	3,931	21,656	12,708	2,263	982	338	41,878
% of Total G.O.	9	52	30	6	2	1	100
Total G.O. England and Wales	4,171	25,724	19,369	2,658	2,722	507	55,151
Scotland							
Hill Sheep Farms							
Gross Output	72	1,096	4,577	77	34	213	6,069
% of Total G.O.	1	18	75	2	1	3	100
Upland Farms							
Gross Output	1,302	8,688	7,836	511	127	1,275	19,766
% of Total G.O.	7	44	40	2	1	6	100
Total G.O. Scotland	1,374	9,784	12,413	588	161	1,488	25,808
Total G.O. G.B.	5,545	35,508	31,782	3,246	2,883	1,995	80,959
% of Grand Total G.O. G.B.	7	44	39	4	4	2	100
Total Net Farm Income G.B.							20,377

Source: England and Wales, calculated from data in Farm Incomes in England and Wales, 1967, and Farm classifications in England and Wales, 1967. Scotland, calculated from data in Scottish Agricultural Economics, 1968, and data supplied by the Department of Agriculture for Scotland.

* It is stressed that the information in this table is, at best, a rough estimate.
† Mostly milk and milk products in England and Wales.
‡ Livestock, Mainly Sheep Farms.
§ Livestock, Sheep and Cattle Farms, Wales and the Northern Region.

TABLE 4

GROSS OUTPUT PER FARM. ALL FARMS IN EACH SIZE GROUP BY FARM TYPE IN ENGLAND, WALES AND SCOTLAND, OF HILL AND UPLAND FARMS, 1967

	275–599		*600–1,199*		*1,200 and over*		*All Sizes*		
	Gross Output per farm £	*Gross Output All farms* £000's	*Gross Output per farm* £	*Gross Output All farms* £000's	*Gross Output per farm* £	*Gross Output All farms* £000's	*Gross Output per farm* £	*Gross Output All farms* £000's	£000's
England and Wales									
Livestock, Mainly Sheep	2,225	3,338	4,421	6,189	10,071	6,043	4,232	14,812	
Livestock, Sheep and Cattle	3,227‡	13,231*	7,492‡	22,334*	14,105‡	14,105*	5,564	44,961	
Scotland									
Hill Sheep Farms	2,396	1,323	4,138	1,850	8,906	2,805	4,620	6,071	
Upland Farms	2,499	4,871	5,716	5,373	9,788	5,794	5,146	17,913	
Total Great Britain		22,763		35,746		28,747		83,757	87,256†
Gross Output as a % of Total Output of Hill and Upland Farms in Great Britain		26		41		33			100

* Calculated by multiplying the number of farms in the Northern and Wales regions in each category by the Gross Output per farm of the Livestock, Sheep and Cattle farms, in England and Wales.
† Because of the above; percentages are calculated on a 87,256 figure, which equals the sum of the totals of each size group in Great Britain.
‡ Livestock, Cattle and Sheep farms. All England and Wales.

million accounted for over 90 per cent of the gross output, 39 per cent of which was derived from sheep and wool and 44 per cent from cattle. The importance of sheep and cattle varied between types of farms. Sheep were more important on hill farms, and cattle and other enterprises became more important on the upland farms.

Table 4 shows the estimated gross output per farm,[4] [5] and for all hill and upland farms in Great Britain, calculated on the same basis as for Table 3, by size group. In Great Britain 41 per cent of this gross output was produced by the 5,768 medium sized[2] hill and upland farms, while the 8,101 farms in the small groups[2] and 2,507 farms in the large groups[2] produced 26 per cent and 33 per cent respectively.

TABLE 5

COMPARISONS OF VALUE OF HILL AND UPLAND PRODUCTION WITH THAT OF GREAT BRITAIN, 1967

Item	*Value of Output from Hills and Uplands* £m	*Value of Total G.B. Output* £m*	*Hills and Uplands Output as a % of Total G.B. Output*
Crops	6	368	2
Cattle	36	242	15
Sheep and Wool	32	100	32
Pigs, Eggs and Poultry, Milk and Milk products and Other Cattle	5	822	1
Total Livestock	73	1,166	6
All agriculture	81	1,760	5

* Source: Annual Abstract of Statistics.

In Table 5 the value of hill and upland production is compared with total agricultural output for Great Britain in 1967. The estimated £81 million gross output produced by hill and upland farming constituted about 5 per cent of the total gross output of agriculture in Great Britain.

It is evident from Table 5 that in respect of sheep and wool production, the contribution of hill and upland farming is of considerable importance, nationally.

[2] Small—275 to 599 smds, medium—600 to 1,199 smds, large—1,200 and over smds.

It should also be emphasised that the £32 million gross output in the case of sheep and wool and the £36 million gross output in the case of cattle includes a high proportion of stock sold at store prices. The value added to such store stock when fattened after transfer to the lowlands has not been included in the calculations.

Table 6 shows Net Farm Income by size and type of farm in Great Britain.

TABLE 6

NET FARM INCOME PER FARM, BY SIZE AND TYPE OF FARM
ENGLAND, WALES AND SCOTLAND, 1967

Smd. Groups	*275–599*	*600–1,199*	*1,200 and over*	*All sizes*
	Net Farm Income	*Net Farm Income*	*Net Farm Income*	*Net Farm Income*
England and Wales	£	£	£	£
Livestock, Mainly sheep*	558	945	2,633	1,262
Livestock, sheep and cattle*	1,047	2,093	3,749	1,592
Specialist Dairy farms	1,018	1,881	4,148	1,306
Cropping Mostly Cereal Farms	1,283	2,809	5,592	3,276
General Cropping farms	1,227	2,697	5,637	3,413
Mixed Farms	1,586	1,825	5,303	2,487
Pigs and Poultry Farms	1,048	2,228	4,947	2,648
Scotland				
Hill Sheep Farms	674	870	789	776
Upland Farms	701	971	806	821
Dairy Farms	686	1,187	2,771	1,750
Cropping Farms	882	844	2,893	1,818
Rearing with Arable Farms	559	861	932	729

Source: Farm Incomes in England and Wales 1967 and Scottish Economics No. XVII—1968.

* For 275–599, 600–1,199 and 1,200 and over smd. groups, all farms in England and Wales. All size groups, Northern Region of England and Wales, weighted.

Considering all sizes, incomes from hill and upland farms, with the exception of 'Rearing with Arable' farms in Scotland, are lower than other types of farms. Nevertheless, where net farm incomes are examined by type and size groups there are differences between size groups and regions. However, in general, one can conclude that hill farming is less remunerative than other types of farming, this being a reflection of the small average size of business (Table 2) and the poor quality of land.

TABLE 7

COST OF DIRECT GOVERNMENT SUPPORT TO HILL AND UPLAND FARMS
1955–56 TO 1968–69 (ESTIMATE) £m

	1955–56	*56–57*	*57–58*	*58–59*	*59–60*	*60–61*	*61–62*	*62–63*	*63–64*	*64–65*	*65–66*	*66–67*	*67–68*	*68–69*
Livestock Rearing Land	1·5	1·6	1·4	1·5	1·5	1·5	1·5	1·5	1·4	1·4	1·3	1·0	0·9	0·6
Hill Land														0·6
Winter keep										2·5	3·4	3·7	4·5	4·6
Marginal production assistance	1·6	2·1	2·4	2·2	1·7	1·0	0·8	0·7	0·7					
Hill cattle and hill cows	2·6	2·7	2·9	3·1	4·1	4·6	5·0	5·4	5·6	5·7	6·7	7·5	8·7	10·3
Hill sheep	1·1	1·1	—	—	—	0·7	0·8	1·4	2·4	6·0	4·4	8·0	5·9	7·2
Total	6·8	7·5	6·7	6·8	7·3	7·8	8·1	9·0	10·1	15·6	15·8	20·2	20·0	23·3

Source: Annual Review and Determination of Guarantees 1968, 1970.

Government Support Measures

The methods of government support to hill farming have changed over the years, but in general the amounts have increased considerably. The major Acts covering support to hill farms are the Hill Farming Act, 1946, The Livestock Rearing Act of 1951 and the Hill Land Improvement Scheme embodied in the Agriculture Act of 1967. These Acts cover a number of complex support measures. The total expenditure on agricultural support to the hills and uplands is difficult to calculate accurately as hill farmers receive proportions of many types of grants which are available to other farmers.

Table 7 illustrates the increase in direct support costs to hill and upland farms since 1955–56. Over the fourteen-year period from 1955–56 to 1968–69, direct support costs have risen by 242 per cent, as shown in Table 7. Table 8 shows the hill and upland direct support costs as a percentage of total government support to agriculture over the past fourteen years.

TABLE 8

HILL AND UPLAND DIRECT GOVERNMENT SUPPORT COSTS AS A PERCENTAGE OF TOTAL ESTIMATED EXCHEQUER SUPPORT TO AGRICULTURE 1956–57 TO 1968–69 £m.

	Total Estimated Government Support to Agriculture	*Total Direct Support to Hill and Upland farms*	*Total Direct Support to Hill and Upland farms as a % of total estimated Govt. support to Agric.*
1955–56	205·9	6·8	3·3
1956–57	239·2	7·5	3·1
1957–58	284·1	6·7	2·4
1958–59	241·4	6·8	2·8
1959–60	256·9	7·3	2·8
1960–61	262·9	7·8	3·0
1961–62	342·6	8·1	2·4
1962–63	309·6	9·0	2·9
1963–64	294·5	10·1	3·4
1964–65	265·1	15·6	5·9
1965–66	237·6	15·8	6·6
1966–67	229·1	20·2	8·8
1967–68	261·5	20·0	7·6
1968–69	265·4	23·3	8·8

Source: Columns A & B. Annual Review and Determination of Guarantees 1968, 1970. H.M.S.O. London.

TABLE 9

NUMBER OF SHEEP RECEIVING THE HILL SHEEP SUBSIDY IN GREAT BRITAIN, 1960–68

Year	*Rate**		*Number of sheep receiving both rates (million)*	*Cost to the Exchequer (£m.)*
	Full	*Reduced*		
1961	3/6	1/9	4·8	0·8
1962	6/–	3/–	4·8	2·3
1963	10/–	5/–	4·8	5·8
1964	25/–	12/6	4·9	4·3
1965	18/–	9/–	5·0	4·6
1966	19/–	9/6	5·1	5·2
1967	21/–	10/6	6·8	7·1
1968	21/–	10/6	7·0	6·6

Source: (a) Rates and cost: Annual Review and Determination of Guarantees.
(b) Number: Agriculture's Import Saving Role, E.D.C. for Agriculture 1968.
(c) 1961, 1967 and 1968. Correspondence with M.A.F.F. 1968 estimated.

* Excluding winter keep.

TABLE 10

NUMBER OF CATTLE RECEIVING THE HILL COW SUBSIDY IN GREAT BRITAIN, 1960–68

Year	*Rate/Cow** *£ s.d.*	*Number of cattle receiving the Grant (000's)*	*Cost to the Exchequer (£m.)*
1961	12.0.0	363	n.a.
1962	12.0.0	340	n.a.
1963	12.0.0	407	n.a.
1964	12.0.0*	420	5·0
1965	13.0.0*	452	5·9
1966	13.0.0*	506	6·6
1967	14.5.0*	537	7·7
1968	16·5.0*	558	9·1

Source: (a) Rate: Annual Review and Determination of Guarantees.
(b) Number and cost: Correspondence with the M.A.F.F. 1968 estimated.

* Excluding winter keep.

This seems to have remained fairly steady between 1955–56 and 1963–64. From 1964–65 onwards the proportion of total Exchequer support going to the hills has shown a significant increase. Tables 9 and 10 show the rate of hill sheep and cow subsidies, the number of sheep and cattle receiving the subsidy and the cost of Exchequer support for these subsidies over the past eight years. All show a significant increase. In 1968, the number of ewes on which the hill sheep subsidy was paid accounted for 63 per cent of all breeding ewes in the United Kingdom—a reflection of the importance of hill farming as a reservoir of stock.

TABLE 11

GOVERNMENT SUPPORT TO HILL AND UPLAND FARMS IN GREAT BRITAIN, 1967–68

Recorded support	*Hill Farms** £m.	*Upland Farms†* £m.	*Total* £m.
Hill Cow Subsidy‡	3·2	5·5	8·7
Hill Sheep Subsidy‡	4·4	1·5	5·9
Winter Keep‡	1·7	2·8	4·5
Livestock Rearing Land‡	0·4	0·5	0·9
Total	9·7	10·3	20·0
Share of Other Support			
Beef Cow§	N.S.	0·3	0·3
Calves§	0·6	3·6	4·2
Fertiliser and lime§	0·2	1·4	1·6
Implementation of price guarantees**	3·1	9·8	12·9
Administration**	0·1	0·4	0·5
Farm Improvements**	0·1	0·4	0·5
Others§	0·1	0·4	0·5
Total	4·2	16·3	20·5
TOTAL	13·9	26·6	40·5

Source: (a) Annual Review and Determination of Guarantees, H.M.S.O., Cmnd. 3965 1969.
(b) Private Correspondence with the M.A.F.F. (FMS), 1969.
(c) Scottish Agricultural Economics, Vol. XIX, Table 177, 1969.

* England, Livestock Rearing—Mainly Sheep Farms: Scotland, Hill Sheep Farms.

† England, Livestock Rearing—Cattle and Sheep Farms: Scotland, Upland Farms.

‡ Total expenditure recorded in the Annual Review, allocated proportionately to each farming type. Proportions calculated by using F.M.S. and Scottish Survey average farm receipts of each support by farm type.

§ F.M.S. and Scottish Survey, farming type average data per farm multiplied by the number of farms of each type in Wales, the North of England and Scotland.

**Calculating the contributions of each farming type enterprise to the Gross output of Great Britain. Support for each enterprise is then assumed to be the same percentage as the contribution to Gross Output.

In addition to direct support, hill and upland farms have received a proportion of other support available to all farmers. Estimates for recorded and unrecorded support to hill and upland farms in 1967–68 are shown in Table 11. In brief, about half of the support is direct and half indirect, but as can be seen, indirect support tends to be channelled more towards upland farms rather than hill farms.

Policies for Hill Farming

The Agriculture Act, 1967

The 1967 Act embodies the Hill Land Improvement Scheme and Rural Development Boards. Both these schemes affect the policies and future of hill farming. The former scheme widens the scope of the 1946 and 1951 Acts and allows for greater support to hill and upland farming. The aim of the new policies is to ensure that 'more is done to make the best use of the agricultural resources in the hill and upland areas'.[6] Problems in many areas appear to be concerned with the size of hill farms. Many farms are held to be too small to afford a satisfactory living to the occupiers. The need for coherent planning of the use of land in these areas is important. Rural Development Boards are to look into these problems.

The Government considers that the subsidies which have been available to hill farmers in varying forms since 1940 are fully justified. The 1967 Act authorises the hill sheep and cow subsidies on a long-term basis. It also maintains the winter keep subsidy. These subsidies will be reviewed from time to time in order to permit the best use of livestock and hill sheep land.

The Hill Land Improvement Scheme will provide for grants of 50 per cent of the cost on a number of land improvements of importance to hill and upland farming. Those already eligible under the Farm Improvement Scheme will therefore have a preferential rate; other items such as fence restoration will be included. A supplementary grant of 10 per cent is also available for drainage.

The Government plan in the first instance is to select one or two areas and appoint for each a Rural Development Board. The function of the Boards is to draw up a programme of rural development for their area covering agriculture, forestry and other land uses such as recreation and tourism. It is expected that the Boards will work in co-operation with all those concerned in the area.

The Boards will have to have certain powers in order to fulfil their functions.

(*a*) They will need to be consulted before any private amalgamation schemes in the area are approved; or before any voluntary state purchases of land in the area is made to secure amalgamation.

(*b*) The Forestry Commission will have to consult the Boards on their planting proposals in the areas. In addition, the Board's consent will be required to private afforestation projects.

(*c*) The Boards will also have powers to purchase land on a voluntary basis and also to intervene where land comes on to the market.

(*d*) Should the Boards produce a detailed programme of agricultural and forestry reorganisation within the area, where owners and occupiers of almost all the land are in agreement with the Scheme, Boards have reserve powers of purchase designed to prevent frustration of the whole scheme by a small minority. Such powers will only be used as a last resort. Individuals will be given normal rights of appeal against the pre-emptive and reserve powers of the Boards.

(*e*) The Boards will also be able to give limited financial assistance in order to promote certain aspects of their development programme.

The Rural Development Boards will work in close liaison with the Regional Economic Planning Councils and Boards, local authorities and other public bodies. They will consist of independent persons including some with local knowledge and experience, appointed by the Minister.

The Payment to Outgoers Scheme[1] includes hill and upland farmers. Under section 27 of the Act, Grants are payable to farmers of 'uncommercial units' (defined as those requiring between 100 and 600 standard man days), who will release their land so that it can be used for an approved amalgamation. Grants can be paid in two forms, either lump sum grants or annuities for life, depending on the age of the occupier. In the former case, conditions are attached to the use to which these grants are put while, in the latter case, the farmer is barred from full-time farming. In both cases the farmer may retain the farmhouse and undertake part-time farming as long as the business size of the unit does not amount to more than 100 smds.

The Farm Amalgamation and Boundary Adjustment Scheme[1] also applies to hill and upland farms. The Scheme allows for grants of up to 50 per cent of all costs incurred as a result of amalgamation of land, apart from the cost of the land itself. Similar grants are payable on the costs of boundary adjustments. The Act also empowers the Minister to purchase land which is brought on to the market, where there is no private amalgamation scheme, in order to amalgamate it later with other holdings.

Hill Farming and the N.E.D.C. Report

The average value of sales of fat lambs and sheep during the three years up to 1967–68 was £86m. a year and wool £16m. The total of £102m. represented 8 per cent of the value of sales of livestock products and 5 per cent of total farm

[1] For further details of these schemes, see Agricultural Adjustment Unit Bulletin No. 6, Farm Size Adjustment Appendix III.

sales. Obviously, hill and upland farms have played a major role in contributing to this production. Table 5 shows that the hills and uplands produce just over 30 per cent of the output from sheep and wool and this includes a high proportion of stock sold at store prices. The value added to store stock when fattened was not included in the calculations.

The N.E.D.C. report estimates that the home industry produced 43 per cent of our mutton and lamb and 12 per cent of our wool in the above period. As the home industry provides less than half of our total mutton and lamb the report states that demand is not a limiting factor for expansion. Nevertheless the report states that the trend in demand is downward. The decrease was estimated to be 7 per cent by 1970. Sheep numbers have also decreased in the period 1966 to 1969. There has been a decrease in the number of sheep in some lowland areas and a slight increase in the number in upland and hill areas. The hill sheep subsidy was increased in the 1967 review with the aim of increasing production.

The N.E.D.C. report emphasises the importance of sheep production in the hills and uplands. Impediments to expansion are held to include rigidity of farm size and structure, and the problems arising from the two million acres of common land.

The increase of cattle in hill areas are claimed to have helped to improve the quality of grazing for sheep and in doing so have helped to increase sheep numbers in these areas.

The store sheep market is still uncertain and the N.E.D.C. report points out that many areas in the uplands are capable of improvement to the point where fat lambs rather than stores could be sold.

The report points out the importance of greater subdivision in order to effect better control of grazing—a key factor to improving carrying capacity, lambing percentages and lamb quality. The report estimates that five million acres of land in the U.K. are capable of improvement by various methods—given the incentive and necessary capital injection.

The annual costs for an improvement of one and a half million acres by 1972–73 are estimated to be approximately £1m. The N.E.D.C. report estimates that expansion of sheep production by the required amount would save imports of £1·3m. per annum. As a result the proposals for expansion were for 300,000 lambs in the hill and upland areas. The raising of the hill sheep subsidy and the new provision of the Hill Land Improvement Scheme will provide some incentive for this expansion.

Cattle and their products account for over half the value of farm sales of livestock products and livestock, and nearly two-fifths of total farm sales. Fat cattle made a contribution of £285m. to farm sales and dairy cattle £424m. in the three years up to 1967–68.

Table 5 shows that the hills and uplands produce approximately 11 per cent of output from cattle and, once again, this figure takes no account of the value added component mentioned earlier.

The N.E.D.C. report states that government policy under the selective expansion programme should be to increase beef production to the full extent of technical possibilities by 1970. The hill cow and hill cattle subsidies would therefore not be decreased during the period of selective expansion. Both expansion of the dairy herd and the beef cow herd was necessary to fulfil this expansion.

The report states that imports contributed 25 per cent of the U.K. supplies. It was estimated that domestic demand for beef and veal would increase by about 50,000 tons above the 1966 level by 1972. This increase was modest—equivalent to about 200,000 head of fat cattle a year. Nevertheless, the group felt there was ample scope for import replacement. World supplies might be tight in relation to demand by early 1970.

Beef cow numbers had increased since 1962 as shown in Table 12.

TABLE 12

BEEF COW NUMBERS U.K. MILLIONS

1962	*1963*	*1964*	*1965*	*1966*	*1967*
0·98	1·01	0·98	1·02	1·11	1·14

Source: M.A.F.F. Statistics.

The group decided because of the adequate increase in beef cow numbers over the last few years of about 55,000 cows per year, that an expansion of no more than 60,000 cows per year over the five years was necessary. This rate of expansion would raise the beef herd to 1·44m. by 1972. Half the additional cows would be in hill areas. The additional beef from the expanded suckler herd would be 64,500 tons.

The incentives provided by the Hill Land Improvement Scheme and the increased hill cow subsidy could be adjusted to encourage the expansion required for beef production in hill areas.

The provision of grants for fencing under the above scheme will increase the incentive for fencing and allow for greater controlled grazing of hill and uplands and therefore a greater stocking rate. The group felt that in this connection the rules limiting payment of hill cow subsidy to cows stocked at a rate of more than 5 acres to the cow are a psychological impediment to improvement and should be reviewed.

The Agriculture Act 1967 and its provisions relating to hill and upland farming and the N.E.D.C. report suggest and provide greater incentives in the form of increased grants for expansion in these areas. Along with these incentives, the 1967 Act also provides schemes for improving the structure of these areas with a view to the long-term viability of hill and upland farms.

II. ECONOMIC ASPECTS OF HILL SHEEP FARMING

Present Commercial Systems of Farming

Systems of hill sheep farming are not clearly defined and commercial classification can perhaps be most conveniently based on the nature of the sale product—whether lambs are sold store or fat, pure or crossbred, and whether or not cattle are kept. This in turn depends on the quantity and quality of available land, the structure of the farm and the available capital. There are, however, economic features that are common to all systems, which result from the peculiar physical characteristics of hill farming areas. These common economic features probably influence the commercial results of hill farms more than variations of systems.

All hill farming systems are based on sheep, supplemented to varying degrees by cattle. Agriculturally there are no other commercial opportunities. Breeds must be hardy enough to withstand adverse climatic conditions. They must be capable of producing and rearing healthy offspring, when maintained on herbage of relatively low nutritive value which is at times in short supply.

Under existing methods of management, hill land is stocked so that it will carry the ewes and cows and their offspring during the summer, and the breeding animals in the winter. In practice, therefore, the number of breeding units that the farm can carry is limited to what can be maintained through the winter months. In these circumstances sheep stocking rates and lamb crops are low relative to those achieved under lowland conditions. Stocking rates range from 1 to 10 acres per ewe, and lambing rates from 50 per cent to 100 per cent. Thus a feature of present hill farming systems is low output relative to other systems of farming. This low output is the major economic problem of hill farming. It generates low profits that are inadequate to provide the capital that is necessary if higher output and profits are to be achieved.

The greatest part of the produce of hill farms is sold during August, September and October at the store lamb, draft ewe and calf sales and the state of trade at this time of the year has a major influence on hill farming profits. Most livestock are sold as stores, the market for which is traditionally unpredictable, being principally influenced by economic conditions in lowland areas. Factors such as the state of the market for fatstock, the availability of keep on lowland farms, and the economic opportunities presented by competing enterprises in lowland areas, all have a bearing on the demand for store cattle and sheep at this time of the year. At the same time pressure is exerted on the hill farmer to sell his stock, by the need to free the breeding stock from competition for limited supplies of winter keep, and the often pressing necessity to satisfy his capital requirements.

Although hill farms possess these common features, different commercial systems can be identified. They are different mainly in the degree to which they

enable the inherent problems of hill farming to be mitigated. Differences of system follow differences in the quality of land, and in farm structure.

Hills vary widely in soil condition and composition of herbage, which determines their stock carrying capacity, both in winter and summer. Up to the present only few attempts have been made to change the basic condition of hill grazings. The hill is accepted for what it is and the system of farming adjusted to fit in with it. Factors responsible for this attitude are possibly the paucity of research on this subject, and the absence of adequate capital to finance new methods of using hill land.

Farm structure varies between areas in the relationship that exists between the acreage of hill and inbye land. The quantity of inbye has a bearing on the ability to provide adequate winter keep, and hence the extent to which the potential summer stock carrying capacity of the hill can be realised. It influences the level of nutrition of the ewes, and therefore the size of the lamb crops, mortality rates, and the number of ewe lambs that need to be retained for replacement purposes. It also determines the extent to which lambs can be sold fat or store.

Another way in which structure can influence the system of farming is whether the hill is 'open' subject to common or stinted grazing rights, or 'enclosed' in sole occupation. Unlike the open hill, the enclosed hill permits land improvement and easier and more effective shepherding. This can result in increased stocking rates, better ewe performance and higher labour productivity.

A third factor influencing system is the availability of suitable buildings. When stock can be housed in winter, the stocking rate is less limited by the winter stock carrying capacity of the land. There are better opportunities for carrying cattle. Time of calving can be varied according to economic and market requirements; the opportunity to fatten store stock is increased, and some degree of insulation from the uncertainty of the store market can be achieved.

In practice three broad commercial hill farming systems can be identified. The first is found principally in the North of England on those farms where more of the hill land consists of 'open' common grazing. The second is where the hill land is enclosed in sole occupation, as in the Scottish Highlands, and is supplemented by a limited acreage of inbye land. The third is where the hill land is enclosed, as in parts of Wales, and is supplemented by a substantial acreage of inbye. There is no recognised optimum relationship between the acreage of hill and inbye but in practice a ratio of 15: 1 would normally be regarded as adequate and anything wider than 20 : 1 as limited.

When there are common grazing rights, improvement of the land is difficult to achieve. There are a few examples of bracken eradication and drainage being carried out on stinted commons when commoners have acted together and paid

for the work through an agreed levy. In practice, however, such agreement has rarely been obtained, and generally under these circumstances, fencing has not been carried out and close management at tupping and lambing is difficult.

In these circumstances ewe mortality rates are relatively high, often being more than 10 per cent a year. Lambing rates calculated as a percentage of lambs weaned to ewes put to the tup are sometimes as low as 50 per cent. High mortality and low lambing rates result in little opportunity for culling and selective breeding, and fewer lambs and draft ewes for sale. Further, in the more mountainous areas, lambs may grow so slowly that shearling ewes are not big enough to go to the tup, and a proportion of wether lambs need to be carried over to the following year to be sold as wether shearlings. Normally all sales are of store stock, and cattle are not an important feature on these farms.

Gross outputs per 100 ewes, excluding the hill sheep and winter keep subsidies can be extremely variable, and are normally within the range of £300–£350. The current rate of hill sheep subsidy is 21s. per ewe to which is added a winter keep supplement of 3s. 6d. per ewe.

Labour requirements are normally higher for this system than for others. A shepherd would typically tend about 400 ewes and he may require further help for tupping, lambing, clipping and gathering when necessary.

When the hill land is enclosed, and is supplemented by a limited acreage of inbye, the restrictions already described are less stringent. There are opportunities for land improvement. Fencing is possible which permits closer management control than on the open hill. Ewe mortality is normally nearer 5 per cent than 10 per cent, and lambing percentages range from 85 per cent to 100 per cent. The limited available inbye is required for the provision of winter keep and often for accommodating the hill flock at various stages in the production cycle. There is little opportunity for fattening, and normally all lambs and draft ewes are sold as stores.

Many of these farms carry small suckler herds of hardy cows maintained mainly on the hill throughout the year. They produce first cross calves, many of which are late born and not well grown by the time of the autumn sales. As facilities for overwintering are generally lacking, calves are frequently sold at very low prices.

Gross outputs per 100 ewes, excluding hill sheep and winter subsidies, being largely dependent on the store market, are variable and are often in the range of £400–£480. Gross output for suckler cows, excluding hill cow and winter keep subsidies will often be within the range of £32–£37. The hill cow and winter keep subsidies are currently £23 15s. 0d. per cow.

Labour requirements are normally less than on the hill, a shepherd would normally tend up to 500 ewes, with additional seasonal help.

The third commercial category, where an enclosed hill is supplemented by a substantial acreage of inbye, suffers less commercial restrictions than the other two systems. The larger acreage of inbye relative to hill increases the wintering capacity of these farms and enables the summer stock carrying potential of the hill to be more nearly realised. Stocking rates of 1 ewe to 2 acres of hill are not uncommon, and a rate of 1 ewe per acre is sometimes achieved. Better levels of nutrition result in higher lambing rates, which can exceed 100 per cent. Lambs thrive better and command better prices when presented for sale.

There is the further opportunity on these farms to fatten all or a proportion of the lamb crop from grass or forage crops grown on the inbye land. The uncertainty of the store market is avoided and a measure of stability introduced into farming returns.

A feature of these farms is the practice of crossing a proportion of the pure hill breed flock with larger framed tups, such as the Teeswater, Wensleydale and Border and Blue Faced Leicester to produce half bred lambs bigger than their dams, which are able to make more economic use of the better quality land that is available. Depending on the acreage of inbye land, 25 per cent to 50 per cent of the hill ewes might be crossed in this way, giving lambing rates varying from 110 per cent to 130 per cent. Gross outputs per 100 ewes excluding hill sheep and winter keep subsidies, on farms in this category range from £450 – £620. Hill sheep and winter keep subsidies applicable to this system, are currently 14s. 0d. per ewe.

Suckler herds feature more prominently on this type of hill farm. They are mainly composed of cross bred cows mated to a beef type bull, producing calves suitable for fattening on lowland farms. Calving can normally be early, often before the turn of the year. Calves are normally well grown by the time of the autumn sales, and command prices £2 and £3 per cwt higher than what is paid for the smaller calves produced when the land resources are more limited. Gross outputs per cow, excluding hill cow and winter keep subsidies will often be within the range £45 – £55.

Thus a feature of these farms is higher output relative to the other two systems. This output is dependent to a lesser extent on an unpredictable store market and so is relatively more stable. Such capital investment that has occurred on hill farms in recent years has taken place mainly within this group. It has been mainly in the form of land improvement, the provision of sheep handling facilities, and buildings for housing cattle, and in a few cases for sheep. Cattle housing has increased the cattle carrying capacity of farms in winter. Calving can take place earlier, enabling calves to be sold at heavier weights. Calves that are not ready for sale can be over-wintered and sold subsequently in a more marketable condition. Where housing is available for sheep, the opportunity exists for fattening lambs indoors at times when fattening outside is not feasible. Sheep housing presents the further opportunity of wintering breeding ewes indoors, and so bringing the

winter stock carrying capacity of the farm more closely in line with what it will support in the summer.

The range of hill farming conditions, however, is so variable that investment in buildings cannot be universally justified on economic grounds. Justification depends on the extent to which, in individual cases, the cost of the investment is likely to be exceeded by increases in output consequent upon higher production of cattle and sheep, better prices or more stable returns.

This section has outlined the features that are common to all systems of farming in hill farming areas. These are the limited range of commercial opportunities, the restrictive effect of winter stock carrying capacity, low output per acre and per breeding unit and the uncertainty of the market, culminating in low profitability, that is incapable of generating the capital that is necessary if higher profits and outputs are to be achieved.

Differences between commercial systems follow the nature of the sale products, and these in turn are determined by the different quality of the hill land and the various forms of farm structure that exist.

Labour on Hill Sheep Farms

Hill sheep farming by its nature, is carried on in the remoter areas of the country. Geographically and climatically these areas present particular problems of staffing. These problems exist whether the farm is a family farm, or one which relies on hired labour. They are probably well recognised, but it has been considered of merit to include some discussion of them here.

The isolated nature of many hill farms can give rise to social and economic problems which are very real, and which affect the continued recruitment of labour. Household supplies cost more, due to high transport costs. Frequently there is no delivery service, apart from mail, and regular visits to local stores have to be made. Without transport facilities, either private or provided by an employer, many hill shepherds would find isolation difficult.

Where children of school age are in the family, there is usually a daily transport service provided by the local authority. Hill shepherds' cottages are seldom situated on a main road, however. This can result in children having to walk some considerable distance, when going to school in the morning, and when returning in the evening. The further they have to travel, naturally, the earlier they require to leave in the morning, and the later they arrive home in the evening. In some cases very young children require to wait at school in the afternoon until older children finish, and a 10-hour absence from home is not uncommon in some cases. Daily transport facilities cannot be laid on in certain areas, in which cases the local authority requires the children to be boarded out at public expense for the duration of their education. The latter provides a deterrent to the hired employee in such areas.

When children leave school, there is frequently no local employment available. They must either leave home, or the parents move to an area where there is a source of employment available.

The lack of organised social activities is frequently quoted as another reason why young people in remoter areas leave home. Most young people would prefer to live and work in some sort of community where social contact and employment are readily available.

At one time the standard of housing provided for the hill shepherd was poor. Much has been done to improve this. Government grants have been available to improve existing houses, and to provide new ones. Farmers have found it necessary to provide good housing in order to get shepherds. Such are the problems today, however, that even good quality houses lie empty in many areas because there are not shepherds to fill them, or there are not families who are prepared to live and work in too remote an area.

The provision of a house in a village or township has been advocated as a means of overcoming some of the social problems and is now practised by a number of farmers in Scotland. There is a disadvantage in bad weather when the shepherd may be cut off from his sheep at a time when his presence could be vital.

With the available labour on hill farms much reduced in recent years it is common practice to hire temporary help at lambing and at clipping times, although casual labour of this type is expensive and not plentiful. The recruitment and training of young men as shepherds has been recognised as a serious problem for some years and it is encouraging to note that special courses for shepherds are now being promoted in some areas.

A normal handling for a hill shepherd is considered to be of the order of 500 ewes plus ewe hoggs for replacement stock. As wages continue to rise, the cost per ewe for labour is increasing rapidly. Not so many years ago 20s. 0d.–25s. 0d. per ewe was considered to be an average cost. Today the figure is probably nearer to 40s. 0d.–45s. 0d. per ewe.

The solution in some cases has been to attempt to carry more ewes, or to improve lambing percentages. In other cases fewer shepherds are employed, resulting in less close shepherding, but more ewes per shepherd.

Factors Affecting the Profitability of Hill Sheep Farming

Hill sheep farming is carried out under a very wide range of soil and climatic conditions. These affect the densities with which hill pastures are stocked and the level of output achieved per ewe carried. They also affect the levels of fixed and variable costs incurred, and lead to a wide range in the values of output and costs when examined on a farm basis.

Published data on hill sheep farms normally include some production from cattle and crops and because of variation in the amount of land suited to cropping, it is difficult to assess production and costs for hill sheep only.

For this reason the following discussion is limited to a consideration of some of the relationships which affect production from a hill ewe flock.

Output: The production from a hill sheep flock consists of lambs, draft and cast ewes, wool, and income from hill sheep subsidy. Stock numbers are maintained by the retention of a sufficient number of ewe lambs each year. The following assumed levels give the orders of magnitude of High, Average and Low performance.

	High	*Average*	*Low*
Av. lamb sale price	£5	£4	£3·5
Lambing per cent	120%	85%	65%
No. of lamb crops	5	4	5*
Mortality of ewes and hoggs per cent	2%	5%	10%
Av. ewe sale price (draft plus cast ewes)	£4	£3	£2·5
Total wool clip (expressed per ewe put to tup)†	£1·2	£1	£0·75
Hill Ewe Subsidy	£1·15	£1·15	£1·15

* Where lambing percentages are low, there are likely to be insufficient replacement ewe hoggs of the desired quality for breeding. Ewes are therefore retained for longer than would otherwise be the case.

† All wool, including that from tups and hoggs.

Output per ewe is normally expressed after deducting purchases of livestock. In a self-contained ewe flock the normal livestock purchases are limited to rams, and in these calculations it is more convenient to treat ram purchases as a variable cost per ewe.

In practice it would be exceptional for a flock to achieve any one of these three levels of performance exactly, and it is unwise to think of them in these terms. Nevertheless, it is of interest to look at the potential income per ewe for each of these levels of performance. These are respectively £7·8, £5·1 and £3·6 per ewe for the High, Average and Low performance levels. They do not reflect the possible extremes of performance, but are rather levels of income under these specific physical and financial situations.

Variable Costs: The variable costs incurred consist of such items as the costs of wintering ewe hoggs; tup replacement; haulage; feedingstuffs purchased; seeds; fertiliser; vet. and medicine; dips; casual wages. These will normally fall within a range of £0·4 – £1·5 per ewe.

Fixed Costs: The following range of fixed costs per ewe would appear to cover the published data from economic reports.

	Range/ewe		
	£		£
Labour	1·00	—	2·5
Rent, rates	0·25	—	0·7
Power	0·2	—	0·6
Repairs	0·05	—	0·2
Miscellaneous	0·2	—	0·4
Total Fixed Costs	1·7	—	4·4

Profit per Ewe: With the above ranges in output, variable and fixed costs, it is obvious that profit per ewe can vary considerably, and that of course losses can be all too easily incurred. It does not follow that the High level of output will be allied to high levels of cost, nor that Low output will incur low costs. A profit of £1 per ewe is considered to be average; £0·6 per ewe poor; £1·5 per ewe good. Such profits can be achieved through a wide permutation of output and costs.

III. FACTORS AFFECTING THE PRODUCTIVITY OF HILL FARMING AREAS

Discussion of the physical limitations to increased productivity in hill farming areas inevitably centres on the inter-related climatic and soil factors of the environment.

While the lowlands of Britain tend to be associated with outcrops of Mesozoic or younger rocks, the uplands are of Palaeozoic or older age. These rocks are generally of the harder sedimentary or crystalline igneous and metamorphic types, resistant to weathering and producing soils which are shallow and stony, low in nutrient elements and, on steeper slopes, subject to a high rate of erosion. On lower, moderate slopes, eroded material accumulates to produce limited areas of deeper, favourable soils, especially where the parent rock is not markedly siliceous. On more level and undulating ground, drainage conditions vary markedly over small distances, from free to very poor, giving complex soil distribution patterns.

Generally, climatic factors have the overriding influence in the hill environment, dominating soil processes and affecting the plants directly. The general effect of increasing altitude is to increase rainfall, cloud cover and wind speed and to decrease solar radiation and temperature. The most marked deterioration of climate with altitude is experienced in the high rainfall areas near the west coast. Further east, the drier conditions give improved summer growth despite a shorter season. In addition to the poorer overall climatic conditions at higher altitude there is the added complication of considerable variation in weather in different years and the susceptibility of present systems of animal husbandry to losses under severe conditions. There is, however, no evidence of significant winter mortality in indigenous pastures though yields may be severely reduced by adverse conditions.

In recent years, some interest has centered on the partition of climatic and soil effects on the growth of plants under hill conditions [7],[8],[9]. An average decrease in yield of 2 per cent has been recorded for each 100 ft. increase in altitude in the approximate range 750 ft. to 1,750 ft. in the East of Scotland. The rate of decrease may well become greater above this level, though data are lacking. In the west of the country the same trends can be expected, but compressed into a smaller altitudinal range. Great variation can occur within the growing season, however, according to the relative seasonal importance of temperature, soil moisture supply and wind exposure. In spring the rate of growth and hence early season yield may decrease with altitude at a rate of about 5 per cent per 100 ft. as compared with an average of 2 per cent over the whole season. In summer, however, it is possible for yields at lower altitudes (less than 1,000 ft.) in freely drained eastern districts to be depressed by water shortage. The highest yields may then occur at 1,500 ft. or at intermediate altitudes if other factors such as low temperatures become limiting at the highest altitudes [10],[11].

The exact importance of wind exposure for pasture yields has not been clearly established although it is likely to be of real significance in coastal areas and at the higher altitudes where the average wind velocity may exceed 12 m.p.h. Under these conditions, growth falls considerably below that calculated from potential evapotranspiration formulae[12]. The importance of solar radiation in respect of aspect, altitude and cloud cover and its influence upon pasture yield is similarly insufficiently understood.

An important reason for low productivity in upland areas is low soil fertility and, as a general rule, natural fertility declines with increasing altitude. High rainfall, low evaporation rates and low temperatures give rise to soil moisture surpluses which lead either to excessive leaching, and hence improverishment, or to severe waterlogging where topography and permeability allow it. Not only are most hill soil types extremely acid but the rate of decomposition of organic matter is retarded and, inevitably, there is often acute deficiency of available nitrogen and other cycling nutrients. Both acidity and waterlogging retard humification and where there is under-utilisation of herbage the rate of decomposition of organic matter is further retarded. Only where soil parent material is base-rich does extreme acidity cease to be a problem. The majority of areas of less acid soil stand out in marked contrast to the general background, and the vegetation they carry is superior to both in terms of yields and feeding value.

Soils and Drainage

The principal types of upland soils and their main characteristics are well-known and have been concisely described by Crompton[13]. In the present context it is reasonable to consider them in five groups:

(1) Skeletal soils: these occur on steep slopes or on very hard rocks, usually at the higher altitudes. Because of their shallowness and the broken nature of their cover they contribute little and can be discounted.

(2) Blanket and Hill Peat: depths of peat vary from about 1 ft. to 20 ft. or more and its general characteristics are well-known. Invariably, upland peats are extremely acid, with surface pH values of less than 4·0 and their available nutrient status, particularly N and P, is low. They are also prone to copper and cobalt deficiency.

(3) Podzols: under free drainage conditions, especially on the lighter textured soils, where leaching is intense, the tendency is towards podzolisation and soil impoverishment. Under the acid conditions litter accummulates as a surface layer of raw humus whilst the upper mineral horizons of the soil become structureless. Podzols are extremely low in both major and minor nutrient elements.

(4) Gleys, Peaty Gleys and Peaty Gley Podzols: where drainage is impeded, the grey colours and rusty mottlings characteristic of poor aeration predominate giving 'gleyed' profiles. Shallow peaty layers often form at the surface. Soil acidity is less and the nutrient status is higher in gleys and peaty gleys than in peaty gley podzols though N deficiency may be severe. It should be emphasised that because gleys cover so large an area of accessible ground on the lower slopes and their nutrient status can be so much higher than that of freely drained soils, they constitute an important natural resource in the hill grazing complex.

(5) Brown Earths and Calcimorphic Soils: these are the most valuable soils in upland areas and more akin to good lowland soils than are the other kinds. Even so, the majority of upland Brown Earths are very acid by lowland standards.

Very little is known about the distribution of upland soil types. There is a need both for reconnaissance soil surveys to locate those portions of the uplands which contain appreciable areas of better quality soils, and for subsequent detailed surveys within these areas to facilitate the efficient application of improved farming practices. If the scientific information collected during the soil surveys is to be readily applied to farming the soil maps will need to be interpreted in the form of land classification categories which are of significance for upland farming. Existing land classification schemes are mainly orientated towards the appraisal of land in terms of lowland intensive agriculture. The integrated application of existing geological, ecological and pedological knowledge to the interpretation of air photographs should enable large areas of hill land to be surveyed adequately and rapidly on a reconnaissance basis. The more detailed surveying of selected areas would again be greatly aided and accelerated by the use of low level air photographs including, possibly, colour photographs taken at two different seasons in the year. There are, however, certain areas with complex soil distribution patterns where it would be neither possible nor necessary to delineate individual soil types during the course of detailed soil mapping. In such circumstances it would be sufficient for practical purposes to indicate the type of soil complex or association which is present.

In general terms poorer peaty soils and deep peats predominate where the annual rainfall exceeds 60 in. In Scotland there are approximately 1·5 million acres of hill peat and in England and Wales 0·8 million acres. The 1936 Grassland Survey of England and Wales revealed that approximately 2·5 million acres was occupied by *Nardus*, *Molinia*, heather, cotton grass and deer grass. While large areas of freely drained soils capable of high productivity remain undeveloped in eastern areas, in the west of Britain further intensification must be based on organic and gleyed soils unsuited to cultivation.

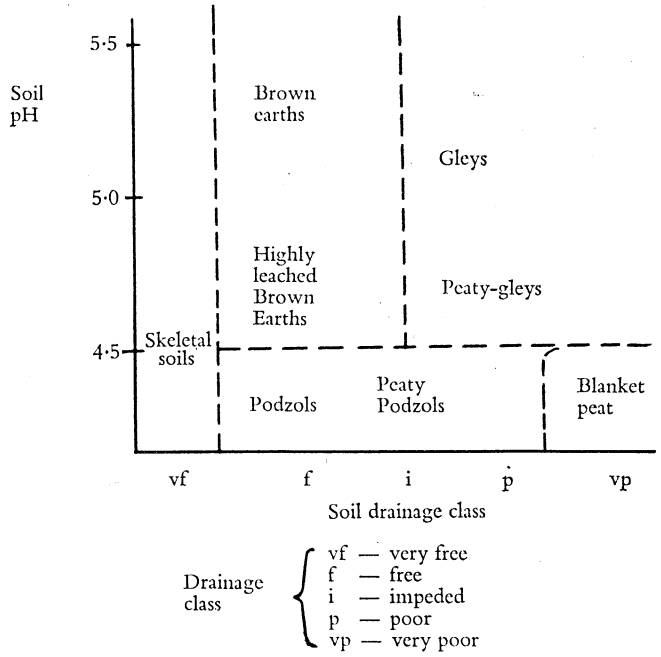
Whether the wetter areas of hill land should be extensively drained is a question difficult to resolve. Undrained hill land acts as a sponge, retaining water after rain and liberating it gradually into mountain streams whence it finds its way to the lowlands. Open ditching has proved to be so effective in removing surface water that resultant differences in the water levels in main streams have been readily discernible to the naked eye. Thus, extended drainage of the hills could have serious repercussions by significantly changing the pattern of river flow to such an extent that the lowlands may become subject to serious flash flooding. Furthermore, drains set too steeply down a slope can cause soil erosion during periods of heavy rain. Consideration of the role of hill areas in water conservation is outside the scope of this Bulletin, but water conservation is likely to become of increasing national importance and policies may have to be drawn up regarding drainage requirements in hill areas.

Vegetation

The factors which appear to have the greatest influence in the species composition of the present vegetation of hill areas are soil drainage conditions and pH and it is convenient to treat these as indices of the soil environment. Similarly, grazing pressure (associated with burning where appropriate) can be used as a biotic index. On this basis, most of the site-types important on hill grazings can be described in terms of four indices: climate, soil pH, soil drainage and biotic pressure, and these can be related to the vegetation and its productivity. Because there is little evidence to support the view that local variations in climate have any major direct effects on the composition of pasture vegetation, at least below 1,750 ft., as distinct from indirect effects through soil type, climate need not be considered in this context. The relation of the composition of the vegetation to the other three indices is summarised in Figures 1, 2 and 3.

Figure 1 shows the general relationship between soil-type, pH and drainage. In Figure 2 the vegetation is related to the same soil factors under conditions of high grazing pressure, while Figure 3 shows the additional species which are associated with or replace those in Figure 2 under low grazing pressure. Under most existing hill conditions grazing pressure varies from site to site and the vegetation is therefore represented by a combination of Figures 2 and 3. The evidence for many of these biotic relationships is to a great extent circumstantial, based upon interpretation of field observations (cf. King and Nicholson[14] and McVean and Ratcliffe[15]). Occasionally, however, changes in vegetation associated with changes in biotic pressure have been observed as they took place, although only a small plot scale[16],[17],[18].

Fig. 1. SOIL PROFILE TYPES IN RELATION TO SOIL pH AND DRAINAGE.



In general, grazing pressures tend to increase with increasing base status so that, in most parts of the country on the less acid soils, heather has been replaced by grassland. On the more acid soils the pressure may be high enough to eliminate heather but not to prevent the relatively unpalatable grasses *Nardus* and *Molinia* from becoming dominant in its place. These species are characteristic of much undergrazed pasture in the South of Scotland, the North of England and Wales. In theory, if the biotic pressures were increased still further, these *Nardus* and *Molinia* dominant grass-heaths should be convertible to a form of *Festuca/Deschampsia* grass-heath as indicated in Fig. 2. However this has seldom been observed to occur except in small enclosures, although from the pastoral point of view such a change must be regarded as a desirable and beneficial one. The effects of burning and grazing on blanket bog and related vegetation appear to parallel the effects on shrub-heaths and grasslands though not with such desirable results. Heather tends to be eliminated from the bog vegetation, *Eriophorum* and *Trichophorum* spp. becoming dominant. This may not be an overall improvement despite the belief that *Eriphorum vaginatum* is of value to sheep in early spring. There is also a reduction in the *Sphagnum* component and in addition all these changes may also be associated with retrogressive alterations in the peat itself[19],[20].

Fig. 2. HILL VEGETATION TYPES UNDER GRAZING/BURNING PRESSURES IN RELATION TO SOIL pH AND DRAINAGE.

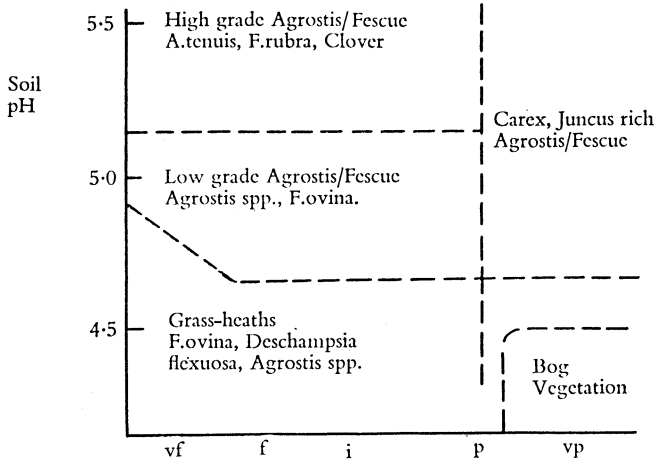
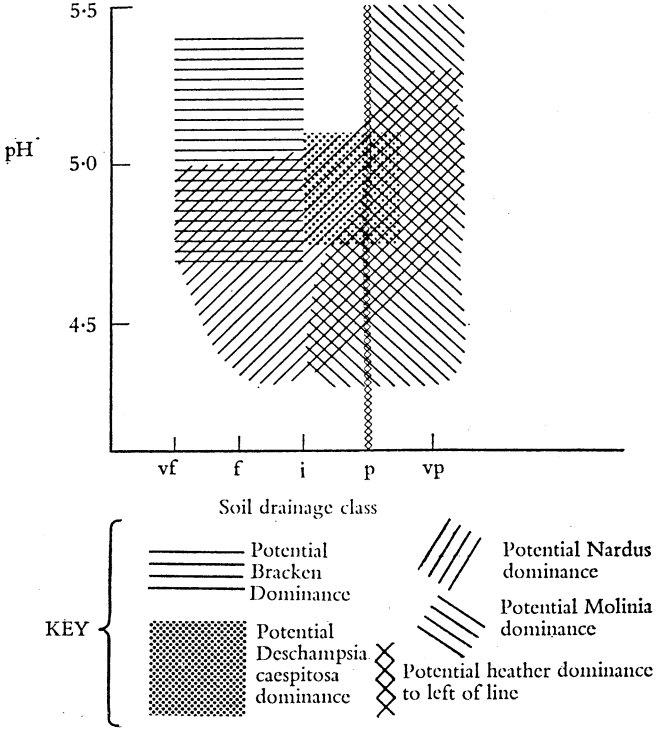


Fig. 3. POTENTIAL DISTRIBUTION OF ADDITIONAL SPECIES TO THOSE IN Fig. 2. OCCURRING AT LOW GRAZING/ BURNING PRESSURES.



From a pastoral point of view, by far the most important group of vegetation types are the *Agrostis-Festuca* grasslands on which depend to a very large extent the productivity of existing hill grazings. These grasslands are found on soils above about pH 4·7 ranging from freely to poorly drained and appear to be reasonably stable under high grazing pressures. Below about pH 5·0 clover does not survive and *Agrostis-Festuca* and *Festuca ovina* predominate giving rise to a lower grade of pasture (Fig. 2). Below about pH 4·7 the vegetation increasingly assumes the character of a *Festuca-Deschampsia* grass-heath, usually in the *Nardus* or *Molinia* dominant form (Fig. 3). On poorly drained soils if grazing pressure is low, the *Agrostis/Festuca* pastures also may be dominated by these species.

The yield of natural *Agrostis-Festuca* and grass-heath pastures can be expected to decline with decreasing soil pH and other associated factors. This is due in part to the decline in the frequency of the occurrence of white clover, together with the more productive species (*F. rubra, A. tenuis*) and the complementary increase in abundance of species such as *F. ovina* and *D. flexuosa*, observed on moving to more acid soils. The less active nitrogen cycle on the latter is of particular significance since, in low input systems higher yields are primarly dependent on increasing the quantity of N cycled through the animal and returned to the pasture as dung and urine. Floate[21] has shown that on an *Agrostis/Festuca* sward, full pasture utilisation by the animal with full return of excreta can increase by a factor of ten times the quantity of N available for plant growth compared with the quantity available by decomposition of uneaten herbage. On *Nardus* grass-heath the increase was even larger. However, the effect of such an increase in N turnover on pasture composition does not seem to have been much studied. Milton[16] and Milton and Davies[17] found that by using controlled grazing, together with an application of lime, thereby increasing N turnover, they were able to convert a low grade *Agrostis/Festuca* pasture to a relatively high grade *Agrostis/Festuca/Poa* sward with an accompanying increase in yield. The change was inhibited if the pH was too low. For still greater production it is not sufficient to rely only on an increased turnover of N through the animal. A large input of N into the system is also necessary and this is undoubtedly best supplied by white clover. Indigenous white clover, already present, if only in small amounts, on most hill soils of pH 5·0–5·2 and above, is of prostrate habit and in association with grass is relatively unproductive compared with cultivated wild white types such as S.184.

S.184 wild white clover has been found capable of fixing up to 140 lb. N per acre under hill conditions[22] compared with 200 lb. in the lowlands and levels of 70–80 lb. N per acre have been reported from a hill environment by other workers[23]. Where possible it would probably be sensible to try to introduce S.184 clover rather than rely on the indigenous type. Neither type will thrive if the pH is too low (5·3–5·5) or if phosphate and potassium levels are very low.

So far when discussing pasture production reference has been made only to relative yields. Absolute yield values are difficult to interpret and to compare because they are greatly affected by the method of harvesting. As may be seen from Figs. 1–3 *Agrostis/Festuca* pastures occur over a wide range of soil types and for this reason alone a wide range of yields is to be expected and, in addition, so many other variables can affect productivity that only the broadest comparisons can be made. A yield of 3,300 lb. dry matter (D.M.) per acre from a grazed *Agrostis/Festuca* pasture has been obtained by measuring directly the amount consumed by the animals and adding to this the amount uneaten[24]. This is possibly the only value in existence which can be accepted as a close approximation to the productivity of such a sward under continuous grazing. The pasture was in a paddock subject to complete return of urine and faecal N and it is almost certain that under extensive uncontrolled grazing the yield would have been lower. Using monthly cutting, average total yields of 2,100 lb. D.M. per acre have been reported from unfertilised *Agrostis/Festuca* pastures in Wales[16]. On the other hand, more than double this yield has been obtained elsewhere[25].

Relatively high yields, for example, 3,600 lb. D.M. per acre, have been recorded from *Molinia* pastures[26],[27] but these measurements refer to standing crops cut in late summer and bear little relationship to harvestable yields under pasture conditions. Monthly cutting is a very rough approximation to grazing conditions and a number of workers have made measurements on this basis. For example, Milton[16] records an average season's yield over 4 years of 1,000 lb. D.M. per acre for a *Molinia* grass-heath and a value of 2,000 lb. D.M. per acre for *Agrostis/Festuca*. *Nardus/Festuca/Deschampsia* grass-heath has been recorded (monthly cuts) as yielding nearly 2,000 lb. D.M. per acre[18]. The annual production of edible material by heather appears to be in the range 1,000–2,500 lb. D.M. per acre[28], depending on the age and growth-form of the stand, which compares well with grass-heath production on similar soil types.

Most hill pastures will give increased yields when fertilised. The *Nardus* grass-heath mentioned above gave increases of up to 100 per cent when 100 lb. per acre N was applied. Under grazing conditions with Ca NPK fertilisers and with full return of dung and urine, Milton[16] recorded average *Agrostis/Festuca* yields of 3,200 lb. and 3,500 lb. D.M. per acre which are comparable with 2,000 lb. obtained without fertilisers. Hunter[29] quotes data from 11 Northumbrian sites which ranged in altitude from 525 ft. to 1,640 ft. where the following yields were obtained:

Indigenous pasture, no fertiliser	2,400 lb. D.M. per acre
Indigenous pasture+Ca NPK	4,300 lb. D.M. per acre

Higher yields than these are possible on good soils with high fertiliser rates and reseeded grass/clover swards. For fertilised reseeded swards at the same 11 Northumbrian sites a mean yield of 6,800 lb. D.M. per acre was obtained over a three year period. Over 2 years, yields of 7,000 to 8,400 lb. D.M. per acre were recorded from a *F. rubra*/S.184 white clover sward growing in micro-plots at between 1,000 and 1,750 ft. altitude[30].

At Aberystwyth[31] using a wide range of levels of N application, reseeded grassland proved much more responsive than *Festuca/Agrostis* and *Molinia* communities. At the highest level of nitrogen the yield of ryegrass/white clover was nearly 10,000 lb. D.M. per acre on the mineral soil and 7,000 lb. D.M. per acre on peat, while the yield of fescue was 2,500 lb. and *Molinia* 1,000 lb. *Molinia* proved to be particularly unresponsive to N, showing no measurable response to very high nitrogen applications. These yields are equivalent to approximately two-thirds of those obtained under lowland conditions and there is clearly no serious limitation to high production on hill environments, provided the input of nutrients is sufficiently high to offset the effects of poor drainage or adverse climatic conditions.

As in the lowlands, it must always be remembered that ameliorative treatment of most unpromising soil with lime and fertilisers, and drainage where necessary, can usually lead to the gradual formation of productive soils. However, under the generally adverse hill conditions, even with a high standard of management, the main impediment to high production is the cost of nutrients required to offset the effects of high rainfall, inherent low soil fertility and the factors associated with altitude.

Animal Production

In the hill environment the most important single factor influencing animal output is nutrition. Nutrition is more critical at certain periods than at others, during the first year of life and thereafter, prior to mating, in the late stages of pregnancy and during lactation.

Since most hill sheep flocks are self-replenishing the treatment of the ewe hogg over its first winter assumes some importance. There are two factors which should influence the strategy of management of ewe hoggs in relation to nutritional levels:

(1) During their first winter a high plane of nutrition becomes of less importance provided growth up to weaning is improved. The better the growth up to this stage the less vital it is that 'wintering' should be of high quality and thus the cheaper the wintering may be under certain circumstances.

It should be noted nevertheless that growth in ewe lambs can be so retarded at 6 months of age that improved levels of winter nutrition are unlikely to overcome this stunting. This may be partly due to the lowered growth potential which hill breeds seem to exhibit during the winter months.

(2) There is no point in inducing early growth beyond a point which cannot be sustained by the adult nutritional environment. If hoggs are grown too well during the first winter in relation to the hill conditions in which they will be run, there will be an increase in lamb production in the gimmer year but it will decline in subsequent years. Moreover, the evidence suggests that well grown animals are more prone to a higher mortality in later years.

Thus it is only where improvements are made in the general level of adult nutrition that there is a justification for changes in hogg wintering nutrition levels.

As a general target, liveweight gains of ewe hoggs will be adequate if they are around 0–8 lb. over the winter months. The appropriate target should be based on the degree of maturity reached by weaning age taking into account the mature size of the breed, or strain, under consideration.

The choice between the various wintering techniques such as on the hill, on arable crops, in sheds or away on lowground farms, is, apart from the first, dependent on the costs involved to achieve a similar target, and the overall stocking rate of the farm.

Experience and investigations have shown that reproductive potential in the hill breeds is relatively high and that it is rarely exploited under most hill conditions.

Preliminary experiments on Hill Farming Research Organisation farms with Cheviot and Blackface ewes given liberal supplementary feeding prior to and during mating, increased the lambing percentage from approximately 100 per cent to around 150 per cent[32]. Subsequent experiments have demonstrated that fertility is markedly influenced by condition at mating. Level of food intake during mating will have very little effect on ewes which are in very good condition whereas in thin ewes it will have a pronounced effect.

Thus it is not the potential fertility of hill breeds which is limiting but the level of nutrition on the hill before and at tupping time.

On most hills, ewes begin to lose weight by late October or early November and thereafter there is a rapid decline in weight, frequently before, and in most instances during tupping.

It would seem important to avoid weight loss at this time and that weight should be maintained as cheaply as possible. To this end, exploitation of pastoral

resources would seem to be the best technique and this is discussed in the section to follow.

It is generally appreciated that the hill ewe is invariably undernourished in late pregnancy. The extent to which this occurs will vary from year to year depending on the amount of early herbage growth which occurs before lambing time. It will also vary according to the types of herbage present on different farms.

This energy deficit is met by the ewe drawing on body reserves so that her condition in early winter is of importance. The developing foetus tends to have priority so that the extent to which the ewe must draw on reserves is also dependent on foetal weight and so will be greater with twins.

Recent research by Russel and his collaborators at H.F.R.O.[33] has accurately defined the nutrient requirements of some types of hill ewes during late pregnancy. A 110 lb. ewe with an average sized foetus would require 800–900 g. Digestible Organic Matter (D.O.M.) to prevent undernourishment. A similar twin bearing ewe would require an additional 350 g. D.O.M. (an increase of 40 per cent approx.). Even on a good grassy hill, Eadie has shown that intake of herbage in late pregnancy is sub-maintenance and is around 350–500 g. per day D.O.M. although this may rise to 700–800 g. during the last month before lambing.

It should be realised that even under the best hill grazing conditions lamb birth weight is reduced below its potential but this is only of importance when it falls to a level below which lamb mortality increases, udder development is reduced and the onset of lactation is delayed. Nutrition is clearly more critical as the number of twin bearing ewes increases. Therefore, in flocks where the aim is a high lambing percentage, supplementary feeding is essential.

Lamb growth rates, in the early weeks of life, and certainly up to 6–7 weeks, are primarily a reflection of the milk production of the ewe. This in turn is entirely dependent on the nutrition of the ewe during lactation. By lambing time the ewe has used up much of her body reserves so that, if nutrition is inadequate during lactation, she responds by reducing milk production in line with her low level of nutrition.

Research by Peart[34] has shown that, when hill ewes are adequately fed, sufficient milk can be produced to sustain growth rates of 0·7 lb. per day with Scottish Blackface lambs in the first 6 weeks of life. If sufficient improved grazing or supplemenary feeding of good quality is available these gains can be sustained up to 12 weeks.

Peart has also subjected ewes to a degree of undernourishment during late pregnancy greater than that likely to be encountered in practice and compared their subsequent lactation with ewes extremely well fed during pregnancy. In the latter group twins weighed 9·0 lb. and single lambs 10·1 lb. at birth while in those

from the undernourished group, twins weighed 5·9 and singles weighed 7·7 lb. at birth. Although the previously poorly fed ewes produced less milk in the first 10 days of lactation, they reached the same peak of milk production at 2–3 weeks. Their lambs grew more slowly but the differences obtained were substantially due to differences in solid food intake. It was concluded that severe undernourishment in late pregnancy was not in itself incompatible with reasonable milk yields.

The evidence suggests that production per ewe is limited by nutrition in autumn, early winter, late winter and in early summer. It follows therefore that improvement in total production will come from better nutrition over the whole year but it is more important at some stages than at others.

Pasture Production and Utilisation in Relation to Animal Production

The year-long, free range, set-stocked pastoral systems characteristic of hill farming operating in association with a highly seasonal pasture growth cycle inevitably result in a cyclical pattern of nutrition. The energy intake cycle is a reflection of the cycle of ingested pasture quality.

Cyclical patterns of nutrition are not, of course, unusual. They occur in other environments in which sheep production takes place, both in the U.K. and in other parts of the world. But the important characteristic of the cycle in hill sheep farming is the generally low level at which it operates, giving rise to a low range of body condition[35].

Maximum values occur in May–June, but these are low relative to lowland standards. Energy intakes decline from these maximum values throughout the summer when the decline accelerates towards the end of the pasture growing season, to give sub-maintenance energy intakes from early November through to some time in March. An improvement in diet quality takes place in late pregnancy, but the degree of improvement is very variable from year to year.

A consideration of the available evidence on the components of animal performance under hill conditions in relation to the nutrition cycle, together with the evidence on relations between nutrition and performance presented in the previous section, shows that at each and every stage in the annual cycle of events nutrition is a limiting factor to production.

Current growth rates of single lambs are well below those of which hill lambs are capable. Early lamb growth can be improved by improvements in the nutrition of grazing ewes during lactation. Lamb growth rates decline from marking onwards, and this is a function of the decline in ingested pasture quality. This again is a nutritional problem and current work is aimed at elucidating the relative roles of milk and pasture in maintaining growth rates.

Current levels of reproductive performance in hill sheep are a function of nutrition and body condition at conception. Body condition in hill sheep is generally quite poor at mating by any standards other than those of hill sheep farming, because body condition recuperation is limited as a consequence of the decline in ingested pasture quality which takes place when lactation has declined to a low level. Mating takes place not only at a time of sub-maintenance nutrition, but also at a time of declining nutrition.

Winter nutrition is poor, but, provided body reserves are adequate this need not be inconsistent with good performance. Late pregnancy nutrition invariably results in quite severe undernourishment at that time, and there is little doubt that in most hill environments pre-partum feeding will improve lamb survivability and in some will lead to improved weaning weights.

All in all, however, the conclusion must be that nutrition is limiting to sheep performance the year round and that really significant improvements in sheep performance require an overall improvement in the nutrition cycle. This leads to the further conclusion that the nutritional problem is basically a pastoral problem, and that although supplements have a part to play there is no escaping the fact that the key to real improvements in sheep performance lies in pasture improvement.

In a previous section it was shown that pasture production in the hills is poor by lowland grassland production standards. It might therefore appear that the problem of the hills is basically one of low pasture production. This is undoubtedly one of the problems but it must be seen in its proper perspective, that is, within the context of management systems whose consequences are poor pasture utilisation and poor nutrition.

That poor utilisation of the pasture production is the rule in hill pasture systems can be easily demonstrated. It can be calculated from data on herbage intakes of hill sheep that the dry matter intake of the 'average' hill ewe, weighing some 110 lb., is in the region of 1,000–1,100 lb. D.M. per annum. Stocking rates of around 2 acres per ewe are probably associated with pasture production in the region of 1,800–2,000 lb. per acre per annum which points to a utilisation efficiency in the region of 30 per cent. Similar calculation in poorer hill environments indicate utilisation efficiencies of a lower order, whilst data on lowland sheep production systems produce values in the region of 65–70 per cent[36]. The reasons for these poor levels of pasture utilisation lie in the nature and consequences of existing hill land management systems.

These are, in the main, year long, set-stocked free-range systems. They operate against a background of highly seasonal pasture growth. Stocking rates are maintained at levels which allow for a certain minimum level of winter nutrition, which inevitably results in stocking rates which are very low in relation to levels of summer pasture production. So that utilisation of the pasture growth during the summer is poor, and the consequences of this are of great importance.

In situations where the degree of utilisation of the contemporary pasture production is poor a great deal of that production is ungrazed. This neglected herbage matures and its feeding value declines. At the same time, since sheep are selective grazers, they are constantly depleting the fund of available herbage of some of its higher quality fractions, so that at the end of the pasture grazing season the material conserved, as it were, *in situ*, and from which the sheep must select their winter diet, is already of poor quality. The need to allow sheep to select an adequate quality diet from this material ensures that utilisation of this fund is poor, and that a considerable carryover takes place from one season to the next, despite the processes of plant death and decay.

It might be thought that low stocking rates in relation to levels of pasture production would ensure an adequate degree of selection opportunity in early summer to produce satisfactory levels of nutrition in lactation. This however has been shown not to be the case, and the reason for this is that selection opportunity is determined not only by grazing pressure, but also by attributes of the available herbage, of which the within-sward gradient of quality or digestibility is extremely important. The evidence is that even at the low grazing pressures which exist in summer the quantity of dead herbage is of such a proportion as to set a moderate ceiling on ingested herbage quality[37].

Hill pastures are vegetationally heterogeneous and it is obvious that some pastures, notably Agrostis-festuca pastures and flush grassland, are more closely grazed than others. Hunter[38] has shown that a pasture type tends to support a characteristic seasonal pattern and intensity of grazing. But sheep range over a variety of pasture types in the course of day's grazing, and are thus given ample opportunity to dilute diet quality.

It is contended that both set-stocking and free range grazing are important factors in determining diet quality, and in limiting overall utilisation in hill pasture systems.

This analysis of the problem is based on studies in a predominantly grassy hill environment and the question of its applicability in other hill environments is important. But evidence of the required kind from other environments is non-existent. There is however a distinct possibility that the nature of the plant material in many non-grassy situations is an important limiting factor to diet quality. However, even if this were to be the case the major part of the above analysis would remain intact, although the implications with regard to improvement would be different.

Existing hill pasture management systems also vary somewhat from region to region, and particularly with regard to the amount of time sheep spend away from their hill pasture at tupping, during the later part of the winter, and during lambing. Manipulations of this kind tend to be reflected in the relationship between

overall stocking rate and summer pasture production, making the relationship a closer one and improving overall pasture utilisation. Any gains of this kind are however made at the expense of other resources, and of this relieves the summer nutrition problem, since although the absolute amount of dead material carried over from one season to the next is reduced, any tendency for this to result in improved summer nutrition is counteracted by a higher grazing pressure.

It is therefore contended that these system differences do not affect the overall argument to any marked degree, and that the major reason for poor levels of pasture utilisation in hill sheep farming is the management system itself. Better pasture utilisation therefore requires a degree of grazing control.

Existing hill vegetation exists in balance with current patterns of grazing intensity as well as reflecting soil and climatic factors. Many hill soils are capable of supporting alternative types of vegetation in response to changes in grazing management. Others will respond to combinations of grazing management and soil improvement. So that hill pasture improvement does not necessarily mean soil improvement together with plant introduction in all situations. The point is that there is a range of possibilities, the choice between them depending upon a series of factors both technical and economic.

IV. ECONOMIC IMPLICATIONS OF INTENSIFYING HILL SHEEP FARMING

In general, in the hill sheep farming sector it is difficult to improve the economic performance by reducing the level of costs within a farm. A prominent feature of the fixed cost structure is the cost of labour. It is probably true that, over the industry as a whole, there is room for a degree of labour rationalisation; it is also true that attempts to reduce labour in many situations will depress output in the absence of other measures, although where the cost reduction exceeds the fall in output the net result may be worthwhile. But it is unlikely that the economic problems of hill sheep farming generally could be solved in this way. It must therefore be concluded that the opportunities for cost reduction at existing levels of output are limited. It is also difficult, in present circumstances, to achieve income increases by way of increased prices for output. There is no guaranteed price and no generally accepted objective means of measuring improved quality in respect of store lambs. Even if there were, improved quality would not necessarily be reflected in higher store prices. In some instances, fat lambs can be finished on hill sheep farms and it might be possible to achieve increased income through the production of quality fat lambs. But the absence of generally accepted grading standards for fat lambs may be an impediment to this.

In general, therefore, improvements in economic performance must come from increased output. This can be brought about by either (a) an intensification of farming within the existing structure or (b) an extensification of farming by changing the structure, leaving fewer and larger farms.

It is difficult to envisage a major change in structure in the short run. On the other hand, intensification may be a palliative rather than a long term remedy due to limitations imposed by the small average size of business. Thus intensification within the existing structure may merely be delaying the need for structural change. An attempt could be made on an appropriate sub-regional and type of system basis to define a minimum economic size of farm business in terms of the number of livestock units required to provide an adequate livelihood. This minimum could then be compared with the current structure to give a measure of the need for change. An analysis of this sort was outside the terms of reference of the group and this section is therefore concerned with the economic implications of intensification within the present structure of hill sheep farming.

In Section III an analysis of the technical factors affecting the productivity of hill sheep farming showed that the key to increased output both in terms of higher carrying capacity and in sheep performance lay mainly in pasture improvement. Although the impact of innovation on hill sheep farming has obviously been much less than on lowland farming generally, some advances have been made and new

techniques introduced. In addition changes have been made on many farms in the control of disease, methods of hogg wintering, lamb fattening and supplementary feeding of ewes pre-lambing. However, in applying this knowledge in practice, the problem ceases to be simply a technical question and becomes one with an important economic component. Significant increases in output cannot be achieved without the investment of capital and the acid test of any improvement scheme is whether it is economically worthwhile or not.

It is not the purpose of this Bulletin to make a detailed economic appraisal of each of the techniques which are available to intensify hill sheep production. There are in the first place, a wide range of possibilities and secondly, the costs and returns attributable to many techniques have not yet been examined in detail. There is therefore a need for the economic assessment of a number of recently introduced techniques. This is best done on the individual farm, taking account of the resources and limitations which are peculiar to that farm. Evaluation of the same technique on a wide range of farms may result in the establishment of the costs and returns to be expected in different areas and under differing systems.

It is however possible to make certain generalisations. Increases in output come about either through improvement in ewe performance or through increased stocking.

TABLE 13

EFFECT ON OUTPUT OF INCREASING LAMBING PER CENT, WITH VARIABLE LAMB PRICE

Lambing %	*Output per Ewe*		
	Av. Sale Price per Lamb		
	£4	*£5*	*£6*
85	5·1	5·65	6·2
90	5·3	5·9	6·5
95	5·5	6·15	6·8
100	5·7	6·4	7·1
105	5·9	6·65	7·4
110	6·1	6·9	7·7
115	6·3	7·15	8·0
120	6·5	7·4	8·3
125	6·7	7·65	8·6
130	6·9	7·9	8·9

The Relative Significance of Improvement in Ewe Performance

Improved performance from the ewe can be obtained from improvement in some or all of the following components; lambing percentage, lamb sale price, draft and cast ewe price, longevity, wool clip and mortality. The following is an attempt to illustrate the relative economic significance of improvements in these components. Use is made of the average performance levels quoted in Section II which show an output per ewe of £5·1. Tables 13, 14 and 15 show the effect on output per ewe of increasing lambing percentage with variable lamb price, of changes in mortality with variable lamb price and of changes in the number of lamb crops per ewe with variable cast ewe sale price. The method of calculating output per ewe is given in the Appendix.

TABLE 14

EFFECT ON OUTPUT PER EWE OF CHANGES IN MORTALITY, WITH VARIABLE LAMB PRICE

Mortality Rate	*Output per Ewe*		
	Av. Sale Price of Lambs		
	£4	£5	£6
	£	£	£
0	5·3	5·9	6·5
0·025	5·2	5·775	6·35
0·05	5·1	5·65	6·2
0·075	5·0	5·525	6·05
0·100	4·9	5·4	5·9

TABLE 15

EFFECT ON OUTPUT PER EWE OF CHANGES IN THE NUMBER OF LAMB CROPS PER EWE WITH VARIABLE CAST EWE SALE PRICES

No. of Lamb crops	*Output per Ewe*		
	Av. Sale Price per Ewe		
	£3	£4	£5
	£	£	£
4	5·1	5·35	5·6
5	5·15	5·35	5·55
6	5·18	5·35	5·52
7	5·21	5·35	5·49

The relative importance of these components can be better appreciated by reference to Figure 4 which brings the above tables together in graphical form. It should be noted that no change in inputs or cost structure are assumed at this stage.

As can be seen, the most significant effect on output is achieved by improvement in lambing percentage and in lamb sale price. The latter, it should be remembered may be a function of quality as well as market price.

The effect of changes in the age at which ewes are cast is small, and when the average sale price of ewes is increased to £4 which is the average sale price of lambs, it will be noted that variation in casting age has no effect on output, which remains the same (£5·35 per ewe) irrespective of casting age. When average cast ewe prices exceed average lamb sale price, output could be increased theoretically by casting at earlier ages.

The importance of wool production from hill sheep is very often underestimated and the significance of an increase in wool clip in the above example could be substantial. It is interesting to note that an additional 1 lb. of wool at 4s. 0d. lb. is equivalent to an increase of 10 per cent in lambing percentage.

It is difficult to imagine a hill ewe flock without mortality. In Table 14, a mortality of 5 per cent is equivalent to £0·2 per ewe, which is the measure of increased output achieved by reducing mortality to zero. This calculation, however, takes no account of any potential increase in lambing percentage through a reduction in ewe mortality.

The shortcomings of the above illustration are, of course, that it does not differentiate between what is technically feasible and what is economically justifiable. For example, high lambing percentage may in certain cases, result in poorer lambs which may sell at a lower average price. It may also, of course, require costly inputs, e.g. foods; it may affect longevity and mortality, and may also affect the fixed cost structure. The correlations which exist between factors at various production levels are not understood. There is a lack of technical knowledge, but this should not of necessity detract from an examination of economic criteria.

Output can also be improved by an increase in the number of ewes carried. This may or may not be accompanied by changes in individual ewe performance and by changes in the variable and fixed cost structure. In the following, an attempt is made to examine the significance of stocking density coupled with changes in cost structure and in individual ewe performance.

The Assessment of Marginal Capital Investment

In the majority of cases, when technical improvement is sought, additional capital will be required for such things as fencing, reclamation, housing and for any increase in ewe numbers which may be required.

Fig. 4. THE RELATIVE SIGNIFICANCE OF IMPROVEMENT IN THE COMPONENTS OF EWE PERFORMANCE

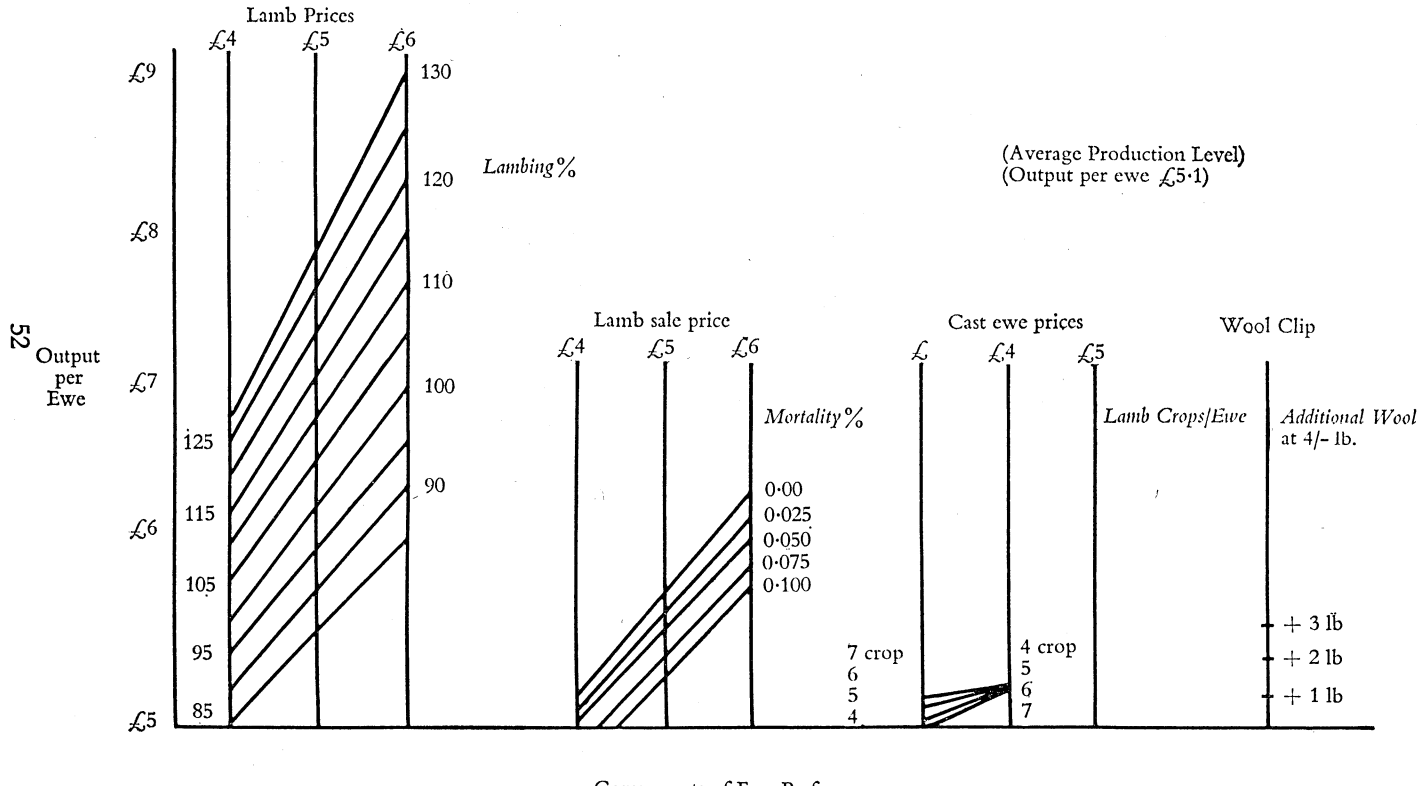
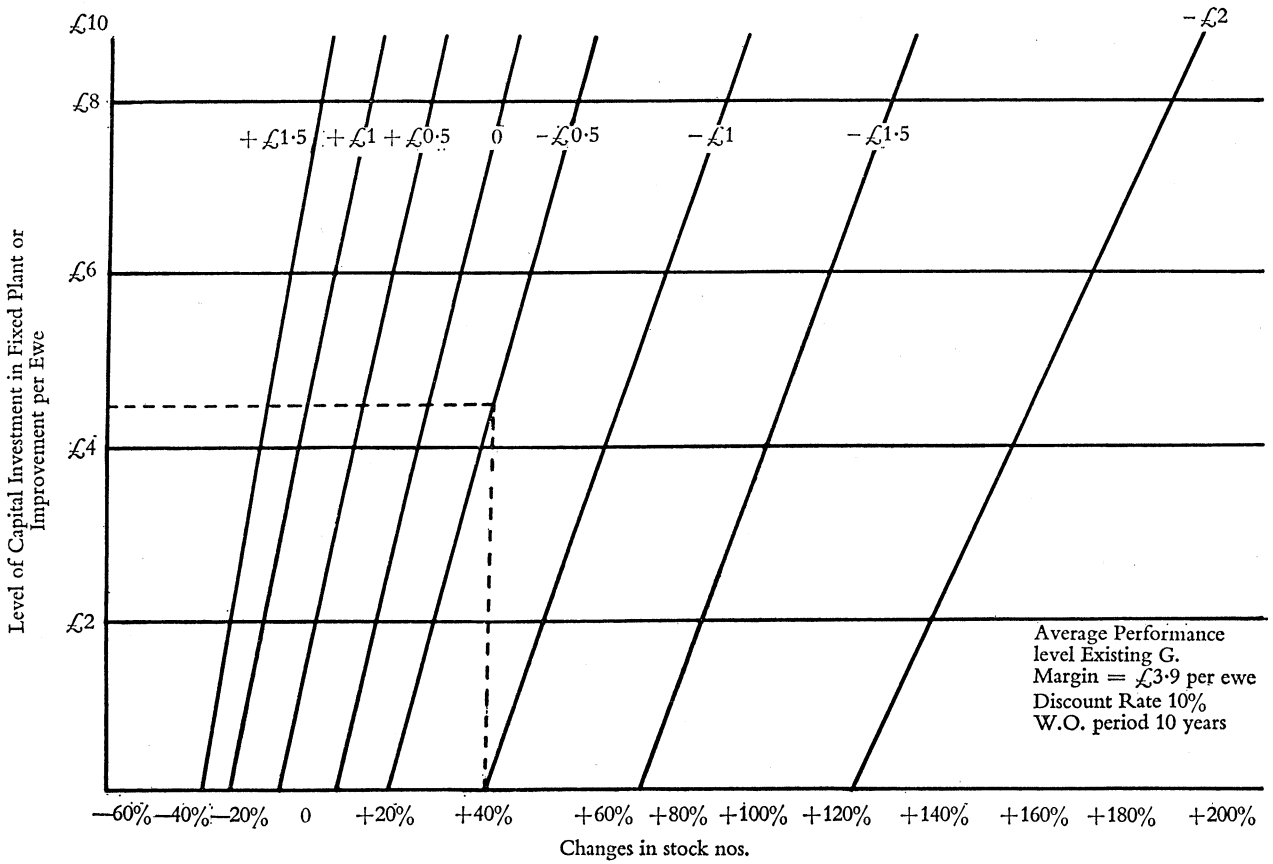


Fig. 5. BREAK-EVEN VALUES



(Sloped lines represent different levels of change in gross margin per ewe.)

Any marginal investment must be serviced in terms of interest and repayment, or depreciation, and if a predetermined rate of interest and depreciation is decided upon, then it is possible to calculate breakeven performance levels for any given situation.[1]

Such breakeven values can vary considerably from one farm situation to another, and it would be wrong to generalise from any one set of results.

In Figure 5 breakeven values are illustrated for ranges of capital investment, nett-of-grant per ewe: of gross margins per ewe, and of stocking rates. These have been calculated from the average performance data, using the methods shown in the Appendix and which show an existing gross margin of £3·9 per ewe. If one knows two of these variables then it is possible to read off the third. For example, if, as the result of changing technology, it were forecast that the resultant gross margin per ewe would be decreased by £0·5, allied to an increase in stocking rate of 0·4, i.e. 40 per cent, then the maximum capital one could afford to invest would be £4·5 per ewe. This capital would yield 10 per cent and be written off over 10 years. Similarly, if one knew that the capital cost of the change was to be £4·5 per ewe, and that the likely performance would show a gross margin reduction of £0·5 per ewe, one can see that the number of ewes must be increased by a minimum of 40 per cent. Again, if one knew that the cost of the change would be £4·5 per ewe, and that the possible increase in stock carry would be 40 per cent, then to break-even, the gross margin per ewe could be reduced by not more than £0·5 per ewe under the new situation.

It is suggested that the use of such a graph can help in the examination of technical feasibility within a limited economic framework. This may in some circumstances help in the determination of targets of performance. For example, if the result of change in the above example was to increase the variable costs by £2, with no change in output per ewe, and if the investment per ewe required was £5·5, then the ewe stock would require to be increased by 170 per cent. If it were possible to increase output per ewe at the same time (a) by £0·5, (b) by £1, then the ewe stock would only require to be increased by 110 per cent and 72 per cent respectively.

It should perhaps be pointed out that changes in the gross margin per ewe can be derived from many permutations of the factors affecting output, and of variable costs. In the following example, a reduction of £0·5 in gross margin can eventuate from a number of different combinations of change:

[1] See Harkins, J.—'Assessing New Capital Investment on Hill Sheep Farms' Scottish Agriculture. Vol. XLVII, No. 4, Autumn 1968.
and Appendix.

Combination of Changes	*Change in Output/ewe*	*Change in Variable Cost/acre*	*Net Change in Gross Margin*
	£	£	£
1. Higher lambing % + higher food costs	+0·5	+1·5	−0·5
2. No change in output + higher food costs	0	+0·5	−0·5
3. Reduced mortality + higher lambing % + lower sale prices + higher variable costs	−0·2	+0·3	−0·5
4. Higher output + higher variable costs	+1·25	+1·75	−0·5

The foregoing are not methods for determining the costs and returns to any particular technical change. However, they do give some indication of the relative significance of the components of ewe performance and a conceptual framework whereby the necessary performance targets can be established to justify various levels of investment, making allowance for interest rates, recoupment period and the effect of associated changes in variable costs. These approaches could be used to establish the priorities for expenditure on research projects and to examine the likely impact of policy changes. They also indicate broadly where farmers should concentrate improvement but economic evaluation of particular techniques must still be made on the individual farm within the limitations imposed by the farmer's own problems of capital availability, the rates of interest at which he is able to borrow money, and so on.

There is no doubt that, in the past, insufficient attention has been paid to cost/returns relationships by hill farmers in relation to additional capital investment. The profitability of hill sheep farming over the last decade and more has not lent itself to capital accumulation on any scale, and to be relevant to this problem, emphasis in future technical development must be on low cost but effective methods. In the next section technological aspects of intensifying hill sheep farming are examined with this constraint in mind.

V. TECHNICAL ASPECTS OF INTENSIFYING HILL SHEEP FARMING

Many of the practical developments which are discussed in this Section are in the early stages of large-scale investigation in the Hill Farming Research Organisation, and elsewhere.

Pasture Improvement

Most unimproved, native vegetation as it exists today, especially that occurring on highly leached acid soils and which is undergrazed, has a low digestibility and low content of such elements as Calcium, Magnesium and Phosphorus. Under-utilisation of vegetation, leading to an accumulation of senescent and dead material, is a very important factor contributing to its low digestibility. Not all hill species are inherently indigestible and there is considerable scope for improvement in output by better grazing management. Pasture improved by fertilising or reseeding and the vegetation occurring on base-rich soils or flushed areas, where it is more completely grazed, is mainly of higher digestibility and productivity.

Overgrazing can produce harmful effects in wetter areas, particularly in Wales, where existing stocking rates are considered to be high. In the North and in South-Eastern Scotland where freely drained soils predominate, this problem is less likely to be encountered. However, when grazing is uncontrolled sheep spend a disproportionate amount of time on the more productive areas of vegetation.

The problem with each hill farming enterprise is to know how far to go with improvements; for any given sheep production requirement and combinations of site types, there will be an optimum over-all input level. In certain environments a high input, involving reseeding and appropriate after-management might be justified on limited areas. However, in many areas it may make more economic sense to have large paddocks of comparatively low yielding pasture but of satisfactory nutritional quality, produced at a low cost per acre, than to aim for a high cost/high output pasture. This approach is based mainly on adequate control of grazing. This is essential. The object is to produce a pasture with a low content of dead herbage and therefore of adequate digestibility.

Starting with a grass-heath this usually would involve elimination of *Molinia* or *Nardus* which may be difficult to achieve by grazing alone without depressing animal production. However, we know that the botanical change, which is an essential component of improvement here, will be greatly speeded up by liming. Spray application of Dalapon or Paraquat at very low rates, or severe mechanical defoliation may also have a place in accelerating botanical change, though these methods may prove to be too costly. If the soil pH is not too low, say greater than 5·0, then by good grazing management an efficient turn-over of N through

the animal can be achieved and the long term tendency should be to transform grass-heath into an *Agrostis-Fescue* pasture. Alternatively, starting with the latter type of vegetation on soils of pH 4·9 to 5·2, improvement of herbage digestibility could be sought simply by good grazing control. The improved rate of N circulation should lead to increased production and a slow botanical change towards an *Agrostis/Fescue/Poa* type of pasture. This low input approach has not yet been adequately tested on large paddocks and it is not known how long it would take to achieve the level of improvement sought. It is only suitable for *Agrostis/Fescue* pastures and, in view of these limitations and uncertainties, caution should be exercised in applying the method on a farm scale. The conversion of either grass-heath or low-yielding *Agrostis/Fescue* into a high yielding *Agrostis-Fescue-Clover* pasture or better requires a much higher input. Usually reseeding is carried out to accelerate the rate of pasture change and the problems and economics of the method are well known. Such a high input approach can of course be applied to a wide variety of soils including blanket bog[39].

Pasture improvement relying on the introduction of white clover to indigenous swards has not been greatly used in practice perhaps not without reason, for it is not without its technical difficulties. It is a fairly high cost system in that fertilisers are required, though it can be used where orthodox cultivation and reseeding are impracticable.

In technical terms, then, on some categories of hill land there is a wide spectrum of pasture improvement possibilities ranging from simple enclosure, through various degrees of soil upgrading, to ploughing and reseeding. On other categories the range of possibilities is much more limited. The important implication of the cost/returns approach is that where a choice exists it ought to be made subject to input/output considerations rather than on the basis of the degree or rapidity of the improvement created by the various alternatives.

The available evidence on this question is limited but suggests that the rather slower upgrading of the better classes of hill land, although much less dramatic than the application of large amounts of inputs, is less capital intensive and therefore more sensible in view of the general lack of capital in hill farming.

In future it is probable that in pasture improvement more attention will have to be given to input-output relationships. The optimum may be different on different soils and will also depend on the pasture type as well as on the production level required.

Various other measures are often advocated as part of a scheme of hill land improvement. But whilst these may be technically impeccable the issues are perhaps less clear in other respects. Prominent among these measures is drainage, and there is no doubt that much of our hill land would benefit from better drainage. But if the cost/returns test is applied a great deal of proposed hill drainage may be

uneconomic unless associated with other improvements. In addition, the impact of hill drainage upon river behaviour in the lowlands and upon future needs for water conservation would have to be taken into consideration should there be any major shift towards extensive draining.

Bracken eradication is a traditional form of hill land improvement but is probably better considered as a part of an overall plan designed to produce a specific type of pasture required to fulfil a particular nutritional requirement, rather than simply as the eradication of a weed from an existing pasture. However the problem of rapidly reducing the density of the fern has still not been solved. Spraying is, unfortunately, still too costly although manufacturers of cutting and crushing machinery seem to have assumed that sprays have taken over. Although bracken is unlikely to be a problem in properly grazed paddocks, there seems to be no economically viable method of bracken eradication on the open hill. On poorly drained soils invasion by rush (*Juncus*) species is a potential problem associated with pasture improvement, especially when certain soils are ploughed and reseeded, though this is unlikely to present insuperable problems[40],[41]. In some instances weeds are not a major problem but in the majority of cases they can hardly justify a priority call on the available funds.

The perspective lent to land improvement by the cost/returns approach will often result in an order of priorities rather different to that which might be expected on wholly technical grounds. It may even, on occasion, indicate that some quite high potential land resources be left alone, and attention directed to something which, on the face of it, is of lesser inherent value.

In the case of grazings on the better soils, land improvement is likely to take the form of upgrading at comparatively low cost per unit area, initially by fencing and perhaps liming, fairly large areas. Later a proportion of the enclosed land may be more radically improved but present indications are that cost/benefit considerations are likely to favour the enclosure and modest improvement of fairly large blocks of this class of land, rather than the more radical upgrading of more limited areas.

In poorer hill environments where peat soils predominate and mineral soil areas are very limited the choice is also limited. There is unlikely to be much alternative to the radical improvement by fertilisers and sown seeds of much smaller areas. Between these extremes exists a spectrum of intermediate possibilities. However improvement is made, the outcome will be an area of improved pasture which has to be integrated with the remaining open hill to best advantage.

At the present stage of development it is difficult to predict with any precision the outcome of these measures except in a general way. It seems likely that the low cost upgrading of the better parts of the better hills will be reflected initially in improved carrying capacity, and the marked upgrading of much smaller areas

appropriate to the poorer environment will be more readily reflected in improved individual sheep performance. Invested capital has to be serviced, and in any improvement scheme a measure of improvement in output as early as possible will be desirable to enable this to be achieved.

Improvements in Animal Nutrition

During lactation and pre-mating, nutrition has priority, and the management of improved pasture will be best devoted to this end. Where the amount of improved pasture is small in relation to sheep numbers, as it often will be, the most acute problem will occur during lactation and a careful appreciation of priorities, e.g. preference for improved pasture to twin-rearing ewes, and to gimmers with single lambs over older ewes with single lambs will ensure the most efficient use of these limited areas.

Many of the measures discussed have dealt only with summer nutrition, but what has perhaps been inadequately appreciated in the past is that the winter problem arises partly from the fact that existing summer nutrition leads to the body condition of the ewe being inadequate in early winter. Improvement of summer nutrition, leading to better body reserves, will make an important contribution to the solution of the winter problem. In future systems, as now, there will also be a need to improve nutrition in late winter-early spring. A problem which may arise following the kind of pasture improvements which lead to marked increases in stocking rate is that of the need to increase winter carrying capacity at existing levels of nutrition. Work on this problem suggests that in some environments at least this is capable of solution.

During the period up to 3½ months after tupping, hand feeding should rarely be required unless severe weather reduces herbage availability. Then the feeding of hay is adequate and for most ewes 1–1½ lb. daily is sufficient. If longer periods of bad weather occur in late pregnancy, a more liberal ration of hay may have to be given.

Following land improvement, more attention will have to be given to the need to improve nutrition in late pregnancy. It is probable that a concentrate supplement with around 14–16 per cent Crude Protein with a high energy content and containing minerals, particularly calcium and phosphorus, will suffice although 12 per cent Crude Protein would seem to be adequate on improved grazings. The amounts fed should be adjusted so that the greatest quantity is fed during the final weeks of pregnancy. As an example, a total of 28 lb. concentrates per ewe will be more effective if fed at ½ lb. during the 4th week prepartum, ¾ lb. 3rd week, 1¼ lb. 2nd week and 1½ lb. during the final week rather than as ½ lb. over 8 weeks. The technique of feeding should aim to disturb the natural grazing habit of the ewe as little as possible.

Self-help blocks can be of value on open inaccessible hills by reducing labour requirements and making it possible to retain the ewes on the hill and out of enclosures for a much longer period than is practised at present. This practice also helps to avoid the overgrazing of enclosures in winter and early spring, which can seriously reduce grass production. Trials at Pwllpeiran Experimental Husbandry Farm[42] have demonstrated that self-help blocks fed over an 11 week period on the open hill cost 12s. 0d. per ewe and that this form of feeding gives a similar ewe performance to hay and concentrates fed on enclosures at lower altitude.

The extent to which urea nitrogen is an essential and important component of self-help blocks is as yet unclear. It is probable that on improved or grassy hills its contribution is negligible yet it may be of importance on unimproved mountain where the herbage protein content may be very low. Over 50 per cent of self-help blocks is composed of high energy carbohydrates and this is probably the most important constituent.

When ewes are wintered in accommodation paddocks the bulk of the diet will be provided as hay and it should be supplemented with concentrates if the ewes are confined about 6 weeks before lambing. Since it is likely that those practising this type of management will seek a higher lambing percentage, then a more liberal level of concentrate feeding should be considered depending on anticipated performance. Flocks lambing at 120–130 per cent will justify up to 1·0 lb. concentrates (12–14 per cent C.P.) per ewe daily while, at 150 per cent lambs dropped, $1\frac{1}{4}$–$1\frac{1}{2}$ lb. would be more desirable for large ewes and proportionally less for small ewes. Food will be more efficiently used if ewes can be taken off the hill according to time of lambing, so that marking at mating time will be a desirable adjunct to more efficient management. When ewes are put back on to the hill, before there is ample herbage, supplementary feeding must be continued if full lamb growth potential is to be achieved.

In-Wintering

Thus far, the assumption has been that the development of what might be called year-round grazing systems will be more relevant to the industry's future. But there is some interest, and enthusiasm in some quarters, for in-wintering hill sheep flocks and, although the economic advantages of in-wintering have not been clearly established for hill flocks, it is being practised.

A sound scientific or biological argument can be used on which to base the advocacy of in-wintering[36]. One of the basic reasons for the inefficiency with which hill pasture resources are used is that sheep have to be maintained on their pasture continually. Winter food has to be conserved *in situ* and this is an inefficient process, rendered even more inefficient when the need to maintain a certain minimum level of nutrition for the sheep results in the use of only a small proportion

of the conserved material. There can be no doubt that the avoidance of this inefficient process would markedly improve the efficiency of use of pasture.

On nutritional grounds, it can be argued that in-wintering cannot be expected to greatly improve individual performance. However, through the greater flexibility in management which is gained from in-wintering systems it should be possible to give lean ewes preferential treatment, gimmers can be segregated from older ewes and those most likely to have twins can be penned separately and all fed according to their needs. A further advantage of in-wintering may be some saving in lamb losses but, against this, disease problems may increase. In general, experience of in-wintering supports the view that marked increases in per ewe production are unlikely to follow in-wintering. This means that the necessary increases in output have to come from increases in stocking rate, which in many cases will have to double to make the venture worthwhile. This may be within the carrying capacity of some classes of hill-grazing, but not of some of the poorer hills. However, associated investment in land improvement aimed at improving summer nutrition and hence overall sheep performance may make the whole exercise worthwhile.

The technical advantages must be assessed in economic terms and compared to costs. In-wintering requires a substantial capital investment which must be realistically serviced. It also leads to a substantial rise in variable costs due to the cost of additional winter feeding and the increase in output required to justify these additional costs can be very large indeed. Investment in housing would only have a first call on scarce resources in exceptional circumstances, for example, where stocking rates are held artificially low for some reason such as inaccessibility or distance in winter or to save losses of high value breeding stock. However, because of its longer term implications the whole matter is worthy of more investigation.

The Place of Cattle on Hill Sheep Farms

There is no doubt about the value of cattle as improvers of hill pasture. Their less selective grazing habits result in the removal of herbage rejected by the sheep and they therefore contribute to better utilisation of hill pastures. In one experiment reported by H.F.R.O. the presence of cattle improved the grazing so that an improvement in sheep performance was obtained both through an increase in lambing percentage (+10 per cent) and also in lamb weaning weight (+4 lb.). This amounted to an increase of 37 per cent in the output of lambs and wool and of course the output from calves was additional.

Under present systems of management, cattle numbers on hill farms tend to be maintained at levels consistent with the area of cuttable grassland from which their winter-feed requirements can be met. On many hill grazings, and certainly

on the better ones, this provides a summer cattle stocking well below that from which these hill grazings would benefit. Particularly on the grassier hills, where the low-cost development of larger areas is appropriate, the pace of improvement will be the faster the more cattle there are available, and when the initial improvements have been carried out, the role of cattle in helping to maintain these improved pastures will also be substantial. Cattle will have a very important maintenance role to perform and there seems no reason to suppose that this will be inconsistent with at least existing levels of performance.

On grazings where only limited areas can be improved, the need for cattle as aids to improvements is much less pressing. But these areas are often in the wetter parts of the country and inbye land is very limited so that cattle numbers are often already very low. Again a summer cattle stocking will be an asset and there is no reason to suppose that the improvements suggested will be any impediment to more intensive cattle-stocking.

There is no reason why the place of cattle in hill-farming should in all circumstances remain secondary to that of sheep. There are, on the contrary, good reasons why the establishment of beef-oriented systems should be considered on some classes of hill land.

Improvements could be brought about by an extension of the practice of taking in dairy replacements for summer grazing. This provides the hill farmer with a useful cash income and the benefits of mixed stocking without requiring capital investment in additional cattle. For the dairy farmer, such an arrangement provides cheap rearing of dairy replacements under disease-free conditions and maximum utilisation of his own land with productive stock.

The conditions under which cattle are likely to contribute and the best form of grazing management have never been systematically investigated in the hill environment and more research is needed before the possibilities offered by cattle can be more realistically assessed and well-founded developments proposed.

Husbandry and Management Changes

It is difficult to discuss labour in hill-sheep farming in general terms, but if one generalisation can be made, it is that efficiency in labour use is much more likely to come from control by fencing than from any other source. This is now being recognised by a number of hill farmers and there is no incompatibility between the measures which have been urged here on output grounds, and those which are now being advocated on the grounds of greater labour efficiency.

Good arguments can be made within existing systems for a much greater degree of control at lambing than is now customary. These arguments gain in force and point where better overall performance is likely to follow land improvement. In practice control at lambing can be facilitated by raddling tups at mating

which becomes a more practicable proposition where mating takes place in improved enclosed pasture.

Where ewes are to be fed in late-pregnancy as a matter of course, much of the difficulty encountered in getting them to take feed can be eased by teaching them as hoggs. This, too, becomes possible with sub-division.

Existing hogg-wintering practices vary. In some of the better areas hoggs are wintered on the hill, but there is little doubt that the problems which arise during snow storms, for example, would be greatly eased if hoggs were run apart from the adult ewe-stock. Some sub-division of the hill offers opportunities here. Again the existence of suitably managed, suitably-sized and sited enclosures may provide a cheaper alternative to away or in-wintering. Some feed would have to be provided but the additional costs involved are likely to offer useful savings on existing costs.

Farmers with an adequate area of in-bye land could consider the possibility of finishing their own lambs. Much will depend on the needs for conservation and flushing. However, even where lambs cannot be finished at pasture, where suitable buildings are available the hill farmer could use these to intensively finish his store lambs. The factors of importance in ensuring economic success are the relationship between buying and selling price, food costs, efficiency of food conversion and mortality. These and other husbandry changes which are cost and labour saving will not, of themselves, substantially change the economics of hill-sheep farming but may contribute to a sensible rationalisation of improved systems of production.

VI. CONCLUSIONS

In this Bulletin, hill sheep farming has been considered in general. Regional and sub-regional differences, although important, have not been detailed. The object has been to examine the current situation in hill farming, to consider hill sheep farming systems and to outline current knowledge which could be applied on farms in the future. The main consideration has been to study hill sheep farming with particular reference to its future potential.

The wider issues, concerning the place of hill farming in relation to the other land uses of forestry and recreation, and also to water use and wild life conservation and the integrated development of remoter rural areas, have not been discussed in this Bulletin but some of them have been considered in detail elsewhere.[1] Clearly, the long term future of hill farming cannot be considered completely separately from these issues but they were beyond the scope of the present study.

It is estimated that hill farming contributes approximately 5 per cent of the total output of British agriculture. Hill farming is the occupation of an estimated 43,000 people and is an important source of store stock for fattening in the lowland areas. The role of hill farming in national sheep production is important and approximately two-thirds of all breeding ewes in the United Kingdom qualify for the hill ewe subsidy.

It is generally recognised that hill farming is in a difficult economic situation. Problems arise from the low natural productivity of the land which results in low levels of physical output. The small average size of hill farms aggravates this problem. Not only is physical output low but the realisations from this output, which is largely in the form of store stock, are also low. These factors tend to have an adverse influence on farm incomes and living conditions. It also limits capital accumulation needed for new investment. Remoteness is an associated problem which adds to the difficulties. These inter-related problems are discussed in subsequent paragraphs.

The low level of productivity characteristic of upland and hill areas is partly due to limitations imposed by climate, topography, soils and natural vegetation and partly to the consequences and deficiencies, if any, of existing systems of management.

The complexity of the natural problems must not be underestimated and they account to a large extent for the relatively slow rate of innovation and technical development in hill farming, compared with other sectors of the agricultural industry. Climate and topography lie outside the control of the hill farmer, but soils and vegetation can be improved by the methods discussed in Section III.

[1] For instance see 'The Remoter Rural Areas of Britain' edited by J. Ashton and W. Harwood Long, (to be published).

These include soil drainage, liming and fertiliser application, surface seeding with improved strains of white clover, such as S.184 and S.100, and subdivision to improve pasture utilisation and nutrient turnover. It is expected that further research will fill gaps in current knowledge of improvement possibilities.

On purely technical grounds, it can be argued that most hill land is capable of improvement, but the results vary between areas, according to the quality of the land and its capacity to absorb and respond to additional inputs. Some areas where hill sheep farming now takes place cannot be economically improved and it is important that these areas should be identified. In this connection, it would be helpful to have a broad assessment of the soils and vegetation of hill and upland areas with reference to their potential not only for farming but also for alternative uses. Such an assessment should include not only estimates of the capital needs of the alternative uses of land, but also the need for restructuring of farms, where applicable. In areas where improvement is economically possible, it is important that the upgrading of soils and vegetation is followed up to the point of increasing cash returns through additional animal output.

It has been emphasised that lasting economic improvement is more likely to be achieved by the application of a combination of changes affecting the whole management system rather than by some single, simple technique. There may be cases where simple remedies could lead to marked improvement on a particular farm, but generally this will not apply.

It has been established that the reproductive potential of the hill breeds is relatively high and existing breeds are not likely to prove a constraint to increasing production. Changes in hill sheep systems have been suggested which should lead to an improvement in the levels of nutrition of the ewe at critical periods. This should enhance the quality and quantity of the output and so improve profitability.

The rising trends in labour costs and difficulties of recruitment put pressure on farmers to increase output per man. While this may be achieved by improvement in existing flock productivity there must also be a trend towards more ewes per man. Marked increases in output per man, with one man handling 800 to 1,000 ewes, require investment in fencing, the construction of access tracks, the creation of lambing paddocks and, in some cases, housing for sheep, if existing performance standards are to be maintained let alone improved.

The main improvements in economic performance must come from increased output per man and per acre of land used. In intensifying production, new techniques must be examined in relation to additional costs and returns, to the capital needs of development programmes and the labour requirements of new methods. Many of the possible improvements in hill farming may involve a development programme spread over a number of years.

Few studies have been carried out into the economic aspects of farm development in hill areas but, as shown in Section II and the Appendix, it is possible to determine whether an investment is financially worthwhile, provided reasonable predictions can be made concerning the influence of management changes on animal production.

A general economic problem in hill farming is the uncertainty over store stock prices, particularly sheep. The way in which Government policy aims to influence price levels for sheep, and hence the development of the industry, is summarised in the most recent Annual Review White Paper:

> 'The Government have sought through their decisions at recent Annual Reviews to encourage greater productivity and growth in the hills and uplands to offset the decline in lowland flock numbers, but this will take time. Moreover sheep are important to husbandry in many lowland areas. If production is to be maintained over the longer term, it is necessary to check and offset the decline in the total breeding flock. To offset higher costs and to give the further resources needed for investment in additional breeding stock the guaranteed price for fat sheep will go up by 3d. to 3s. 10¾d. per lb. This should improve returns for producers in all parts of the country and in all sectors of the industry'.[1]

Whether this latest price increase will achieve the stated objective remains to be seen. Changes in the national sheep flock are of considerable importance to hill farmers, due to the stratified nature of the sheep industry. Increases in the guaranteed price for sheep over recent years have done little to stem the decline in the national sheep flock. In the three years 1966–1969, the national flock fell by 3 million sheep or more than 10 per cent. The number of breeding ewes fell by 8 per cent—almost one million ewes. By contrast the number of ewes receiving the hill sheep subsidy increased in the period. The reduction in sheep numbers has taken place in the lowlands and has been ascribed, partly to the low profitability of lowland sheep production in relation to other enterprises, and partly to developments such as continuous cereal growing in arable areas and the enlargement of dairy herds, both of which have resulted in a fall in the number of breeding flocks. If the competitiveness of sheep production is restored through increases in the guaranteed price, then demand for store stock could harden. But if the decline in the number of lowland breeding flocks was not reversed, sheep production would become concentrated on the fattening of store lambs off temporary pasture on arable farms. If lowland sheep fattening does not increase, store prices may fall as the production of hill farming expands and the supply of store stock exceeds demand. However, the inter-relationships between supply and demand for store stock and the guaranteed price for fatstock are not clear. At present, although there are guaranteed prices for fatstock, the store market tends to fluctuate quite widely

[1] Annual Review of Determination of Guarantees, 1970, Cmnd. 4321, London, H.M.S.O.

without any direct relationship to the level of the guarantee. Some attempts to extend integrated marketing schemes, a few of which have operated on a local basis with modest success, might reduce this hazard and lead to a better return for store stock. As part of such schemes store lambs might be sold on a liveweight basis, though reports on marketing schemes based on this form of selling suggest that they have not so far proved as successful as was hoped, but this should not prevent further attempts to improve the marketing methods of store stock.

A more radical change might be to replace the hill ewe subsidy by guaranteed prices for store stock, based on live weight. This would ensure that the output of hill farms would receive due priority and might also overcome the problem of the farmer who overstocks with ewes primarily to 'farm the subsidy'.

A further possibility may be the production of fat lambs from hill farms. Opportunities for this are likely to be limited to the more productive hill areas, though indoor fattening, if economic, could broaden the scope considerably. Hill farmers should seek to market fatstock whenever possible.

The long-term outlook for sheep-meat consumption is of particular interest to hill sheep farmers. Domestic consumption of sheepmeat in the United Kingdom has stagnated for many years at around 24 lb. per head per year. Demand seems unlikely to increase except from population increases and any marked expansion of the domestic sheep industry would have to depend upon either a major change in consumption patterns or the implementation of import-saving measures.

With regard to consumption patterns, it is possible that the guarantee system encourages the production of lambs which are too heavy for present consumer requirements. Whatever the reason, research is required into the factors affecting consumption levels of mutton and lamb.

If a policy was implemented to achieve saving in imports the result might be to increase the price of sheep-meat to the consumer and it may be that higher prices would give rise to substitution by poultry and pigmeat. It would be of value if the industry were given guidelines as to the amount of expansion envisaged by government.

The industry should also be aware of export possibilities in Europe, where there is a demand for small lambs. The hill breeds would seem eminently suitable to meet this market and such a change in the market requirements of the end-product might enable the finishing of lambs on hill farms.

So far, attention has been directed to difficulties that are general to most hill farms. There are serious problems in some areas concerning farm structure. There are two aspects to this; there are farms which are too small in terms of both acreage and output to be economically viable units either now or in the future, and there are farms which, although large in terms of acreage, are small businesses

in terms of output. Intensification might make the latter economically viable but it is difficult to achieve such a result for small hill farms and substantial changes in the structure of the industry are inevitable. However, structural change seems to be taking place very slowly with a consequent slow rate of improvement in the economic efficiency of the sector, continuing low farm incomes and resultant hardship for small farmers. Government policy has sought to ease and accelerate the process of change through the Farm Amalgamation, Boundary Adjustment and Payment to Outgoers Schemes. These schemes are applicable to the whole of the agricultural industry, and the number of grants to hill and upland farmers which have been approved is not known. Changes consequent on this legislation have so far been imperceptible and it would be worthwhile to review the adequacy of current schemes with a view to securing more rapid change in problem areas.

Rural Development Boards were proposed in two areas where current structure poses problems. In Wales, there has been considerable opposition to the establishment of a Board whilst in the North Pennines, although a Board is now in operation it has only been in existence for a short time. Perhaps the Rural Development Boards should be empowered to take more positive measures than those which have been publicly proposed. Though the functions of Boards are likely to raise strong emotional reactions in rural communities, their activities should not be limited to producing a succession of palliatives but to ensuring a long-term, economically viable, farming structure and a thriving rural community.

A further possibility concerns changes in government policy. For the small farmer, much of the current assistance provided by goverment agricultural policy can be regarded as social rather than economic. This situation could go on indefinitely with continued assistance to small, uneconomic farms reducing the amount of government aid available to the larger and more viable units which could profitably use it. Because the size of farm which can be regarded as a minimum economic unit is increasing, priority should be given to establishing the minimum levels of output necessary to justify economic aid now and in the future. For farms where this minimum level is not likely to be achieved, additional inducement may be required, to that currently available, in order to encourage small farmers to leave the industry and accelerate the rate of structural change.

A small average size of holding, either in physical or output terms or in both, gives rise to a chronic economic problem. Output levels are low and the output, mainly in the form of store stock or cast-for-age breeding ewes, is placed on an unpredictable market during a short period of the year. This system results in high working capital requirements and relatively low realisations for the stock. The profits generated in these circumstances are often too low to provide the additional capital which might enable higher output to be achieved through intensification. Low profits lead to low family incomes and the small unit gives insufficient employment to the farmer and his family.

The opportunities for small farmers to increase the size of business by acquiring additional land released by structural change are limited by the inability to generate sufficient capital to pay the purchase price. The problem is aggravated by the general high levels of land prices relative to their earning power, which is general to agriculture as a whole. It has sometimes been argued that special assistance should be given to farmers for land purchase, through the establishment of land banks which would lend money at low rates of interest. From the purely economic point of view this would result in a distortion of the use of national resources by favouring one sector of the economy at the expense of other sectors. Agriculture has to compete with other industries for limited capital. If agriculture is not profitable relative to other industries then capital will not be made available to agriculture. In this competitive situation, it is difficult to sustain arguments for special assistance for land purchase, particularly if the returns on capital will not justify the market price of land. In any event the provision of cheap credit for land purchase would, to a large extent, be likely to lead to a self-defeating process of farmers bidding up the price of land.

With regard to financing farm development, improvements should only be carried out if financially worthwhile. For a comprehensive development programme to be carried through to completion, including the servicing of invested capital, adequate funds must be available throughout the period of development. Changes in the form of government aid could improve development in hill farming. At present, government aid tends to be piecemeal. For example, the subsidies on hill stock provide an element of income to the farmer and an incentive to increase output. However, without associated changes in management, increasing sheep and cattle numbers may result in overstocking. Similarly, grant aid for hill drainage, whilst of great assistance, will be wasted if not followed through by better grazing management involving perhaps more fencing and heavier stocking and pasture improvement. It would be more appropriate for aid to be based on a whole farm approach, with government assistance provided for integrated improvement schemes which result in increased output, rather than on piecemeal direct grants, which may or may not have a significant effect on output, depending on the farmer's ability to finance follow-up development. Research and intensive advisory work would be necessary in any new approach to hill country development, but men to do this work are scarce and any major diversion of resources to hill farming must be justified in the national context.

Serious sociological problems exist in remoter rural areas, not only for the hill sheep farmer but for the rest of the community. For the hill farmer, remoteness means higher input prices, problems over the education of his children and difficulties in recruiting and retaining labour. The labour required by new systems will call for men who have been adequately trained as all round stockmen rather than as shepherds. High calibre labour demands better wage rates and good living

conditions, and good quality labour may be leaving hill farming more rapidly than the rate at which the industry is capable of changing to meet new demands. The provision of housing for shepherds in village communities has been mooted as one means of retaining labour. But apart from practical problems such as the shepherd being unable to reach his flock in bad weather, there is the wider problem of a lack of employment opportunities for the families of workers within such communities. This contributes to the drift of population to urban areas where employment is available.

It may be that for the future well being of the hill sheep farming industry, there will have to be fewer but more economically viable farms. A reduction in the area of hill land devoted to sheep farming would require the same level of output to be produced from a smaller area if existing levels of production from hill farming were to be maintained. Those who remain in hill sheep farming may therefore face a brighter future. But the adjustment necessary in changing from the present situation will exacerbate the social and economic stresses already present in rural communities. One of the problems in the United Kingdom is that, because of the relatively small rural population, there is no government department and no official machinery specifically concerned with developing comprehensive rural policies integrating the economic and sociological needs of the whole rural population. If such policies were developed, then the stresses resulting from a reduction in the numbers employed in hill farming may be mitigated by the provision of alternative employment in forestry, industry, tourism and services in rural areas.

APPENDIX

Output per Ewe

This has been calculated from the following equation:

$$\text{Output} = E\,[a(X-d-e)+gd+c+s]$$

Where E = number of ewes put to tup.

a = Average lamb sale per ewe put to tup.

x = Lamb to ewe ratio of lambs at weaning per ewe put to the tup.

$$d = \frac{1}{(\text{Number of lamb crops per ewe})}.$$

e = Mortality of ewes and of hoggs expressed as a percentage of ewes put to the tup.

g = Average sale price of cast ewes.

c = Average sale of wool per ewe put to the tup.

s = Subsidy per ewe put to the tup.

Variable Costs per Ewe

These include the cost of tup upkeep, as well as such items as the cost of wintering for ewe hogg replacements; foods purchased; seeds; fertilisers; dip; medicines, haulage; casual labour. These are denoted in the equation for Gross Margin per ewe by the symbol b.

Gross Margin per Ewe has been calculated from the equation:

$$\text{Gross Margin} = E[a(x-d-e)+gd+c+s-b].$$

Break Even Budget

In marginal capital investment calculations the following equation was used:

$$E_1[a_1(x_1-d_1-e_1)+g_1d_1+c_1+s_1-b_1] = E_2[a_2(x_2-d_2-e_2)+g_2d_2+c_2+s_2-b_2-y_2]+L$$

Where y = the annuity required to service interest and repayment of capital invested in fixed equipment and in extra ewes. Capital invested in equipment has been discounted at 10 per cent over 10 years with no scrap value. Investment in additional ewes has been calculated at £5 per ewe, 10 per cent discount, and full recovery after 10 years.

$L = \pm$ changes in regular labour cost.

REFERENCES

1. Report of the Land Use Study Group. Forestry, Agriculture and the Multiple Use of Rural Land, H.M.S.O., 1966.
2. The Structure of Agriculture, H.M.S.O., 1966.
3. Farm Classification in England and Wales, H.M.S.O., 1967.
4. Farm Incomes in England and Wales, H.M.S.O., 1967.
5. Scottish Agricultural Economics, 1968.
6. Development of Agriculture, Cmd. 2738, page 4.
7. Alcock, M. B., Lovett, J. V., and Mackin, D. (1968). 'Techniques used in the study of the influence of environment on primary pasture production in hill and lowland habitats' In 'The Measurement of Environmental Factors in Terrestrial Ecology', Oxford, Blackwell, pp. 191–203.
8. Hughes, Roy and Munro, J. M. M. (1969). 'Climatic and Soil Factors in the hills of Wales in relation to the breeding of special herbage varieties' In 'Hill Land Productivity' *Occ. Symp. No.* 4, *Brit. Grassld. Soc.*, pp. 109–112.
9. Grant, S. A. (1969) 'Temperature and Light Factors Limiting the Growth of Hill Pasture Species' In 'Hill Land Productivity'. *Occ. Symp. No.* 4, *Brit. Grassld. Soc.*, pp. 30–34.
10. Hunter, R. F. and Grant, S. A. (1969) Unpublished data.
11. King, J. et al. (1969) Unpublished data.
12. Burrows, F. J. (1968) 'Climate Potentials' Ann. Rept. Welsh Pl. Breed. Stn. 1968, pp. 63–65.
13. Crompton, E. (1958) 'Hill Soils and their Production Potential' *J. Brit. Grassld. Soc.* **13,** pp. 229–37.
14. King, J. and Nicholson, I. A. (1964). 'Grasslands of the Forest and Sub-Alpine Zones' In *The Vegetation of Scotland*, Burnett, J. H. (Ed.), Edinburgh and London, Oliver & Boyd.
15. McVean, D. N. and Ratcliffe, D. A. (1962). 'Plant Communities of the Scottish Highlands' Monographs of the Nature Conservancy No. 1, pp. 458. London, H.M.S.O.
16. Milton, W. E. J., (1940) 'The Effect of Manuring, Grazing and Cutting on the Yield, Botanical and Chemical Composition of Natural Hill Pastures. 1. Yield and Botanical Section', *J. Ecol.*, **28,** pp. 326–56.
17. Milton, W. E. J. and Davies, R. O. (1947). 'The Yield, Botanical and Chemical Composition of Natural Hill Herbage under Manuring, Controlled Grazing and Hay Conditions. 1. Yield and Botanical Section II. Chemical Section', *J. Ecol.* **35,** pp. 65–95.
18. Nicholson, I. A. (1969) Unpublished data. H.F.R.O.
19. Pearsall, W. H. (1964) 'The Mosses of the Stainmore District', *J. Ecol.* **29,** pp. 161–75.
20. Ratcliffe, D. A. (1964) 'Mires and Bogs' In *The Vegetation of Scotland*, Burnett, J. H. (Ed.), Edinburgh and London, Oliver & Boyd.
21. Floate, M. J. S. (1969) 'The Nutrient Cycle in Hill Soils with particular reference to the Mineralisation of Carbon, Nitrogen and Phosphorous from Plant Litter and Sheep Excrete' In 'Hill Land Productivity', *Occas. Symp. Brit. Grassld. Soc. No. 4,* pp. 149–55.

22. Munro, J. M. M. (1970) 'The Role of White Clover in Hill Areas' White Clover Research Symposium. Belfast. In press.
23. Heddle, R. G. and Herriott, J. B. D. (1968) Proc: Symposium of European Grassl. Ed. pp. 123–28.
24. Eadie, J. (1970) Unpublished data. H.F.R.O.
25. Black, J. S. (1970) Unpublished data. H.R.F.O.
26. Pearsall, W. H. and Gorham, E. (1956) 'Production Ecology I. Standing Crops of Vegetation' *Oikos* **7,** pp. 193–201.
27. Loach, K. (1968) 'Seasonal Growth and Nutrient Uptake in a Molinietum'. *J. Ecol.* **56,** pp. 433–44.
28. Grant, S. A. (1970) Unpublished data. H.F.R.O.
29. Hunter, F. (1962) 'Fertilizer Responses in Hill Grazings in North East England' Proc. European Conf. for Forage Production of Natural Grassland in Mountain Regions, pp. 131–36.
30. King, J., Grant, S. A. and Rogers, J. A. (1969) 'Hill Pastures' Rep. Hill Fmg. Res. Org. 1964–67, pp. 22–32.
31. Munro, J. M. M. (1968) 'Objectives in Hill Land Research' *J. Agric. Soc.*, Univ. Coll. Wales **49,** pp. 15–19.
32. Gunn, R. E. (1967) 'Lifetime Performance of the Breeding Ewe', H.F.R.O. 4th Report.
33. Russel, A. J. F. (1967) 'Nutrition of the Pregnant Ewe', H.F.R.O. 4th Report.
34. Peart, J. N. (1967) 'Lactation and Lamb Growth', H.F.R.O. 4th Report.
35. Russel, A. J. F. and Eadie, J. (1968) 'Nutrition of the Hill Ewe', *Occ. Symp. No. 4, Brit. Grassld. Soc.*
36. Eadie, J. and Cunningham, J. M. M. (1969). 'The Efficiency of Hill Sheep Production Systems', *Rep. Proc. Symp.* 'Crop Potential in the United Kingdom' (in press).
37. Eadie, J. and Black J. S. (1968). 'Herbage Utilisation on Hill Pastures', *Occ. Symp. No. 4, Brit. Grassld. Soc.*
38. Hunter, R. F. (1962). 'Hill Sheep and their Pasture; A Study of Sheep Grazing in South East Scotland'. *J. Ecol.*, **50,** pp. 651–80.
39. O'Toole, M. A. (1968). 'Grassland Research on Blanket Peat in Ireland', *J. Brit. Grassld. Soc.* **23,** pp. 43–50.
40. Moore, H. I. and Burr, S. (1948). 'Control of Rushes on Newly Reseeded Land in Yorkshire'. *J. Brit. Grassld. Soc.* **3,** pp. 283–90.
41. Lazenby, A. (1955). 'Germination and Establishment of *Juncus Effusus*', *J. Ecol.* **43,** pp. 103–19 and 595–605.
42. Pwllpeiran Experimental Husbandry Farm, Farm Guide and Report 1968, pp. 12–14.

LIST OF PUBLICATIONS

Bulletins

	Price	*Postage & Packing*
1. Farmers and the Common Market .. .. B. H. Davey and S. J. Rogers	5s 0d	6d
2. Efficiency in Agriculture and the Share of the Domestic Market .. .. J. Ashton	5s 0d	6d
3. Trends in Agriculture: A Review of Current and Future Developments .. .. B. H. Davey	5s 0d	6d
4. Elements of Agricultural Adjustment .. .. .. S. J. Rogers	5s 0d	6d
5. Farming Systems and the Common Market .. .. C. S. Barnard, H. Casey and B. H. Davey	10s 0d	1s 0d
6. Farm Size Adjustment .. .. A Workshop Report	5s 0d	6d
7. Capital Adjustment in Agriculture .. .. A Workshop Report	5s 0d	6d
8. A Discussion of Current Policies and the Future Structure of Agriculture .. .. A Symposium	10s 0d	1s 0d
9. Stability and the Beef Market .. .. A Unit Study	10s 0d	1s 0d
10. The Changing Agricultural Labour Force .. .. .. Implications for Training C. E. Heath and M. C. Whitby	10s 0d	1s 0d
11. A Comparison of Structural Policies in Agriculture .. S. H. Lane	10s 0d	1s 0d
12. Economic Aspects of the Dairy Manufacturing Industry .. A Workshop Report	10s 0d	1s 0d
13. Hill Sheep Farming Today and Tomorrow .. .. A Workshop Report	10s 0d	1s 0d

Books

Economic Change and Agriculture .. .. Edited by J. Ashton and S. J. Rogers (Oliver and Boyd 1967)	42s 0d	4s 6d
Research, Education and Extension in Agriculture .. Edited by J. Ashton and R. F. Lord (Oliver and Boyd 1968)	30s 0d	3s 0d

Technical Papers

		Price	*Postage & Packing*
TP1A.	Organisational Possibilities in Farming and Types of Business Organisation .. .. by M. A. Gregory and I. S. Stephenson	3s 0d	6d
TP2.	Life Assurance in the Farming Business .. .. by Leo Ménage	3s 0d	6d
TP3.	Management Techniques for Reducing Costs or Increasing Revenues .. .. by R. W. Helme	3s 0d	6d
TP4A.	Current Taxation and Some Future Possibilities .. by R. L. Herdman and I. Weir	3s 0d	6d
TP5.	Insurance in Agriculture .. .. by C. T. Jameson and J. Rawlings	3s 0d	6d
TP6.	Budgeting and Budgetary Control .. .. .. by J. C. Cole	3s 0d	6d
TP7A.	Estate Duty and Capital Gains Tax in Agriculture .. by C. Townsend	3s 0d	6d
TP8.	Modern Management .. .. by J. R. Gemmell	3s 0d	6d
TP9.	Agricultural Cooperative Activities and Case Histories of Cooperatives .. .. by D. G. Bailey and E. T. Gibbons	3s 0d	6d
TP10.	Human Factors in Agriculture .. .. by Dr. J. D. G. Troup	3s 0d	6d
TP11.	The Role of Ergonomics in the Efficient Utilisation of Agricultural Labour .. .. by J. Matthews	3s 0d	6d
TP12.	Efficient Labour Organisation .. .. by N. W. Dilke	3s 0d	6d
TP13.	Labour Relations in Farming .. .. by D. Hodsdon and J. N. Merridew	3s 0d	6d

Details of the publication programme and a subscription scheme can be obtained from the Administrative Officer of the Unit.

April 1970

Printed by Hindson Reid Jordison Newcastle upon Tyne W3533