OPTIMUM PROGRAMMES FOR WHEAT FARMS IN THE NORTH WESTERN SLOPE

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This article describes the second phase of a study of wheat farms in the North Western Slope of New South Wales. The first phase was concerned with obtaining input-output data for the various enterprises and methods of production found on these farms. A previous article[1] discussed the selection and reliability of the sample of farms used for obtaining the data and the validity of the estimates of the labour requirements for crop and livestock operations.

In this article the input-output data, suitably modified in some cases, is used to determine optimum programmes for wheat farms in the North Western Slope, where resources of land, labour and equipment are combined in varying proportions. The technique used is One-Resource-Variable Linear Programming.[2]

1. ACTIVITIES AND INPUT-OUTPUT COEFFICIENTS

The various activities are listed in Appendix I and their input-output coefficients appear in Appendix 2. The calculation of the "gross profit" row is given in detail for each activity in Appendix 3. Some brief comments are due. In Appendix 3, the number of tractor-days directly attributable

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[1] G. J. Tyler, "Labour Requirements on Wheat Farms in the North Western Slope of New South Wales", this *Review*, Vol. 31, No. 2 (June, 1963).

[2] For a simplified exposition of the technique see E. O. Heady and W. Candler, *Linear Programming Methods* (Ames: Iowa State University Press, 1958).

to each crop enterprise has been charged at £6.7 per tractor-day. This figure covers fuel, oil, grease and repairs to tractors and associated machinery. It is based on a linear regression analysis on the sample farms.[3] No great claim is made for the accuracy of the repairs figure, other than that it is probably of the right order of magnitude. When changes in costs that have occurred since 1951 are taken into account, the figure is fairly comparable with those given by Druce[4] for Central-Western wheat farms.

The input and output coefficients for feed have been calculated on a quarterly basis to take account of seasonal changes in both plant growth and livestock requirements. Livestock energy requirement are as recommended by McClymont[5] and are listed in Appendix 4.

In attempting to relate the output of feed crops and pastures to the input requirements of livestock there are many problems, some of which are:—

(*a*) Few farmers keep records of yields of feed crops and pastures. This is probably partly due to the fact that, unless they are harvested for hay, etc., this is a virtually impossible task for a farmer. Recourse has therefore to be made to experimental results from research stations or field trials conducted on farms.

There can be a very large variation in the recorded yields of dry matter, starch, etc., from one trial to another and from year to year. The farms on which trials are held are not necessarily "average" and, in any case, there is the further problem of translating the results from plot experiments into those that could be expected under commercial farming conditions.[6]

(*b*) There is a suggestion that, at least as far as sub-tropical grasses (which are of prime importance in the north west wheat belt) are concerned, "feeding standards based on starch equivalents and total digestible nutrients which are used in temperate environments are highly inaccurate when applied to these sub-tropical species".[7]

(*c*) There is the problem of disparity between the yield of nutrients of a pasture or feed crop when cut and when grazed by livestock, i.e. the problem of utilization.

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[3] The regression equations were

(*a*) $Y = 19 \cdot 8 + 3 \cdot 13X \quad (r = 0 \cdot 67^{xxx})$
where Y = total fuel cost on farm (in £)
X = total tractor days

(*b*) $Y = -90 \cdot 9 + 3 \cdot 57X \quad (r = 0 \cdot 77^{xxx})$
where Y = total repairs to tractors and machinery (£)
X = total tractor days

Tractor days per farm were estimated from the total acreage of crops and pasture.

[4] P. C. Druce, "The Cost of Operating Farm Machinery on Central-Western Wheat Farms", this *Review*, Vol. 19, No. 3 (September, 1951).

[5] G. L. McClymont, "Hand Feeding of Sheep", *Agricultural Gazette of New South Wales.* Vol. 67, No. 10 (October, 1956).

[6] See B. R. Davidson, "Crop Yields in Experiments and on Farms", *Nature,* Vol. 194, No. 4827. (May 5, 1962.)

[7] R. Milford, "Criteria for Expressing Nutritional Values of Sub-tropical Grasses", *Australian Journal of Agricultural Research,* Vol. 11, No. 2 (March, 1960).

(*d*) The possible difference between the nutritive requirements of grazing livestock and those estimated from pen-feeding experiments presents further difficulties. Fels and others state "there are no generally accepted figures for the maintenance requirements of grazing sheep".[8]

In view of these difficulties it was decided to attempt to directly relate the feed requirements of livestock and the output of feed crops and pastures. A multiple linear regression analysis[9] was carried out on the survey data. Farms on which any cereal grains or purchased fodder were fed were excluded from the analysis, as there was no accurate information on what quantities had been used. For similar reasons, farms with irrigation were excluded.

With some modifications the regression coefficients were used as estimates of the feeding value, in thousands of pounds of utilized starch equivalent, of grazed cereals, improved and natural pastures, respectively. Again, no great accuracy is claimed for the coefficients but they are probably of the right order of magnitude. If the actual level of the feeding standards recommended by McClymont is, for example, too high, then the coefficients will to that extent be too high. However, as long as these standards (Appendix 4) are in approximately the right *ratios* for the different classes of livestock, then the coefficients for the different types of feed crop also should be approximately in the right ratio, amongst themselves and in relation to the feed requirements of livestock. It should be noted that the form of the analysis implies that in this study the relationship between sheep and cattle in regard to feed is assumed to be competitive. The actual *distribution* of the total yield for each crop over the four quarters of the year has been based on the evidence of Departmental field trials.

Labour coefficients (see Appendix 5 for details) were discussed in a previous article.[10] In that article, there was evidence of economies of scale in labour use for certain livestock operations. However, though there are procedures for handling this sort of situation in linear programming,[11] routines for electronic computation on SILLIAC, the Sydney University computer used for this study, are not yet available. Handling the problem

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8 H. E. Fels, R. J. Moir, and R. C. Rossiter, "Herbage Intake of Grazing Sheep in South-Western Australia", *Australian Journal of Agricultural Research*, Vol. 10, No. 2 (March, 1959).

9 The regression equation was

$$Y = 117 + \cdot 456X_1 + \cdot 534X_2 + \cdot 417X_3$$

where Y = S.E. requirement in thousands of lb.
X_1 = acreage of grazed cereals
X_2 = acreage of lucerne, sorghum almum and Sudan grass
X_3 = acreage of natural pasture
$R = \cdot 89$ ($n = 27$)

10 Tyler, *op. cit.*

11 See for example—

H. Giaever and J. Seagraves, "Linear Programming and Economies of Size", *Journal of Farm Economics*, Vol. 42, No. 1 (Feb., 1960).

W. Candler and R. Manning, "A Modified Simplex Solution for Problems with Decreasing Average Costs", *Journal of Farm Economics*, Vol. 43, No. 4 (Nov., 1961).

W. F. Musgrave, "A Note on Integer Programming and the Problem of Increasing Returns", *Journal of Farm Economics*, Vol. 44, No. 4 (Nov., 1962).

with existing routines would have proved cumbersome and costly and it was decided that the extra cost could not be justified in relation to the removal of the small errors that might be involved in assuming linearity, i.e., no economies of scale.

Some flexibility in the time at which operations are carried out has been introduced in both crop and livestock operations. There is some evidence from Departmental field trials that there is a relationship between the time elapsing between the date of first ploughing and the subsequent yield of wheat, possibly connected with nitrification under fallow. This has been allowed for by having three activities P_1, P_2, P_3 for wheat growing, differing only in the date of initial ploughing and their gross profits.

As regards sheep, it has been assumed that crutching or shearing should be carried out in (i) September *or* October and (ii) February, to act as a control of fly-strike in the worst periods. Thus, if shearing is carried out in September or October, crutching will be in February and vice-versa. Various other livestock operations (see Appendix 5) have certain dates attached to them, e.g., pre-lamb drenching of ewes but there are a certain number of operations which need not necessarily be carried out at a particular time but can be fitted into the farm organization when convenient. The labour requirements for these operations are aggregated and are included in the "total" row but do not appear in any of the rows for "monthly" labour coefficients.

Activities for the production of oats for grain and barley for grain have not been included. These crops require approximately the same resources as wheat and produce similar yields in the area but oat and barley prices are substantially lower than that for wheat. Thus, unless there is a good technical reason for including these crops in the rotation, wheat would take precedence in planning a farm programme, though this is not to say that oats or barley might not have to be sown in a particular season as a second best.

2. RESOURCE RESTRICTIONS

Land has been assumed to be homogeneous and all potentially arable. With the technique of One-Resource-Variable Linear Programming the acreage of land available is allowed to vary continuously from zero upwards.

Survey results indicate that about 90 per cent of farms in the North Western Slope have a labour force (including the farmer) of 3 full time workers or less. Though casual or contract labour is probably available throughout the year, most farmers appear to prefer to restrict their use of casual or contract labour to crutching, shearing and, sometimes, cereal harvesting. In this study therefore it has been assumed that such labour is used for crutching and shearing in all cases and that an extra man is hired for cereal harvesting in the case of the one-man farm.

Monthly labour restrictions have been taken as 30 man-days for each full-time worker, which allows labour to work 56 hours per week for a month if this is necessary at busy periods. However, to allow for holidays, weekends, days of sickness, etc., the usual figure of 275 man-days per man is taken as the total labour available over the year. The previous article on labour requirements [12] showed that about 36 per cent of the labour available is required for work of an "overhead" nature, such as repairs and maintenance to plant and machinery, fencing, etc., which can generally be fitted-in during the slacker periods of the year. Thus it has been assumed that 175 man-days per man are available for direct crop and livestock work.

Interest lies not only in the differences in optimal programmes and profits between one, two and three-man farms but also in differences associated with different complements of machinery. For example, it would be interesting to know whether it would be worthwhile purchasing a second tractor and its complement of cultivating equipment to allow expansion of cropping on a two-man farm, largely devoted to sheep. Thus corresponding restrictions have been placed on the availability of tractor-days. It will be noted that the tractor coefficients for each crop activity are identical to those for labour, except for cereal harvesting and hay-making, when, for example, there may be two men required but only one tractor.

Wheat and sorghum harvesting restrictions have been included to restrict the availability of labour for two-man harvesting systems to two men. These restrictions are only operative on the three-man farms.

There remains the question of timeliness of operations. Ideally, information would be required on the expected number of days that would be suitable for carrying out each operation in relation to the weather and the nature of the soil, the variability from year to year and the effect on yields of carrying out each operation at less suitable times. Little information is available and it has therefore been assumed that crop and livestock operations will only be limited by the restrictions on labour and tractor resources in the months specified for each operation.

Capital has not been included as a restriction as it is considered that there appears to be no fundamental reason why "working" capital, i.e. for purchase of livestock, materials, payment of labour, etc., should be restricted to any particular level. Except for periods when a government "credit squeeze" is in operation, it would appear that, as long as it could be shown by properly prepared budgets and capital budgets that a particular programme should be profitable and that the loan could be repaid in a reasonable time, the necessary short or medium term capital would generally be forthcoming.

In this study therefore it has been assumed that working capital is not a limiting resource and a 6 per cent interest charge on direct costs and livestock capital, where applicable, has been added to the costs of each activity.

There are several ways of handling the problem of crop rotations and the maintenance of soil fertility and crop yields, when using linear programming, which, of course, assumes independence of the activities. One way is to assume that a rotation is not necessary to maintain soil fertility and crop yields, at least within the planning horizon.[13] When there is little or no evidence from long-term experiments about the fertility-depleting

[12] Tyler, *op. cit.*

[13] This is the implicit assumption in:—

"The Economics of Crop Fattening of Beef Cattle in Southern and Central Queensland 1959." Bureau of Agricultural Economics, Canberra and Department of Agriculture and Stock, Queensland. (August, 1960.)

or fertility-building properties of different crop successions in a region, this may be a justifiable first approximation and in any case may form a basis with which comparisons can be made. In some parts of the northwest it may even be quite close to reality, as there is some evidence of particular farms where wheat has been cropped continuously for two or three decades with no *apparent* loss in soil fertility or in crop yields.

A second method is the one most commonly adopted[14] of representing a whole rotation by one activity. For example, P_1 might represent the rotation wheat, wheat, wheat, barley, oats, oats, P_2 the rotation wheat, wheat, wheat, barley, oats, sorghum and so on. The drawback of this method is that a different activity is needed for each rotation and with only a small number of crops the possible theoretical combinations of crops over say a 6-year period would be truly enormous. It is likely that there would be only information from experiments for a small number of such combinations, in any case, so that the coefficients (inputs of fertilizer, crop yield, etc.) for other combinations would have to be guessed. Further, the optimal programme may include a number of activities (equal to the number of limiting resources), meaning that a number of different rotations would have to be followed simultaneously on the same farm, which may be a little impractical.

A third way of meeting the problem is to assume that each crop (represented by one activity) is independent but maxima or minima are specified for certain crops or groups of crops. For example Barnard and Smith[15] specified that at least 20 per cent but not more than 35 per cent of the arable acreage should be devoted to leguminous crops. This method allows a certain amount of flexibility to the cropping programme. However, there is sometimes the drawback that the final solution involves crop activities in such proportions that it is difficult to synthesize a practical rotation that will correspond to these proportions.

Fourthly, there is the method by which certain crop activities have resource requirements which can be met only by the outputs of other activities. This is the method adopted in this study. Referring to Appendix 2 it will be seen that there is a "legume" row, with positive entries for the cereal crop activities and negative entries for the lucerne activities. This appears to be the simplest way to meet a situation in a

[14] See for example:—

G. A. Peterson, "Selection of Maximum Profit Combinations of Livestock Enterprises and Crop Rotations", *Journal of Farm Economics,* Vol. 37, No. 3 (August, 1955).

P. Duane and A. H. Rowe, "Planning the Response to Economic Change on an Irrigated Farm", *Quarterly Review of Agricultural Economics,* Vol. 13, No. 1 (January, 1960).

I. G. Simpson, "Linear Programming for Increased Farm Profits—A Yorkshire Example", *Farm Economist,* Vol. 9, No. 7 (1960).

[15] C. S. Barnard and V. E. Smith, "Resource Allocation on an East Anglican Dairy Farm", Occasional Papers No. 6, Farm Economics Branch, School of Agriculture, Cambridge, 1959.

See also:—B. Bowlen and Earl O. Heady, "Optimum Combinations of Competitive Crops at Particular Locations", Agricultural Experiment Station, Iowa State College, Research Bulletin 426 (April, 1955). Ames, Iowa.

G. J. Tyler, "An Application of Linear Programming", *Journal of Agricultural Economics,* Vol. 13, No. 4 (January, 1960).

region where there are no detailed long-term rotational experiments but where there is evidence of nitrogen levels declining after years of cultivation[16] and where the nitrogen level can be raised by periods under lucerne. In the work cited it was stated that similar nitrogen loss occurred under a wheat/grazing oats rotation as under a continuous wheat programme. Also, it was stated that the regeneration of native medics under the short periods of return to natural pasture, raises the nitrogen level to a negligible extent.

The actual size of the legume coefficients adopted, which require a minimum legume acreage, equivalent to the total cereal acreage, was suggested by discussion with Departmental agronomists.

Finally, a combination of two or more of the various methods can be adopted. Waring and others[17] in a linear programming study in a particular area in the north west, used a combination of the second and fourth methods.

3. SOLUTIONS

OPTIMAL PROGRAMMES

The results of the application of One-Resource-Variable Linear Programming are given in Appendix 6 for one-man, one-tractor farms; two-man, two-tractor farms and three-man, two-tractor farms. Some discussion of other resource combinations is given in later sections in the text. It should be noted that, due to the linearity assumption, optimal programmes for farm sizes other than those given in the tables can be obtained by linear interpolation.

It will be noticed that the three sets of programmes exhibit very similar patterns of enterprise combinations. Each set of programmes at some stage or other includes wheat ploughed in November or December, (P_1), lucerne hay fed in winter (P_7) both systems of grazing lucerne (P_8 and P_9), autumn-lambing Crossbred ewes (P_{14}), spring lambing Merino ewes (P_{19}) and beef cows (P_{24}).

For farms of up to 1,450 acres, wheat occupies half the farm acreage which is the maximum consistent with the legume constraint, the other half being occupied by lucerne. With greater farm acreages no further expansion of wheat cropping is possible due to limitations of labour at harvesting. On two-man farms the expanding farm acreage is devoted entirely to natural pasture but on three-man farms additional farm acreage is devoted first to sorghum (and lucerne) and later to natural pasture.

Lucerne is never included at an acreage greater than the minimum necessary to satisfy the legume constraint. It is at first utilized as hay and grazing for sheep but as farm size increases beef cattle substitute for the sheep. On one-man farms at the maximum acreage lucerne is not utilized at all as it is not profitable to carry any livestock (but see below for possible "hidden costs" of non-utilization).

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[16] E. G. Hallsworth, F. R. Gibbons and T. H. Lemerle, "The Nutrient Status and Cultivation Practices of the Soils of the North-West Wheat Belt of New South Wales", *Australian Journal of Agricultural Research,* Vol. 5, No. 3 (July, 1954).

[17] E. J. Waring, J. D. Fahy, and N. H. Sturgess, "Farm Planning in Graman District, N.S.W.—A Linear Programming Study of Adjustment Possibilities for Some Soldier Settlement Farms", this *Review,* Vol. 31, No. 3 (September, 1963).

RESOURCE MARGINAL PRODUCTIVITIES

The marginal productivities of limited resources and intermediate products are given in the tables. Land is a limited resource up to 1,300 acres on one-man farms and up to 20,000 acres on two-man and three-man farms. Beyond these acreages the marginal product of land falls to zero.

Winter feed is limited in all programmes, its marginal value varying between £6.0 and £11.3 per thousand lb. of starch equivalent. Translated into terms of lucerne hay, with a starch equivalent content of 35 per cent this is equal to a price of between £4.8 and £9 per ton. In terms of oat grain it equals a price of between 3s.3d. and 6d. per bushel. The values of spring, summer and autumn feed are in all cases less than that of winter feed and with the larger acreages they have no value, being in surplus supply. The amounts of surplus feed supplies are given in the tables and it will be seen that at the larger acreages they run into the equivalent of thousands of tons of hay. Such excessive waste of feed prompts one to consider whether it could not be utilized in some way, either by conservation for feeding later in a period of short feed supply or by direct grazing.

A further consideration is that there may be costs associated with non-utilization of pastures, especially lucerne, which have not been taken into account, e.g., reduced effectiveness of lucerne for fixing nitrogen due to deterioration of the sward from allowing rank growth and the effect of absence of livestock on the soil-fertility cycle.

The costs of conserving feed as hay depend on the time of the year for conservation. For example on the two-man farm of 5,350 acres, if the surplus feed was conserved in the November-December period, the following costs would be incurred in conserving and feeding each ton of hay.

	£
Direct costs of fuel, repairs, twine, etc.	2.8
.22 Man-days Nov.-Dec. labour x £15.2	3.3
.32 Man-days total labour x £8.7	2.8
Total	8.9

However, if conserved in some other period, such as January, when labour was not limited, the cost would be £5.6. Conserved hay fed out in winter has a value of £9 per ton so that it would be profitable as long as hay-making took place at any period other than November or December. This statement holds, of course, only for the range over which the marginal productivities remain as stated above. In the example quoted, there are thirty man-days of January labour available for hay-making, which would allow only about 130 tons of the surplus to be conserved before the marginal productivity (opportunity cost) of January labour rose from zero to some positive quantity. Another alternative, where farm labour was in short supply, would be to engage a contractor to bale some or all of the hay.

As regards additional livestock to make use of the surplus feed *in situ*, it is obvious that only a livestock enterprise other than those specified in Appendix 3 could be considered as a possibility. Such an enterprise would need to make little or no demand on winter feed supply, which, in the example quoted, has an opportunity cost of £11.3 per thousand pounds starch equivalent. It is possible that the fattening of store sheep or cattle, purchased in the spring and sold in the autumn, would be such an enterprise. Another possibility would be leasing the grazing to other farmers.

The marginal productivity of "legume" is at a maximum of £3.4 per acre at the lower acreages and falls with increasing farm size. This figure is a measure of the value of the soil-fertility building properties provided by the lucerne crop. Lucerne is of value in the cropping programme as a provider of grazing during the spring, summer and autumn, of conserved hay fed in the winter and because of its soil-building properties. It is interesting to note its changing role with increasing farm size. As farm size increases the relative importance of the provision of winter feed increases whilst the provision of feed at other times of the year and the soil-building property of lucerne decrease in relative importance.

Total annual labour is not a limited resource on one-man farms up to 670 acres, on two-man farms up to 1,217 acres and three-man farms up to 1,800 acres. Thereafter it has a marginal productivity of £6.4 per man-day and increases with increasing farm size to maxima of £16.8 per man-day on one-man farms and £28.7 per man-day on two and three-man farms. It is apparent, with such figures, that additional labour could profitably be employed at the margin. Casual labour, if available, would cost approximately £4 per man-day.

Labour at certain times of the year has an even higher marginal productivity. On two-man farms over 1,450 acres and up to 8,600 acres, labour in November has a marginal productivity of £44 per man-day. On three-man farms, the "wheat harvesting labour" constraint, which restricts the availability of labour for the two-man harvesting system to two men, has a marginal productivity of up to £69 per man-day.

These figures for labour productivity can be used as a guide to the profitability of employing a different technique or method of production. For example, the labour coefficients for wheat assume a two-man, bag-to-bulk harvesting system. However, on two-man farms, labour is not fully used until a farm size of 1,217 acres is reached, i.e. with a wheat acreage of 609. Thus it would be profitable to employ a two-man bagging system, which needs more labour per acre but obviates the need for bulk trucks, at least up to the point where labour is fully used. This occurs at 585 acres of wheat.

A fully bulk system would incur an annual cost, for depreciation and interest on bulk equipment, of about £150. It would save 0.016 man-days per acre of wheat. On the two-man farm of 1,217 to 1,416 acres, the marginal value of labour is £6.5 per man-day so that a bulk system would save £0.1 per acre of wheat at the margin. The break-even point occurs at a farm size of 1,430 acres, i.e., with a wheat acreage of 715.

Similar calculations for the one-man farm would indicate that a two-man bagging system could be used up to at least 320 acres of wheat and that the break-even point for a bulk system occurs at about 550 acres.

However, because of difficult seasons and the value of quicker harvesting in such circumstances, the bag-to-bulk and fully bulk systems are likely to be economically justified at acreages much lower than those calculated.

The discussion does, however, illustrate that break-even acreages for various wheat-harvesting systems are likely to differ between farms of differing size of labour force.

STABILITY OF PROGRAMMES

Under the set of assumptions of prices, costs and input-output relationships given in Appendix 3, the programmes give the most profitable combination of enterprises. However, under another set of assumptions they are not likely to be the most profitable. Due to the possibility of error or uncertainty in the original assumptions, it is informative to see to what extent they can differ from the original assumptions before the programmes are no longer optimal. This will be a test of the "stability" of the programmes.

The marginal cost figures given in the tables measure the loss in profit that would be incurred by including these enterprises in the programmes. Thus, for example, on a two-man farm of 1,430 acres, if oats for grazing (P_5) were included in the farm programme there would be a minimum loss in profit of £6.9 per acre. This also means that the total return from grazing oats would have to rise by at least £6.9 per acre before it would be profitable to include it in the programme and thus change the programme. The likelihood of this occurring is very small as can be seen by examining the structure of costs and returns for grazing oats.

Returns		£
Winter feed .3 thousand lb. SE x £8.6		2.6
Spring feed .15 thousand lb. SE x £1.9		.3
		2.9
Costs		
Land 1 acre x £3.6	3.6	
Legume 1 acre x £3.1	3.1	
Nov./Dec. labour .042 man-days x £4.5	.2	
Total labour .18 man-days x £6.8	1.2	
Direct costs	1.7	
		9.8
Profit		— 6.9

For returns to be at least as great as costs they would have to be increased over threefold. However, on three-man farms of 2,640 acres the marginal cost of grazing oats is only £0.74 per acre and a 25 per cent increase in production would bring this enterprise into the programme. Similar calculations can be performed for other enterprises not included in the optimal programmes.

Attention is now turned to enterprises which are included in the programmes and changes in the assumptions on which they are based. The discussion which follows is based on calculations performed only on the programmes for two-man, two-tractor farms[18] but the remarks will probably substantially apply to programmes for other sizes of labour force and equipment.

The profit on wheat (P_1) could drop, from £9.3 per acre, by £4.4 per acre on farms up to 1,217 acres, and by £4.7 per acre on farms between 1,217 and 1,416 acres before the programmes were no longer optimal. The minimum drop in profit is £3.3 per acre on farms between 1,446 and 5,352 acres. A drop in profit of £3.3 could be brought about by a drop in average yield from 20 to 15.3 bushels per acre or by a drop in price from 14 to 10.5 shillings per bushel. In each case such changes in wheat profits would make it profitable to bring sorghum (P_4) into the programmes.

It is not proposed to discuss in detail the changes in profits of other enterprises included in the programmes necessary to bring about changes in those programmes. The profits on the lucerne activities and natural pasture are unlikely to be much in error. As regards the livestock enterprises, quite small changes in some cases are enough to make changes in the programmes necessary. For example the profit on Merino ewes lambing in spring (P_{19}) in the programme is £3.2 per ewe. The valid range for the profit on farms between 1,217 and 1,416 acres is £3.05 to £3.3 per ewe. Below £3.05 it is profitable to bring Crossbred ewes, lambing in spring, (P_{16}) into the programme. A drop of £0.15 per ewe could be brought about by a lambing percentage lowered from 80 to 75 per cent. On the same size of farms, the valid range for Beef Cows (P_{24}) is £18.5 to £30.8, the profit in the programme being £20 per cow. A drop of £1.5 profit per cow would result from a vealer price lowered from 2s. to 1s. 10d. per lb.

Thus quite small changes in the profits of the livestock enterprises, in many cases, necessitate changes in the optimal programmes, with usually the substitution of one livestock enterprise for another.

OPTIMAL FARM SIZES AND RESOURCE COMBINATIONS

Optimal programmes for given farm sizes and given sizes of labour force and equipment have been presented. These programmes can be used to answer two questions:—

(1) With given farm sizes what is the best size of labour force and number of tractors?

(2) With a given number of men and tractors what is the best size of farm to operate?

The first question can be answered by finding that point at which the additional cost of employing an extra man or tractor is equal to the additional returns. The additional returns can be found by a comparison of the gross profits of programmes for farms with differing numbers of men

[18] The procedure necessitates the printing-out of the full matrix at each change of basis. The modified M36 routine used for this took 24 minutes machine time compared to a normal 5-7 minutes. With limited research funds the procedure could not be adopted for all programmes.

and tractors. The annual cost of a full-time worker is taken as £850 and that of a tractor and its complement of cultivating equipment calculated as follows:—

Purchase Price	£	*Annual Fixed Cost*	£
Tractor	1,400	10 per cent depreciation	250
7-ft. Disc plough ..	400	6 per cent interest on half price	75
8-ft. Scarifier	200		
24-ft. Diamond harrows	100		
16 run Combine drill ..	400		
	£2,500		£325

Taking one man and one tractor as the starting point, additional cost of a second man equals additional returns at approximately 1,000 acres. Below 1,000 acres the employment of a second man cannot be economically justified. The best size of labour force and number of tractors, etc., for different farm sizes is summarized below:—

Farm Acreage	*No. Men*	*No. Tractors*
Less than 1,030	1	1
1,030–1,179	2	1
1,180–1,559	2	2
1,560–24,999	3	2
25,000 and over	3	3

In practice, because of difficult seasons the purchase of an extra tractor would probably be economically justified at acreages lower than those shown above. Thus, because of the small acreage range between the one-man, one tractor and two-man, two-tractor situations above, the intermediate stage of two-man, one-tractor has probably little practical significance. However, there is a very large increase in farm size necessary before a third tractor could be justified. It is obvious that at these higher acreages what is required is an extra header and a larger labour force, as well as extra tractors.

We now turn to the question of the optimum size of farm with a given number of men and tractors. This will be found by equating the marginal cost and marginal value product of land. The latter has been given in an earlier section for different farm sizes. This is an *annual* value and thus an annual marginal cost figure is required. The average purchase price of arable land in the North Western Slope is in the order of £20 per acre. At 5 per cent interest (20 years' purchase) the annual cost would be £1 per acre. Equating this with marginal value products the following optimal sizes of farms are discovered:—

No. Men	*No. Tractors*	*Farm Acreage*	*Gross Profit* (£)
1	1	1,296	5,768
2	1	1,355	6,904
2	2	1,446	8,112
3	2	2,002	10,244
3	3	2,156	10,512

In answering the two questions posed, some interesting light is shed on the problem of optimal farm organization. It is apparent, given the costs of land, labour and equipment, that though the employment of a second tractor can be justified on a farm of 1,200 acres, it would be a better combination of these resources if land could be increased to 1,446 acres. This is more easily seen by the following calculations for various alternatives for a farm of 1,200 acres which is at present employing two men and one tractor, with an optimal profit of £6,726:—

(i) Purchase of additional land bringing farm size up to 1,355 acres.

	£
Additional returns £6,904–£6,726	178
Additional costs 155 acres x £1.0	155
	23

(ii) Purchase of additional tractor.

	£
Additional returns £7,100–£6,726	374
Additional costs	325
	49

(iii) Purchase of additional tractor and additional land bringing farm size up to 1,446 acres.

		£
Additional returns £8,112–£6,726		1,386
Additional costs—	£	
Land	246	
Tractor	325	
		571
		815

It is obvious that profit is increased by employment of even more land, labour and tractors. However, it will be seen, by deducting fixed costs of additional land, labour and tractors, that profit is at a maximum with three men and two tractors on a farm of 2,000 acres. Additional land and a third tractor are not employed economically, the limiting factor being the possession of only one harvester. In practice, of course, limited capital or some other factor, such as risk, will limit the indefinite expansion of the farm business by purchase of additional land and equipment and employment of additional labour.

The discussion on optimal farm sizes has some implications for policy-making, especially in regard to closer settlement. Once farms of certain sizes have been established, with buildings and equipment, it is usually extremely difficult to change the size of farm at a later date. It is thus of paramount importance to make farms of the "right" size when they are initially established. The right size will vary due to varying input-output ratios on individual farms, because of different management, soil, etc. However, the above analysis suggests that, on average, and with present prices, costs of land, labour, etc., a wheat farm in the North Western Slope should not be less than 1,300 acres in size. This is the optimal size of farm when run by one man, with casual help at harvesting; but it can be argued that a one-man farm can be very vulnerable because of sickness of the one operator. Moreover, social as well as economic considerations may suggest that a desirable closer settlement policy would centre around the establishment of two-man farms, which could be run by a farmer and a son. In this case the optimal size would be about 1,450 acres. Where land which is not potentially arable has to be included in the farm acreage, even greater acreages would be necessary.

The optimal size of farm for a given size of labour force differs markedly from that size that would just give a return to the farmer of a farm worker's wage and five per cent interest on capital, after covering all other costs. This "minimum" size for a two-man farm would be about 750 acres of arable land. At this acreage no return for the farmer's management or risk-bearing would be forthcoming. Thus a closer settlement policy which uses as its criterion that size of farm which gives a return to the farmer equal only to a farm-worker's wage is likely to lead to the establishment of farms that are much too small to allow an optimal allocation of resources.

COMPARISON OF ACTUAL AND OPTIMAL PROGRAMMES

The preceding sections have presented optimal solutions given the basic farm input-output data and on the assumption that profit is to be maximized. It now remains to see to what extent these programmes differ from those that are actually at present being followed on wheat farms in the North Western Slope. The evidence for the latter is based on the survey data from the 66 sample farms and, as there were only 6 farms with a labour force of three, discussion is restricted to one and two-man farms.

The actual farm programmes followed in the North Western Slope differ so much from farm to farm that to give a detailed presentation of how they differ from optimal programmes would require an extended analysis. Crop rotations vary from continuous wheat cropping, through alternate wheat/fallow and wheat/grazing oats rotations to those involving about half the acreage in lucerne and the other half in cereals. It is intended here only to describe the broad differences between actual and normative programmes for one and two-man farms, which account for about two-thirds of the sample, and, in more detail, for a "typical" farm situation.

The median size of a one-man farm is approximately 600 acres of which 350 acres is arable, the rest being in natural pasture. Wheat accounts for 130 acres, the rest of the arable area being devoted to oats, barley and sorghum for grain, cereals for grazing, lucerne and sown grasses such as Sudan grass and sorghum almum. About 400 Merino ewes and 100 wethers are carried, together with five beef cows and followers.

The optimal programme for a one-man farm of such size would have all the farm under arable, half being under wheat, i.e. 300 acres, and the rest under lucerne. About 330 ewes would be carried, some Crossbred and some Merino, but no wethers or beef cattle. The wide divergence between the actual average size of one-man farms and the optimum of 1,300 acres is to be noted.

The median size of two-man farms is approximately 1,200 acres, with 650 acres arable and the remainder in natural pasture. The wheat acreage is 250 and the rest is devoted to the same crops described for the one-man farms. About 650 Merino ewes and 150 wethers together with 20 beef cows are carried. An optimal programme for such a farm would have 600 acres of wheat and 600 acres under lucerne. The same number of ewes would be carried, i.e., 650, but over a third would be Crossbreds and, again there would be no wethers or beef cattle carried. In the case of two-man farms the average size does not differ so markedly from the optimal size of 1,450 acres.

The programme for an actual farm is now presented in more detail. This farm has been picked out as it possesses certain characteristics which have a value approximating the median value, e.g. farm size, labour force, arable acreage, etc. In the sample there is no farm which possesses *all* characteristics with a value approximating to the median. The average cropping and livestock programme for this farm is as follows:—

	Acres	
Wheat for grain	250	
Oats for grain	100	Fed to livestock
Oats for grazing	120	
Sorghum for grain	120	
Lucerne for hay	30	
Lucerne for grazing	70	
	690	
Natural pasture	520	
	1210	

500 Merino ewes, breeding own replacements, spring lambing.
25 Beef cows.

Using average figures the gross profit for this programme can be calculated:—

	Gross Profit £	£
Wheat 250 x £9.3	2320	
Sorghum 120 x £4.9	590	
Merino ewes 500 x £3.2	1600	
Beef cows 25 x £20	500	
		5010
Oats for grain 100 x —£2	—200	
Oats for grazing 120 x —£1.7	—205	
Lucerne hay 30 x —£3.1	— 90	
Lucerne grazed 70 x —£0.2	— 15	
		—510
Total gross profit		4500

The optimal programme for such a farm would make fuller use of the labour available and give a gross profit of £7,100, an increase of 58 per cent. It would also be more likely to maintain soil fertility.

It will have been noticed that in the optimal programmes for one, two and three-man farms, natural pasture only enters after the optimal size of farm is reached. Up to this stage the value of arable land exceeds that of land which can only be used for natural pasture. This latter value can be calculated by subtracting the marginal cost figure for natural pasture from the marginal productivity figure for land (arable land). Thus on the two-man farm the marginal value of such land is £2.0 per acre up to 1,217 acres, £1.0 per acre up to 1,416 acres, £0.8 per acre up to 1,431 acres and £0.4 up to 1,446 acres. After the optimal size of farm is reached the marginal value of arable and pasture land are equal.

It is obviously profitable to convert natural pasture into arable land as long as the annual charge for the capital cost of clearing is less than the difference in annual value between arable and pasture land. However, there will be many areas which it would be impossible or highly costly to convert to arable land. The optimal programme for a farm with a fixed amount of land in natural pasture will differ from those given in this study and in fact a whole series of programmes for each size of farm with a varying proportion under natural pasture would be required. Waring and others[19] have calculated programmes for a 1,000-acre farm with arable land varying from zero to 100 per cent of total acreage.

4. CONCLUSIONS

There is little doubt that, as long as yields do not drop catastrophically, the most profitable programme for wheat farms in the North Western Slope is to crop continuously with wheat. However, there is evidence that this state of affairs cannot continue indefinitely because of loss of soil fertility and even soil erosion. This is not the place to enter into a discussion of the possible conflict between the interests of an individual farmer in this connection and those of the nation or society at large. Sooner or later the need for the restoration and maintenance of soil fertility becomes of paramount importance. With the present state of the arts, a legume crop, and in the north west this implies lucerne, seems to be the best way of bringing this about. Under the assumption of equal periods under cereals and lucerne, the optimal programmes presented in this study follow logically.

Lucerne not only satisfies the "legume" constraint but, together with associated grasses, provides feed throughout the year which is most profitably utilized by a varying combination of Merino and Crossbred ewes and beef cattle. This provision of feed, through grazing and conservation of hay, obviates the necessity of growing other feed crops such as cereals for grain, hay or grazing. Moreover, though in all cases winter feed is limited, its marginal value, equivalent to prices of £4.8 to £9 per ton of hay and 3s. 3d. to 6s. per bushel of oats, is such that the purchase of feed to increase the carrying capacity of the average farm is also unlikely to be profitable. Very much more lucerne hay would need to be conserved, however, than is done at the moment.

Comparison of optimal programmes with what is currently being practised on average farms suggests that much greater profits could be earned by a movement towards these optimal programmes. This would entail a greatly extended arable acreage by the conversion of natural pasture possessing arable potential. Due to the greater carrying capacity of lucerne about the same total number of livestock could still be carried. Though linear programming solutions are often open to the criticism that they lead to unnecessary diversification of enterprises, due partly to ignoring the benefits of specialization and economies of scale, it is obvious that in this particular study the programmes are more simplified than most of those currently practised.

[19] E. J. Waring, J. D. Fahy and N. H. Sturgess, *op. cit.*

Though quite small changes in the profits assumed for the livestock enterprises are likely to necessitate changes in the programmes, these changes would only involve minor adjustments to the composition of the livestock activities, e.g. the substitution of Crossbred ewes for Merinos. No change in the programme for the typical type of farm, viz. the two-man farm, is necessary until the price of wheat falls at least below 10s. 6d. per bushel and this is likely to apply equally to farms with other sizes of labour force. On the whole, the broad outlines of the programmes presented are likely to remain valid in the face of fairly substantial changes in the enterprise profits assumed.

For most farmers the size of their farm is fixed and the only alternative open to them is to vary the amount of labour and equipment employed. The solutions presented here suggest that the minimum size of farm to justify the employment of two men is about 1,000 acres, of two men and a second tractor about 1,100-1,200 acres and of a third man about 1,500-1,600 acres. However, it is sometimes possible to vary farm size by purchase of additional land, by selling superfluous land and when a farm is first established on new land or a large property resumed for the purpose. In such cases optimal combinations of land, labour and equipment are obtained on farm sizes of about 1,300 acres for one man, about 1,450 acres for two men and two tractors and 2,000 acres for three men and two tractors. There is a wide divergence between the optimal size and the median size of one-man farms and, to a lesser extent, between the optimal and median size of two-man farms. In most cases little can be done about existing farms but it is important that, in the formulation of future closer settlement policy, greater emphasis is placed on the "optimum" rather than the "minimum" concept of farm size.

In the presentation of optimal programmes in this study it is by no means implied that all wheat farms in the North Western Slope should adopt them. Differences in farmers' objectives, input-output relationships, attitude to risk, and many other factors will possibly lead to optimal farm plans differing considerably from those presented here. However, it is submitted that they establish a general pattern of optimal enterprise combinations which should be helpful in acting as guides to individual farmers and extension officers when formulating plans and budgets for particular farms.

APPENDIX 1

Productive Activities Considered

P_1 : Wheat—initial ploughing in November or December.
P_2 : Wheat—initial ploughing in January.
P_3 : Wheat—initial ploughing in February.
P_4 : Grain sorghum.
P_5 : Oats for grazing.
P_6 : Lucerne for hay.
P_7 : Lucerne for hay.
P_8 : Lucerne for grazing.
P_9 : Lucerne for grazing.
P_{10}: Natural pasture.
P_{11}: Purchase spring feed.
P_{12}: Purchase autumn feed.
P_{13}: Purchase winter feed.
P_{14} to P_{24}: Livestock enterprises on various assumptions as described in Appendix 3.

APPENDIX 2
Input—Output Matrix

Resources	Unit	Resource Supplies			Productive Activities											
					P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	P_{12}
Gross Profit	£	....			9·3	7·5	6·3	4·9	—1·7	—3·1	—3·1	— ·2	— ·2	0	—15	—15
Land	Acres	....			1	1	1	1	1	1	1	1	1	1	..	..
Feed—																
Spring	'ooo lb. S.E.	....			..	..	..	..	— ·15	..	..	— ·12	— ·21	— ·10	—1	..
Summer	,,	....			..	..	..	..	..	..	..	— ·30	— ·21	— ·18	..	..
Autumn	,,	....			..	..	..	..	..	— ·8	..	— ·18	— ·18	— ·08	..	—1
Winter	,,	....			..	..	..	..	— ·3	..	— ·8	..	..	— ·04	..	..
Legume	Acres	....			1	1	1	1	1	—1	—1	—1	—1	..	..	..
Labour—		No. of Men														
		1	2	3												
January	Man-days	30	60	90	·042	·042	..	..	·042	..	..	..	..	..	..	..
February	,,	30	60	90	·039	·042	·042	..	·039	..	..	..	..	..	..	..
March	,,	30	60	90	..	·039	·042	..	..	..	..	..	..	..	..	..
April	,,	30	60	90	..	·051	·090	..	..	..	..	..	..	..	..	..
March + April	,,	60	120	180	·051	·090	·132	..	·055	·10	..	..	..	..	..	·12
May	,,	30	60	90	·043	·043	·043	·166	..	..	..	..	..	..	..	..
June + July	,,	60	120	180	..	..	..	·081	..	·012	·112	·012	·012	·006	..	..
Sept. + Oct.	,,	60	120	180	..	..	..	·051	..	..	..	..	..	..	·12	..
November	,,	30	60	90	·083	·083	·083	·043	..	..	..	..	..	..	..	..
Nov. + Dec.	,,	60	120	180	·125	·083	·083	·043	·042	·22	·22	..	..	..	..	..
Sept. + Oct. + Feb.	,,	90	180	270	·039	·042	·042	·051	·039	..	..	..	..	..	·12	..
Total Annual	,,	175	350	525	·30	·30	·30	·34	·18	·33	·33	·012	·012	·006	·12	·12
Tractors—		No. of Tractors														
		1	2	3												
January	Tractor-days	30	60	90	·042	·042	..	..	·042	..	..	..	..	..	..	..
February	,,	30	60	90	·039	·042	·042	..	·039	..	..	..	..	..	..	..
March	,,	30	60	90	..	·039	·042	..	..	..	..	..	..	..	..	..
April	,,	30	60	90	..	·051	·090	..	..	..	..	..	..	..	..	..
March + April	,,	60	120	180	·051	·090	·132	..	·055	·10	..	..	..	..	..	·12
May	,,	30	60	90	·043	·043	·043	·104	..	..	..	..	..	..	..	..
June + July	,,	60	120	180	..	..	..	·081	..	·012	·112	·012	·012	·006	..	..
Sept. + Oct.	,,	60	120	180	..	..	..	·051	..	..	..	..	..	..	·12	..
November	,,	30	60	90	·041	·041	·041	·043	..	..	..	..	..	..	..	..
Nov. + Dec.	,,	60	120	180	·083	·041	·041	·043	·042	·155	·155	..	..	..	..	..
Sept. + Oct. + Feb.	,,	90	180	270	·039	·042	·042	·051	·039	..	..	..	..	..	·12	..
Total Annual	,,	175	350	525	·26	·26	·26	·28	·18	·27	·27	·012	·012	·006	·12	·12
Wheat Harvesting	Man-days	60			·083	·083	·083	..	..	..	..	..	..	..	..	..
Sorghum Harvesting	,,	60			..	..	..	·124	..	..	..	..	..	..	..	..

N.B. On one-man farms, gross profit and Nov., Nov./Dec. and total labour coefficients for activities P_1, P_2, P_3, P_4 P_6, P_7, differ from those above to take account of hired casual labour.

APPENDIX 2

Input—Output Matrix

Resources	Unit	Resource Supplies			Productive Activities											
					P_{13}	P_{14}	P_{15}	P_{16}	P_{17}	P_{18}	P_{19}	P_{20}	P_{21}	P_{22}	P_{23}	P_{24}
Gross Profit	£	....			—15	2·6	2·4	2·8	2·6	2·8	3·2	5·3	6·0	6·7	1·7	20
Land	Acres	....			..	..	..	..	..	..	..	..	..	..	..	..
Feed—																
Spring	'ooo lb. S.E.	....			..	·09	·12	·20	·10	·18	·20	·26	·36	·41	·09	1·33
Summer	"	....			..	·12	·09	·13	·12	·10	·20	·28	·28	·40	·09	1·33
Autumn	"	....			..	·20	·12	·09	·19	·12	·10	·35	·31	·31	·09	1·35
Winter	"	....			—1	·12	·20	·12	·17	·19	·12	·32	·38	·33	·09	1·41
Legume	Acres	....			..	..	..	..	..	..	..	..	..	..	..	..
Labour—		No. of Men														
		1	2	3												
January	Man-days	30	60	90	..	..	..	..	..	..	..	..	..	..	..	..
February	"	30	60	90	..	·002	..	..	·002	..	..	·002	..	..	..	..
March	"	30	60	90	..	..	..	..	..	..	..	..	..	..	..	..
April	"	30	60	90	..	..	..	..	..	..	..	..	..	..	..	..
March + April	"	60	120	180	..	·020	..	..	·018	..	..	·017	..	..	..	..
May	"	30	60	90	..	..	·002	..	..	·002	..	..	·002	..	..	..
June + July	"	60	120	180	·12	..	·022	..	..	·020	..	..	·019	..	..	..
Sept. + Oct.	"	60	120	180	..	..	..	·023	..	..	·022	..	..	·022	..	..
November	"	30	60	90	..	..	..	..	..	..	..	..	..	..	..	..
Nov. + Dec.	"	60	120	180	..	..	..	·002	..	..	·001	..	..	..	..	·04
Sept. + Oct. + Feb.	"	90	180	270	..	·021	·019	·042	·026	·024	·046	·060	·062	·091	·019	..
Total Annual	"	175	350	525	·12	·17	·18	·19	·19	·20	·21	·37	·41	·45	·11	·40
Tractors—		No. of Tractors														
		1	2	3												
January	Tractor-days	30	60	90	..	..	..	..	..	..	..	..	..	..	..	..
February	,	30	60	90	..	..	..	..	..	..	..	..	..	..	..	..
March	"	30	60	90	..	..	..	..	..	..	..	..	..	..	..	..
April	"	30	60	90	..	..	..	..	..	..	..	..	..	..	..	..
March + April	"	60	120	180	..	..	..	..	..	..	..	..	..	..	..	..
May	"	30	60	90	..	..	..	..	..	..	..	..	..	..	..	..
June + July	"	60	120	180	·12	..	..	..	..	..	..	..	..	..	..	..
Sept. + Oct.	"	60	120	180	..	..	..	..	..	..	..	..	..	..	..	..
November	"	30	60	90	..	..	..	..	..	..	..	..	..	..	..	..
Nov. + Dec.	"	60	120	180	..	..	..	..	..	..	..	..	..	..	..	..
Sept. + Oct. + Feb.	"	90	180	270	..	..	..	..	..	..	..	..	..	..	..	..
Total Annual	"	175	350	525	·12	..	..	..	..	..	..	..	..	..	..	..
Wheat Harvesting	Man-days	60			..	..	..	..	..	..	..	..	..	..	..	..
Sorghum Harvesting	"	60			..	..	..	..	..	..	..	..	..	..	..	..

N.B. On one-man farms, gross profit and Nov., Nov./Dec. and total labour coefficients for activities P_1, P_2, P_3, P_4, P_6, P_7, differ from those above to take account of hired casual labour.

APPENDIX 3

Enterprise Budgets

Wheat (P_1) 1st Ploughing November or December

Yield 20 bu./acre. Seed 1 bu./acre

	£	£
Bag to Bulk Harvesting System		
Gross Output per Acre		
19 bu. x 14s.		13.3
Direct Costs per Acre		
Rail freight x 2s. per bu.	1.9	
Cartage to rail—.01 truck-days x £7	.1	
.26 tractor-days x £6.7	1.7	
Depreciation on bags	.1	
	3.8	
6% interest on direct costs	.2	
		4.0
GROSS PROFIT		9.3

For extra man employed for harvesting on one-man farms, deduct from Gross Profit:—

.042 Man-days x £4 = £.17 per acre.

Wheat (P_2) 1st Ploughing in January

Yield 17 bu./acre. Seed 1 bu./acre

	£	£
Gross Output per Acre		
16 bu. x 14s.		11.2
Direct Costs per Acre		
Rail freight x 2s. per bu.	1.6	
Rest as for (P_1)		3.7
GROSS PROFIT		7.5

Wheat (P_3) 1st Ploughing in February

Yield 15 bu./acre. Seed 1 bu/acre

	£	£
Gross Output per Acre		
14 bu. x 14s.		9.8
Direct Costs per Acre		
Rail freight x 2s. per bu.	1.4	
Rest as for (P_1)		3.5
GROSS PROFIT		6.3

Grain Sorghum (P_4)

Yield 20 bu./acre Seed negligible

	£	£
Bag harvesting system		
Gross Output per Acre		
20 bu. x 7s. (in the paddock)		7.0
Direct Costs per Acre		
.28 Tractor-days x £6.7	1.9	
Depreciation on bags	.1	
	2.0	
6% interest on direct costs	.1	
		2.1
GROSS PROFIT		4.9

For extra man employed for harvesting on one-man farms, deduct from Gross Profit:—

·062 man-days × £4 = £.25

Oats for Grazing (P_5)

Direct Costs per Acre

	£
Seed 1 bu. x 8s. 0d.	.4
.18 tractor-days x £6.7	1.2
	1.6
6% interest on direct costs	.1
	1.7

Lucerne for Hay (P_6 and P_7)

Sown under cereal crop—5 year stand.
Yield 1 ton per acre.

Direct Costs per Acre

	s.	d.
Seed 7 lb. x 3s. 6d. over 5 years	5	0
.27 tractor-days x £6.7	36	0
.06 truck days x £7	8	0
Twine	10	0
	59	0
6% interest on direct costs	3	0
	62	0

For extra man employed at hay-harvesting on one-man farms, add to costs:

.065 man-days x £4 = £.26.

Lucerne for Grazing (P_8 and P_9)

Sown under cereal crop—5 year stand.

Direct Costs per Acre

	s.	d.
Seed 4 lb. x 3s. 6d. over 5 years	3	0
.012 tractor-days x £6.7	1	6
	4	6

Crossbred ewes x Downs breed ram

Purchasing all replacements

(P_{14}) *March or April lambing.* Lambing percentage 70.
Wool clip 7 lb. per ewe. Price 4s. 6d. per lb.
Lambs sold July/August. 35 lb. carcase. Price 1s. 10d. per lb.
25% replacement. 4% deaths.

Gross Output per 100 ewes

	£	£
70 lambs x £3.2	224	
21 cull ewes x £2	42	
Wool 800 lb. x 4s. 6d.	158	
		424
Less 25 replacement ewes x £4	100	
½ ram x £25	12	112
		312

	£	£
Direct Costs		
Shearing x £9 per 100	9	
Crutching x £3 per 100	3	
Dips, drenches x 2s. per ewe	10	
2.3 bales wool Packs, £1 Freight, £2 Selling charges, £3	14	
	36	
6% Interest x Direct costs, £36 Livestock £300	20	
		56
GROSS PROFIT		256

= £2.6 per ewe.

(P_{15}) *June or July lambing.* Lambing percentage 80.

Lambs sold October/November. Price 1s. 6d. per lb.
Other assumptions as for (P_{14}).

	£
Gross Output per 100 *ewes*	
80 lambs x £2.6	208
Rest as for (P_{14}).	
GROSS PROFIT	240

= £2.4 per ewe.

(P_{16}) *September or October lambing.* Lambing percentage 90.

Lambs sold January/February. Price 1s. 7d. per lb.
Other assumptions as for (P_{14}).

	£
Gross Output per 100 *ewes*	
90 lambs x £2.75	247
Rest as for (P_{14}).	
GROSS PROFIT	279

= £2.8 per ewe.

Merino ewes x Border Leicester ram

Breeding own replacements from Merino ram.

(P_{17}) *March or April lambing.* Lambing percentage 60.

Wool clip—

8 lb. per ewe. Price 5s. 3d. per lb.
3 lb. per lamb. Price 4s. 0d. per lb.

Lambs sold September/October. 35 lb. carcase.

Price—

Crossbred lambs, 1s. 7d. per lb.
Merino lambs, 1s. 2d. per lb.

25% replacement. 4% deaths.

Gross Output per 100 ewes

	£	£
10 lambs x £2.75	27	
25 lambs x £2	50	
21 cull ewes x £2	42	
Wool—		
800 lb. x 5s. 3d.	210	
75 lb. x 4s. 0d.	15	
		344
Less ½ ram x £25		12
		332

Direct Costs

Shearing 125 x £9 per 100	11	
Crutching 125 x £3 per 100	4	
Dips and drenches x 2s. 0d. per ewe	13	
2.9 bales wool packs, freight, etc., x £6	17	
	45	
6% interest x direct costs £45 livestock £425	28	
		73
GROSS PROFIT = £2.6 per ewe.		259

(P_{18}) *June or July lambing.* Lambing percentage 70.
Lambs sold December/January.
Price—
Crossbred lambs, 1s. 6d. per lb.
Merino lambs, 1s. 1d. per lb.
Other assumptions as for (P_{17}).

	£
Gross Output per 100 ewes	
20 lambs x £2.6	52
25 lambs x £1.9	47
Rest as for (P_{17}).	
GROSS PROFIT	281
= £2.8 per ewe.	

(P_{19}) *September or October lambing.* Lambing percentage 80.
Lambs sold March/April.
Price—
Crossbred lambs, 1s. 8d. per lb.
Merino lambs, 1s. 3d. per lb.
Other assumptions as for (P_{17}).

Gross Output per 100 ewes	
30 lambs x £2.9	87
25 lambs x £2.2	55
Rest as for (P_{17}).	
GROSS PROFIT	324
= £3.2 per ewe.	

Merinos ewes and wethers

Breeding own wethers and replacements from Merino ram.

(P_{20}) *March or April lambing.* Lambing percentage 60.
Wool clip 10 lb. wethers. Price 5s. 3d. per lb.
Surplus ewe lambs sold. September/October.
All wether lambs retained.
Ewe flock 25% replacement. 4% deaths.
Wether flock 20% replacement. 2% deaths.
Other assumptions as for (P_{17}).

	£	£
Gross Output per (100 *ewes* + 150 *wethers*)	£	£
5 lambs x £2	10	
21 cull ewes x £2	42	
27 cull wethers x £1 10s.	41	
Wool 2300 lb x 5s. 3d.	604	
165 lb. x 4s. 0d.	33	
		730
Less ½ ram x £25		12
		718
Direct Costs		
Shearing 305 x £9 per 100	27	
Crutching 305 x £3 per 100	9	
Dips and drenches x 2s. 0d. per head	30	
8.2 bales wool packs, freight, etc. x £6	49	
	115	
6% interest x direct costs £115 livestock £1,025	69	
		184
GROSS PROFIT		534
= £5.3 per (ewe + 1.5 wethers)		

(P_{21}) *June or July* lambing. Lambing percentage 70.
Surplus ewe lambs sold December/January
Other assumptions as for (P_{17})

Gross Output per (100 *ewes* + 175 *wethers*)		
10 lambs x £1.9	19	
21 cull ewes x £2	42	
31 cull wethers x £1 10s.	46	
Wool 2550 lb. x 5s. 3d.	670	
180 lb. x 4s. 0d.	36	
		813
Less ½ ram x £25		12
		801
Direct Costs		
Shearing 335 x £9 per 100	30	
Crutching 335 x £3 per 100	10	
Dips and drenches x 2s. per head	33	
9.1 bales wool-packs, freight, etc. x £6	55	
	128	
6% interest x direct costs £128 livestock £1,125	76	
		204
GROSS PROFIT		597
= £6.0 per (ewe + 1.75 wethers)		

(P_{22}) *September or October Lambing.* Lambing percentage 80.
Surplus ewe lambs sold March/April
Other assumptions as for (P_{17})

Gross Output per (100 *ewes* + 200 *wethers*)	£	
15 lambs x £2.2	33	
21 cull ewes x £2	42	
36 cull wethers x £1 10s.	54	
Wool 2,800 lb. x 5s. 3d.	734	
195 lb. x 4s. 0d.	39	
		902
Less ½ ram x £25		12
		890

	£	£
Direct Costs		
Shearing 365 x £9 per 100	33	
Crutching 365 x £3 per 100	11	
Dips and drenches x 2s. per head	36	
10.0 bales wool-packs, freight, etc. x £6	60	
	140	
6% Interest x direct costs £140 livestock £1,225	82	
		222
GROSS PROFIT		668

= £6.7 per (ewe + 2.0 wethers)

(P_{23}) Merino wethers

Purchasing all replacement wethers.
Wool clip 10 lb. per head price 5s. 3d. per lb.
20% replacement, 2% deaths

	£	£
Gross Output per 100 wethers		
18 cull wethers x £1 10s.	27	
Wool 1,000 lb. x 5s. 3d.	262	
		289
Less 20 replacements x £3		60
		229
Direct Costs		
Shearing 100 x £9 per 100	9	
Crutching 100 x £3 per 100	3	
Dips and drenches x 2s. 0d. per head	10	
3.3 bales wool-packs, freight, etc. x £6	20	
	42	
6% Interest x direct costs £42 livestock £225	16	
		58
GROSS PROFIT		171

= £1.7 per wether.

(P_{24}) Beef Cattle

Producing vealers and breeding own replacements.
Spring calving. Calving ratio 0.8 per cow
20% replacement.
Vealers sold at 12 months. Carcase weight 300 lb., price 2s. 0d. per lb.

	£	£
Gross Output per 10 cows		
6 Vealers x £30	180	
2 cull cows x £45	90	
		270
Less depreciation on ½ bull over 4 years		15
		255
Direct Costs		
6% interest on livestock £850		51
GROSS PROFIT		204

= £20 per cow.

APPENDIX 4

Weekly Feed Requirements of Livestock

	lb. S.E.
Ewes for 6 weeks before lambing—	
Merino	10
Crossbred	12
Ewes for 10 weeks after lambing—	
Merino	14
Crossbred	16
Ewes for rest of year—	
Merino	6
Crossbred	7
Merino wethers	7
Fattening lambs for 3-6 months age	8–10
Merino lambs and hoggets for replacements	8
Beef cow for 8 months after calving	84
Beef cow for rest of year	56
Fattening vealer for 8-12 months age and gaining 1½ lb. live-weight per day	42
2 year old heifer	56

APPENDIX 5

Enterprise Labour Coefficients

(a) Labour Coefficients for Crop and Livestock Operations

	Man-days per Acre
Crops:—	
Ploughing 7 ft. disc	·042
Scarifying 8 ft.	·039
Harrowing 24 ft. diamond harrows	·012
Sowing 9 ft. 6 in.—10 ft. Combine drill	·031
Hay making:—	
Mowing 7 ft. cut	·050
Raking	·040
Baling	·130 (per ton)
Harvesting wheat, barley, oats—12 ft. header:—	
Bags 2 men	·095
Bags 3 men	·125
Bag to bulk 2 men	·083
Bulk 2 men	·067
Harvesting sorghum—12 ft. header:—	
Bags 2 men	·124
Bags 3 men	·168
Feeding out hay	·10 (per ton)
	Man-days per Head
Sheep:—	
Crutching	·008
Shearing	·030
Marking lambs	·007
Dipping	·003
Drenching	·002
Lambing	·008
General	·072

	Man-days per Cow
Beef Cattle:—	
Marking calves	·04
General	·40

(b) Timing and Frequency of Crop and Livestock Operations

Crops:—

	Ploughing	*Scarifying*	*Harrowing*	*Sowing*	*Harvesting*
Wheat (P_1)	Nov. or Dec.	Feb.	Mar. or Apr.	May	Nov.
	Jan.	Mar. or Apr.	May	..	..
(P_2)	Jan.	Mar.	Apr.	May	Nov.
	Feb.	Apr.	May	..	..
(P_3)	Feb.	Apr.	Apr.	May	Nov.
	Mar.	Apr.	May	..	..
Oats (P_5)	Nov. or Dec.	Feb.	Mar. or Apr.	Mar. or Apr.	..
	Jan.	..	Mar. or Apr.	..	..
Sorghum (P_4)	May	June or July	Sep. or Oct.	Nov. or Dec.	May
	June or July	Sep. or Oct.	Nov. or Dec.	..	..
Lucerne grazing (P_8) (P_9).	..	..	June or July	..	..
Lucerne hay (P_6) (P_7).	..	..	June or July	..	Nov. or Dec.
Natural pasture (P_{10}).	..	..	June or July (every 2nd year)		..

Sheep:—

	Lambing Periods		
	Autumn	*Winter*	*Spring*
Lambing	Mar. or Apr.	June or July	Sept. or Oct.
Crutching and Shearing	Sept. or Oct.	Sept. or Oct.	Sept. or Oct.
	Feb.	Feb.	Feb.
Marking lambs	Mar. or Apr.	June or July	Sept. or Oct.
Drenching ewes—pre-lamb	Feb.	May	Sept. or Oct.
Other (X3)	any time	any time	any time
Drenching lambs	Mar. or Apr.	June or July	Nov. or Dec.
Drenching other Sheep (X4) / Dipping / Generally	any time	any time	any time

Beef Cattle:—

Marking calves	Nov. or Dec.
General	any time

APPENDIX 6

Optimum Programmes for One-man, One-tractor Farms

Activity Levels:	Unit	Farm Size (Acres)				
		670	855	968	1041	1296
P_1 Wheat	Acres	335	427	484	521	648
P_7 Lucerne Hay	,,	55	84	92	71	..
P_8 Lucerne Grazed	,,	24	..	142	449	648
P_9 Lucerne Grazed	,,	256	344	250	..	..
P_{14} Crossbred Ewes	No's	142	..	..	..	..
P_{19} Merino Ewes	,,	223	113	..	..	..
P_{24} Beef Cows	,,	..	38	52	41	..
Gross Profit	£	3,888	4,650	5,056	5,216	5,768
Surplus Feed Supplies:—						
Spring	'000 lb. S.E.	..	..	..	..	78
Summer	,,	..	..	25	81	194
Autumn	,,	..	..	..	26	116
Winter	,,	..	..	..	..	..
Marginal Costs:—						
P_2 Wheat	£ per acre	1·8	1·8	1·8	1·8	1·8
P_3 Wheat	,,	3·0	3·0	3·0	3·0	3·0
P_4 Sorghum	,,	4·4	4·5	4·6	4·8	4·8
P_5 Oats Grazed	,,	7·8	7·7	7·8	6·6	6·6
P_6 Lucerne Hay	,,	3·3	5·4	3·0	7·5	7·5
P_7 Lucerne Hay	,,	..	..	..	..	..
P_8 Lucerne Grazed	,,	..	..	..	..	..
P_9 Lucerne Grazed	,,	..	..	..	..	..
P_{10} Natural Pasture	,,	3·8	3·2	3·0	1·9	1·9
Marginal Costs:—						
P_{11} Purchase Spring Feed	£ per '000 lb. S.E.	9·9	13·4	16·0	17·0	17·0
P_{12} Purchase Autumn Feed	,,	11·6	15·2	12·1	17·0	17·0
P_{13} Purchase Winter Feed	,,	7·6	8·4	8·3	7·6	7·6
P_{14} Crossbred Ewes	£ per ewe	..	..	·68	1·4	1·4
P_{15} Crossbred Ewes	,,	·54	·82	1·3	2·5	2·5
P_{16} Crossbred Ewes	,,	·03	·13	·20	1·5	1·5
P_{17} Merino Ewes	,,	·38	·50	1·2	2·2	2·2
P_{18} Merino Ewes	,,	·44	·65	1·0	2·4	2·4
P_{19} Merino Ewes	,,	..	..	..	1·4	1·4
P_{20} Merino Ewes and Wethers	,,	·94	·94	2·0	4·0	4·0
P_{21} Merino Ewes and Wethers	,,	1·1	1·1	1·9	4·5	4·5
P_{22} Merino Ewes and Wethers	,,	·86	·74	1·2	4·1	4·1
P_{23} Merino Wethers	£ per wether	0·16	0·14	0·35	1·0	1·0
P_{24} Beef Cows	£ per cow	8·2	..	..	..	..
Marginal Productivities:—						
Land	£ per acre	5·8	4·1	3·6	2·2	2·16
Spring Feed	£ per '000 lb. S.E.	5·0	2·3	..	..	..
Summer Feed	,,	5·0	2·3	..	..	..
Autumn Feed	,,	3·3	·57	4·0	..	..
Winter Feed	,,	7·4	7·4	7·8	9·4	9·4
Legume	£ per acre	3·3	3·3	3·2	2·6	2·6
Total labour	£ per man-day	..	6·4	9·0	16·8	16·8

APPENDIX 6—continued

Optimum Programmes for Two-man, Two-tractor Farms

Activity Levels:—	Unit	Farm Size (Acres)						
		1,217	1,416	1,431	1,446	5,352	8,620	20,000
P_1 Wheat	Acres	609	708	716	723	723	723	11
P_7 Lucerne Hay	,,	101	132	128	124	104	..	..
P_8 Lucerne grazed	,,	43	14	..	..	..	723	11
P_9 Lucerne grazed	,,	465	562	588	599	619	..	..
P_{10} Natural pasture	,,	..	..	..	..	3,906	7,175	19,978
P_{14} Crossbred Ewes	No's	258	82	..	..	..	..	..
P_{19} Merino Ewes	,,	406	265	332	332	..	..	..
P_{21} Beef Cows	,,	..	45	44	42	170	204	567
Gross Profit	£	7,216	8,026	8,080	8,112	9,672	10,648	11,436
Surplus Feed Supplies:—								
Spring	000 lb. S.E.	..	..	..	5	294	533	1,244
Summer	,,	..	..	..	5	607	1,236	2,845
Autumn	,,	..	..	14	19	194	429	835
Winter	,,	..	..	..	..	..	..	..
Marginal Costs:—								
P_2 Wheat	£ per acre	1·8	1·8	1·6	1·2	1·2	1·8	1·8
P_3 Wheat	,,	3·0	3·0	2·8	2·4	2·4	3·0	3·0
P_4 Sorghum	,,	4·4	4·7	4·3	3·5	1·7	3·3	5·6
P_5 Oats grazed	,,	8·1	7·6	6·9	5·3	1·6	2·5	5·6
P_6 Lucerne Hay	,,	3·0	5·6	6·9	9·0	9·0	7·8	12·1
P_7 Lucerne Hay	£ per acre	..	..	..	..	..	..	7·2
P_8 Lucerne grazed	,,	..	..	..	..	..	..	..
P_9 Lucerne grazed	,,	..	..	..	..	..	..	..
P_{10} Natural pasture	,,	3·9	3·1	2·8	1·8	..	..	..
P_{11} Purchase Spring feed	£ per '000 lb. S.E.	9·9	13·4	14·0	16·0	16·0	16·8	18·4
P_{12} Purchase Autumn feed.	,,	11·6	15·2	15·8	16·0	16·0	16·8	18·4
P_{13} Purchase Winter feed.	,,	7·9	8·2	7·2	4·8	4·8	7·0	12·4
P_{14} Crossbred Ewes	£ per ewe	..	..	0·15	0·25	0·25	1·24	3·06
P_{15} Crossbred Ewes	,,	0·50	0·82	0·96	1·4	1·4	2·4	4·0
P_{16} Crossbred Ewes	,,	0·03	0·13	0·28	0·24	0·24	1·3	3·4
P_{17} Merino Ewes	,,	0·38	0·50	0·57	0·96	0·96	2·0	3·9
P_{18} Merino Ewes	,,	0·40	0·66	0·75	1·1	1·1	2·2	4·1
P_{19} Merino Ewes	,,	..	..	..	..	..	1·2	3·4
P_{20} Merino Ewes and Wethers.	,,	0·92	0·94	1·0	1·6	1·6	3·6	7·3
P_{21} Merino Ewes and Wethers.	,,	1·0	1·1	1·3	1·9	1·9	4·1	8·1
P_{22} Merino Ewes and Wethers.	,,	0·86	0·74	0·76	1·0	1·0	3·5	8·3
P_{23} Merino Wethers	£ per wether	0·16	0·14	0·16	0·27	0·27	0·88	2·0
P_{24} Beef Cows	£ per cow	8·1	..	..	..	..	..	..
Marginal Productivities:—								
Land	£ per acre	5·9	4·1	3·6	2·2	0·40	0·30	0·069
Spring feed	£ per '000 lb. S.E.	5·0	2·3	1·9	..	..	..	..
Summer feed	,,	5·0	2·3	1·9	..	..	..	..
Autumn feed	,,	3·3	0·5	..	..	..	..	..
Winter feed	,,	7·0	7·5	8·6	11·3	11·3	9·8	6·0
Legume	£ per acre	3·4	3·3	3·1	2·5	0·70	0·68	0·61
November labour	£ per man-day	..	..	..	..	44·0	44·0	..
Nov./Dec. labour	,,	..	..	4·5	15·2	15·2	..	..
Total labour	,,	..	6·5	6·8	8·7	8·7	15·4	28·7

APPENDIX 6—continued

Optimum Programmes for Three-man, Two-tractor Farms

Activity Levels:—	Unit	Farm Size (Acres) 1,446	1,800	2,002	2,060	2,637	3,391	5,204	5,354	8,057	18,708	20,000
P_1 Wheat	Acres	723	723	723	723	723	723	723	723	723	723	642
P_4 Sorghum	,,	..	177	278	278	278	278	179	176	..	..	..
P_7 Lucerne hay	,,	120	149	182	188	226	256	322	320	338	..	..
P_8 Lucerne grazed	,,	51	64	31	..	..	..	..	579	..	723	642
P_9 Lucerne grazed	,,	552	688	787	813	775	745	581	..	384	..	..
P_{10} Natural pasture	,,	..	..	..	58	635	1,390	3,399	3,556	6,611	17,262	18,716
P_{14} Crossbred Ewes	No's	307	382	188	154	..	..	..	..	..	..	..
P_{19} Merino Ewes	,,	482	600	443	446	390	218	9	..	..	..	..
P_{24} Beef Cows	,,	..	..	49	57	113	166	278	283	380	490	531
Gross Profit	£	8,572	9,894	10,244	10,300	10,728	11,158	12,080	12,140	13,188	16,372	16,462
Surplus feed supplies:—												
Spring	'000 lb. S.E.	..	..	..	..	..	32	90	100	236	1,160	1,242
Summer	,,	..	..	..	..	50	143	362	384	766	2,672	2,854
Autumn	,,	..	..	..	..	..	..	..	6	86	850	896
Winter	,,	..	..	..	..	..	..	..	..	..	..	..
Marginal cost:—												
P_2 Wheat	£ per acre	1·8	1·8	1·8	1·8	1·8	1·8	1·8	1·2	1·2	1·8	1·8
P_3 Wheat	,,	3·0	3·0	3·0	3·0	3·0	3·0	3·0	2·4	2·4	3·0	3·0
P_4 Sorghum	,,	4·4	..	..	..	..	..	..	..	..	1·3	5·6
P_5 Grazing oats	,,	8·1	3·7	2·9	1·4	0·74	1·6	2·0	1·7	1·7	2·5	5·6
P_6 Lucerne hay	,,	2·9	2·9	5·6	5·6	5·4	3·4	4·9	8·9	8·9	7·8	12·1
P_7 Lucerne hay	,,	..	..	..	..	..	..	..	..	..	..	7·2
P_8 Lucerne grazed	,,	..	..	..	..	0·38	..	..	..	..	..	..
P_9 Lucerne grazed	,,	..	..	..	..	..	..	..	..	..	..	..
P_{10} Natural pasture	,,	3·9	1·7	·80	..	..	..	..	..	..	..	..
P_{11} Purchase spring feed	£ per '000 lb. S.E.	9·9	9·9	13·4	13·4	11·6	16·1	16·1	16·4	16·2	16·8	18·4
P_{12} Purchase autumn feed	,,	11·6	11·6	15·2	15·2	15·0	12·3	13·6	16·2	16·2	16·8	18·4
P_{13} Purchase winter feed	,,	7·9	7·9	8·2	8·2	8·2	8·0	7·6	4·8	5·0	7·0	12·4

APPENDIX 6—continued

Optimum Programmes for Three-man, Two-tractor Farms—continued

Activity Levels :—	Unit	Farm Size (Acres)										
		1,446	1,800	2,002	2,060	2,637	3,391	5,204	5,354	8,057	18,708	20,000
P_{14} Crossbred Ewes	£ per ewe	..	..	..	..	..	0·66	0·56	0·26	0·36	1·2	3·0
P_{15} Crossbred Ewes	,,	0·50	0·50	0·83	0·84	0·96	1·3	1·3	1·4	1·5	2·4	4·0
P_{16} Crossbred Ewes	,,	0·03	0·03	0·13	0·13	0·30	0·21	0·21	0·24	0·36	1·3	3·4
P_{17} Merino Ewes	,,	0·38	0·38	0·50	0·50	0·52	1·2	1·2	1·0	1·1	2·0	3·9
P_{18} Merino Ewes	,,	0·40	0·40	0·66	0·68	0·88	1·0	1·1	1·1	1·2	2·2	4·1
P_{19} Merino Ewes	,,	..	..	..	..	..	..	..	..	0·14	1·2	3·4
P_{20} Merino Ewes and Wethers	,,	0·92	0·92	0·94	1·0	1·9	2·6	1·8	1·6	1·8	3·6	7·3
P_{21} Merino Ewes and Wethers	,,	1·0	1·0	1·2	1·2	1·4	1·9	1·9	1·9	2·2	4·0	8·2
P_{22} Merino Ewes and Wethers	,,	0·86	0·86	0·75	0·75	0·80	1·2	1·2	1·0	1·3	3·6	8·2
P_{23} Merino Wethers	£ per wether	0·16	0·16	0·14	0·14	0·16	0·35	0·33	0·28	0·34	0·90	2·0
P_{24} Beef Cows	£ per cow	8·1	8·1	..	..	..	..	..	..	..	..	..
Marginal productivities:—												
Land	£ per acre	5·9	3·8	1·7	0·95	0·74	0·57	0·51	0·40	0·39	0·30	0·069
Spring feed	£ per '000 lb. S.E.	5·1	5·1	2·3	2·3	4·1	..	..	..	..	..	..
Summer feed	,,	5·1	5·1	2·3	2·3	..	..	..	..	..	..	..
Autumn feed	,,	3·4	3·4	0·52	0·52	0·82	3·7	2·8	..	..	..	..
Winter feed	,,	7·1	7·1	7·5	7·6	7·6	8·0	8·8	11·1	11·1	9·8	6·0
Legume	£ per acre	3·4	1·2	0·96	0·16	..	0·20	0·35	0·70	0·70	0·68	0·62
Nov./Dec. labour	£ per man-day	..	..	..	..	..	..	..	14·5	13·5	..	..
Total labour	,,	..	..	6·4	6·4	6·6	9·0	8·8	8·8	9·4	15·4	28·7
Wheat harvesting labour	,,	..	53	56	67	69	65	59	43	44	44	..
May tractors	£ per day	..	..	..	15·2	17·9	10·3	..	..	..	..	..
Total tractors	,,	..	..	..	..	..	..	3·6	0·72	..	..	..