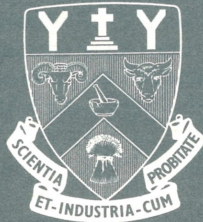


AGRICULTURAL
ECONOMICS
RESEARCH UNIT



Lincoln College

FERTILISER AND PRODUCTION
ON A SAMPLE OF
INTENSIVE SHEEP FARMS
IN SOUTHLAND 1953-64

by

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FERTILISER AND PRODUCTION ON A SAMPLE OF

INTENSIVE SHEEP FARMS IN SOUTHLAND

1953-1964

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THE AGRICULTURAL ECONOMICS RESEARCH UNIT

THE Unit was established in 1962 at Lincoln College with an annual grant from the Department of Scientific and Industrial Research. This general grant has been supplemented by grants from the Wool Research Organisation, the Nuffield Foundation and the New Zealand Forest Service for specific research projects.

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P R E F A C E

In this Publication we set out the results of a comparative study of intensive lamb production in Southland. Farm records for a ten year period are analysed in terms of fertiliser application, stocking rates and net income. The particular sample of farms was chosen from an area where stocking rates were already relatively high, and where further gains in productivity might be achieved with difficulty. The study shows that stocking rates have increased by nearly twenty per cent over the period without greater fertiliser inputs. The technological advance during the period has thus been more in the direction of management organisation rather than in direct inputs. Future advances could clearly be dependent on both of these factors.

We are indebted to the American Potash Institute Inc., of Washington D.D., for providing a substantial grant towards the cost of this investigation.

We also wish to thank the New Zealand Meat and Wool Boards' Economic Service for making their comprehensive records available to us.

We have benefited from the comments of Mr P.D. Blomfield of Potash (N.Z.) Ltd., Mr R.H. Bevin, formerly Director of the Meat and Wool Boards' Economic Service, Mr F. Ward present Director of the Economic Service and Mr W.L. Keen, Statistician to the Economic Service. We are grateful to Mr M. Monteath formerly of the Advisory Division, Department of Agriculture, Gore and now of the Invermay Research Station, for help in field work and helpful comments on the manuscript.

Although New Zealand has now changed to a decimal currency system, we have stated financial results in £'s sterling appropriate to the period under review.

R.W.M Johnson
Acting Director

Lincoln College
August 1967

INTRODUCTION

The Agricultural Economics Research Unit has recently initiated a programme of research into the economics of fertiliser use in New Zealand. This paper is the first publication in this programme, which will be concerned initially with intensive sheep farming areas of Southland.

The paper presents a factual summary of the levels of fertiliser use, and the associated levels of production and income for a sample of intensive sheep farms in Southland, for the period 1953/4 to 1964/5. The information is presented largely in terms of trends and averages.

Statistical analysis has been minimised for two reasons. First, an increasing interest has been shown in recent years in the role of fertiliser in the Southland intensive sheep-farming complex, accompanied by some speculation on the role of fertiliser as an agricultural input. For this reason alone, it is important to provide factual information in a form which can be readily appreciated. Second, later studies will be concerned with more analytical aspects of fertiliser use. A case study approach to the profitability of intensive development¹ will be undertaken; in addition a fertiliser demand study and a production function analysis are planned.

Few studies based on survey information from sample farms are available, because of the lack of adequate data, and because of the time and expense involved in carrying out extensive field surveys. The original data for this paper was obtained from the field survey records of the Meat & Wool Boards' Economic Service, whose officers have assembled both physical and financial data from a sample of Southland intensive sheep farms since 1952.² The sample, originally drawn at random, has changed slightly over the years; if the characteristics of a farm altered so that it would no longer be considered as an intensive sheep farm, it was replaced. The sample has also progressively increased in size since 1951. Varying numbers of farms have entered the calculation, depending on the sample size for the particular time period. The assumption is

¹ The term "development" throughout this paper refers to the intensification of sheep farming on established sheep farms, and not to the subdivision of larger holdings for closer settlement.

² Intensive farms are defined as those producing more than 120 lbs. meat per acre.

made that the sample is representative of intensive sheep farming in the area.

The average size of farm has been about 300 acres over the period, but as the following distribution for 1964/5 shows, the more common farm size is about 240 acres.

<u>Farm Size</u>	<u>No.</u>	<u>Proportion</u>
less than 200 acres	7	14.6 per cent
201 - 280 acres	19	29.6 per cent
281 - 360 acres	9	18.7 per cent
361 - 440 acres	6	12.5 per cent
441 and greater	7	14.6 per cent
	<hr/> 48 <hr/>	<hr/> 100.0 per cent <hr/>

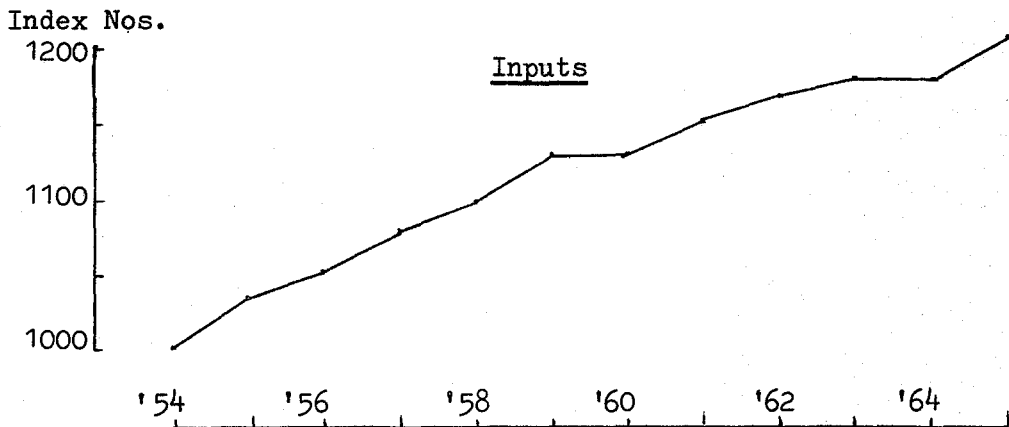
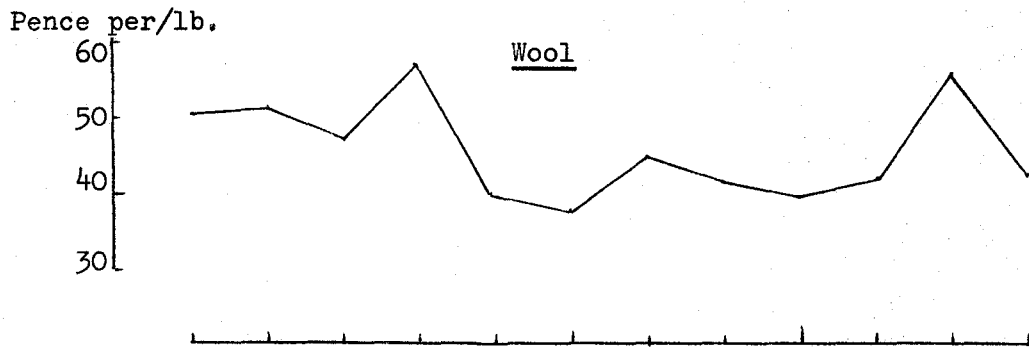
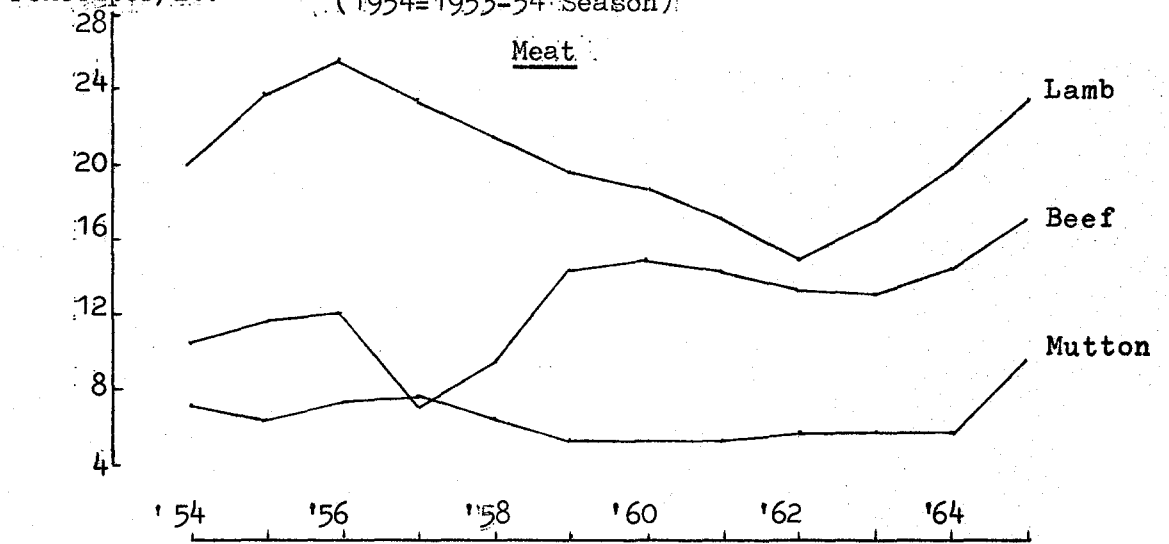
At the beginning of the period the average farm was stocked with about 1,000 breeding ewes plus followers and twelve head of cattle, usually steers or fattening heifers. Lambing percentages have been relatively stable at 120 per cent. Wool produced has averaged 11.5 lbs. per ewe equivalent over the years, without any upwards trend.

The major proportion of gross farm income is derived from the sale of lambs with wool next most important. After accounting for stock purchases, gross income from sheep and lambs has varied from 40 to 50 per cent of total gross income, wool from 36 to 44 per cent, cattle from 3 to 5 per cent of total gross income. There has been no definite trend towards any one of these groups over the period, the fluctuations being accounted for by changes in product prices.

The pattern of expenditure on the sample farms also shows little change. Labour services take approx. 23 per cent of total expenditure; fertiliser, lime and seeds approx. 20 per cent; vehicles fuel and power 13 per cent, and other expenses including overheads 44 per cent.

Figure I shows price changes over the period. Lamb prices are based on the export companies schedule price for woolly lambs; ewe prices on the February-March schedule price; beef prices on the G.A.Q. grade of ox and heifer beef for October of each year. Wool prices are the seasonal average for the Invercargill wool sales. Average prices applying to the specific sample of farms were not available in the records. Changes in

Figure I Price Trends 1954-1965
(1954=1953-54 Season)



the prices of farm inputs are indicated by the New Zealand Meat and Wool Boards' Economic Service Cumulative Index of Cost Movements on Fattening farms (first quarter 1954=1,000).

On average, product prices fluctuate about a constant level, while prices of inputs have steadily risen. As with other sections of the farm industry in New Zealand in this particular period, the adverse effect of this kind of price squeeze can only be met by increasing productivity.

In the New Zealand type of grassland economy, in the absence of farm amalgamation, higher productivity must be achieved by higher inputs at the intensive margin. In particular, the grassland must be managed to carry more livestock. Figure 2 shows the trend in livestock standard units per acre or ewe equivalents per acre from 1953/54 to 1964/65, compared with meat produced per acre and wool produced per acre. Stocking capacity has risen from 4.7 units per acre to 5.5 units per acre over the whole sample. In flock terms, this means that the average farm now puts 1,300 ewes to the ram compared with 1,000 before. Outputs have increased in proportion to stocking capacity.

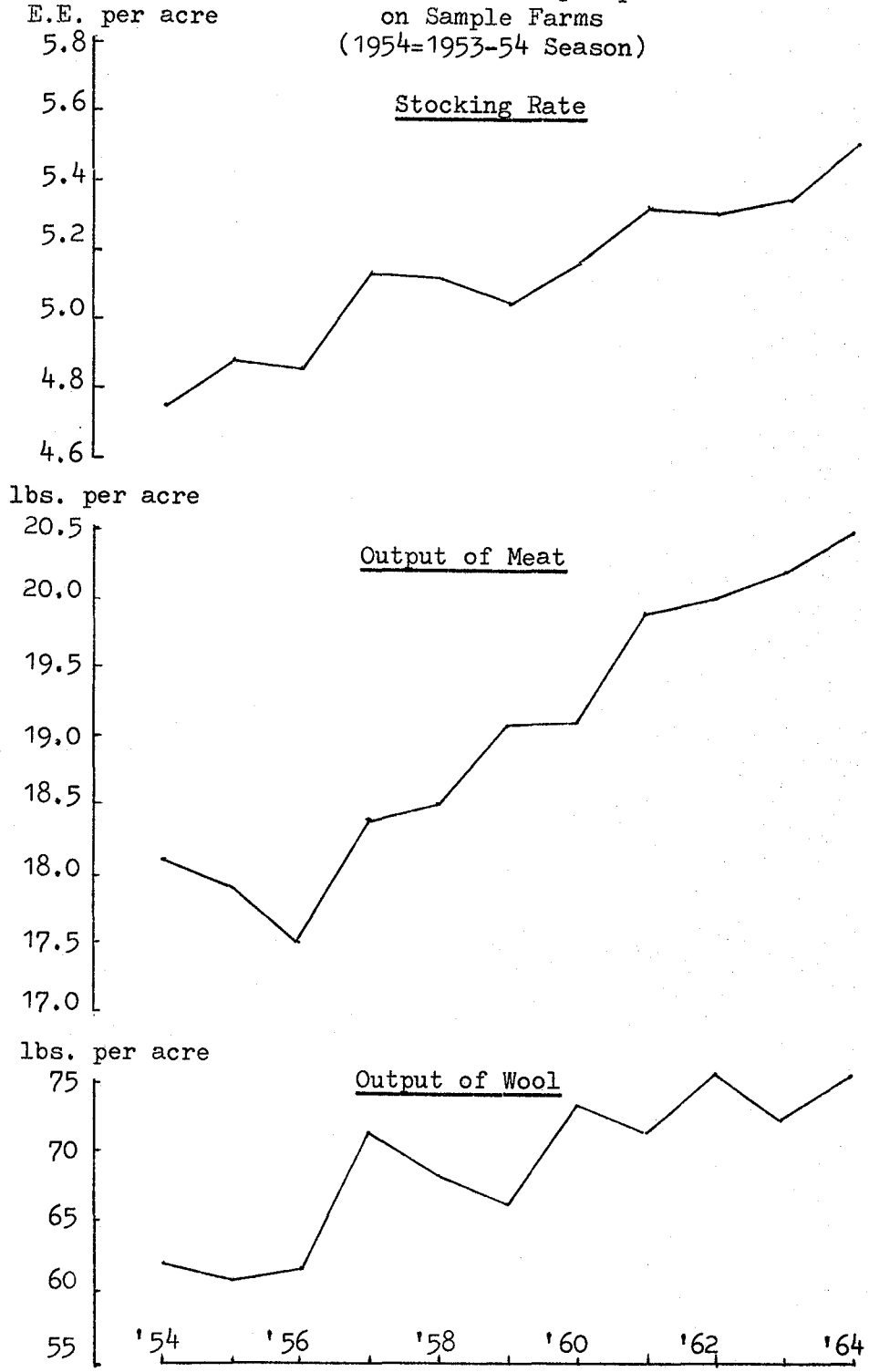
Fertiliser as a Farm Input

There can be no doubt that the higher production and productivity of New Zealand farming has been facilitated by increasing levels of fertiliser use. In many cases, fertiliser applications alone have been responsible for increased farm output. However, other farm inputs are also of vital importance in the agricultural sector. Labour availability, soil type, climatic patterns and technological developments are the major factors which determine the potential production in any area. Management attitudes towards stocking rate policies and fertiliser determine the extent to which this potential will be developed.

The plains of Southland have reached an interesting stage in a metamorphosis from a "mere bog and totally unfit for human habitation" to an extremely productive and progressive farming area. A brief historical sketch is now given, which will demonstrate the dynamic role of fertiliser and other factors in the development of the Southland plains.

During the period from first settlement until about 1880, farming progress was slow - due largely to the difficulty of developing large and often remote holdings with scarce and expensive farm inputs. Road and rail construction, active

Figure 2 Stocking Rate and Output per Acre
on Sample Farms
(1954=1953-54 Season)



subdivision, refrigeration and the discovery of gold, encouraged rapid farm development in sheep growing and dairying, as well as cereal production. Cropping and new grass expanded considerably. Towards the end of the century a period of extensive lime application began. The period from the early 1900's until the Second World War was one of consolidation of farming practices. Heavy liming, increased use of phosphatic fertilisers, closer subdivision, and increased drainage, combined with improved management techniques and better strains of grasses and clover, all contributed to a period of rapid development. The eventual movement from cattle to sheep established the plains in Southland as one of the foremost fat lamb and cropping areas of New Zealand.

The post-war trends in sheep farming in Southland are of particular interest, e.g. the number of lambs tailed increased by 135 per cent from 1946 to 1964. Sustained heavy applications of lime over a long period had raised the pH, particularly of the more fertile soils, to an extent that responses to lime were diminishing. Many farmers were advised to forego topdressing with lime, and to apply lime only on sowing down ((3)p.29). The consequent decrease in lime usage on the survey farms is illustrated clearly in Figure 3. Over the decade of the 1950's lime usage decreased by 70-75 per cent, and appears to have stabilised in recent years. The lower lime usage reflects less frequent rather than lower rates of application, which remain at about one ton per acre.

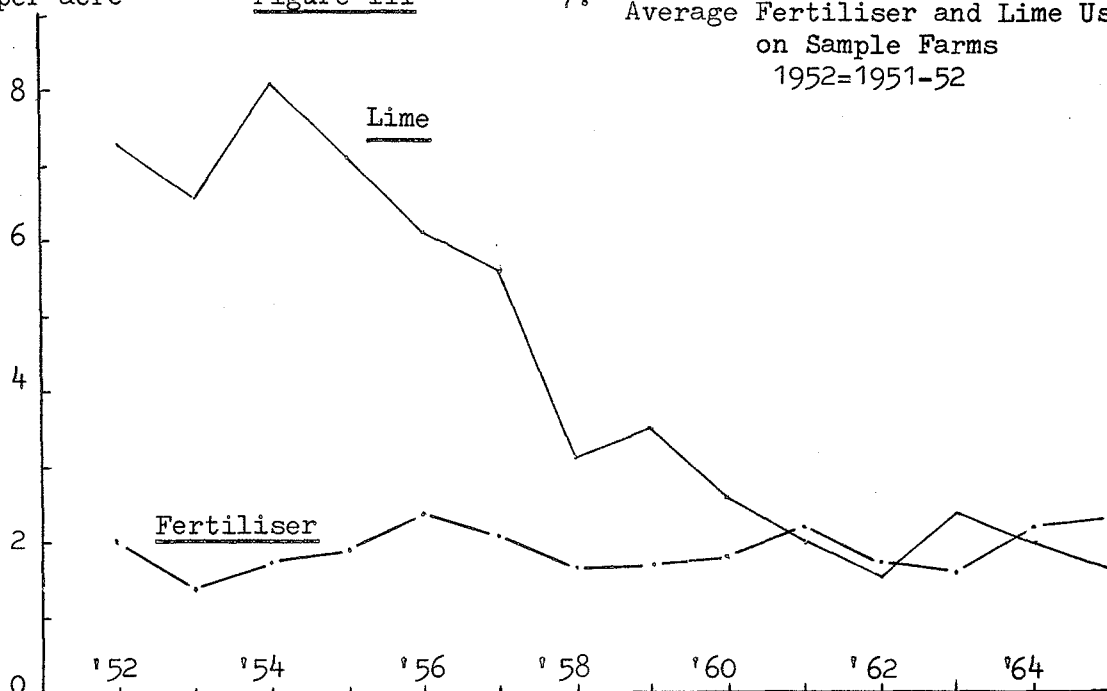
Liberal treatment with lime and phosphatic fertilisers, and the provision of adequate drainage has permitted fairly consistent increases in the stocking rate. The stocking rate figures, as shown in Figure 2, are calculated for sample farms over the productive area of the farm and make no allowance for the substantial increases in cash cropping, particularly wheat, which have occurred in Southland in recent years. They will therefore underestimate the actual stock density. An adjusted measure, the "effective stocking rate" has been calculated, incorporating trends in cash cropping in Southland, and assuming the same variations apply to the sample farms.

Figure III also illustrates the rate of fertiliser use on the sample farms from 1951/2 to 1964/5. Clearly, there has been no general upward trend, although a cyclical pattern seems to emerge, fluctuating around a mean of about 2.0 cwt per acre. The factors which influence fertiliser use in any one year will be the subject of further research. It would appear, however, that farm income levels, general farming prosperity, and conditions affecting availability of farm credit, all influence the level of fertiliser use. It seems possible

Cwt. per acre

Figure III

7. Average Fertiliser and Lime Used
on Sample Farms
1952=1951-52



that movements in fertiliser price have influenced fertiliser consumption to a minor degree. It is clear that farmers in this area do not consider fertiliser as a "fixed" expense, and vary their fertiliser application, within limits, from year to year.

Two further points relating to fertiliser should be mentioned. The intensive lamb farmers of Southland have, on average, been consistent users of fertiliser at fairly high levels for some time. Therefore, the dramatic increase in the total amount of fertiliser purchased in Southland in recent years stems from extensive development of hill country and from land settlement projects, rather than through intensification on existing farms.

Although the quantities of fertilisers used by intensive sheep farmers have not increased substantially, many farmers have found that the development process has necessitated some changes in the types of fertiliser applied. Reserves of available potash on many soil types in the area are being depleted, and higher stock concentrations have focussed attention on the rate of potash replenishment. In soil types where the potash supplying power of the soil does not meet the demands of heavily stocked pastures, potash responses have been significant. This development-induced "deficiency" has been responsible for the noticeable increase in potash use in Southland, largely in the form of potassic super. Apparently about 55-60 per cent of intensive farmers are now using potash in some form. As sheep concentrations continue to rise it can be expected that increasing amounts of potash will be applied. Blomfield (1) suggests that the amount of muriate of potash applied in Southland could well increase from the present level of 16,000 tons to 32,000 tons by 1972.

We can summarise the role of fertiliser in farm development as one essential input in a group of essential inputs, which have created conditions suitable for high stocking rates.

Farms which have achieved a state of advanced development are faced with investment decision problems created by the momentum of development. Although Harris (4) has suggested that there is little economic advantage in exceeding six ewes per acre, several farmers have increased stocking rates up to seven or eight ewes per acre. The ability of a farmer to move beyond the six-ewe level, depends on his ability to control pugging damage, and to provide adequate autumn-saved pastures. Hence further investment in efficient drainage is a necessity. On the other hand, increased stock concentration in turn will demand relatively higher fertiliser treatment, in particular with mixtures containing potash. Further, the purchase, or retention of stock for increased flocks involves a cost. It is also expected that the efficiency of pasture utilisation improves with closer subdivision. The selection of a wise combination of these four apparently profitable, but competing demands for development funds is an important problem, and one which is still unsolved. In a further stage of this project, attention will be given specifically to this problem.

While generalisations are seldom satisfactory, it is probably true to say that in the judgement of most extension and scientific workers, the sustained use of fertilisers, and improved management practices, have created a high volume of pasture production on the Southland plains; and that stocking rates have not been increased commensurately. Two distinct aspects of farm management are involved; first, that of pasture management to achieve a high quantity and quality of forage throughout the year, and second, stock management to effect efficient utilisation of the pastures. Apparently recent rapid advances in pasture management have outstripped farm advances in stock management and have left some farms "understocked".

Stratification of the Sample Farms on the Basis of Fertiliser Use

The remainder of this paper discusses the association of different levels of fertiliser use and other farming characteristics. To facilitate the discussion, the group of forty-eight farms for which figures were available, were divided into three groups on historical records of fertiliser use. The physical quantity of fertiliser applied per acre, averaged over the years 1956/7 to 1964/5 was the basis of stratification. Henceforth, three groups of farms will be analysed:-

- High Fertiliser Use - history of application above 2.2 cwt per acre
(16 farms) per annum for the 9 year period with a group average of 2.6 cwt per acre.
- Medium Fertiliser Use- history of application of between 1.5 and 2.2
(16 farms) cwt per acre per annum with a group average of 1.7 cwt per acre.
- Low Fertiliser Use - history of application of below 1.5 cwt per
(16 farms) acre per annum with a group average of 1.2 cwt per acre.

Variation in the three groups' levels of fertiliser use are shown in Figure IV.

It should be remembered that a grouping on the basis of levels of fertiliser use does not exclude other quite important factors which may be correlated with the levels of fertiliser application. It is quite probable, for example, that high fertiliser use is associated with higher management standards, higher stocking rates, and more intensively developed farms. It is reasonable to expect farms where fertiliser has been consistently applied at higher levels to demonstrate the physical advantages which must accrue.

Average farm size for the three groups is shown in Table I.

TABLE I

<u>Fertiliser Use Group</u>	<u>Average Farm Size</u> (acres)
High	261.9 (a) (b)
Medium	314.9 (b)
Low	321.1 (a)

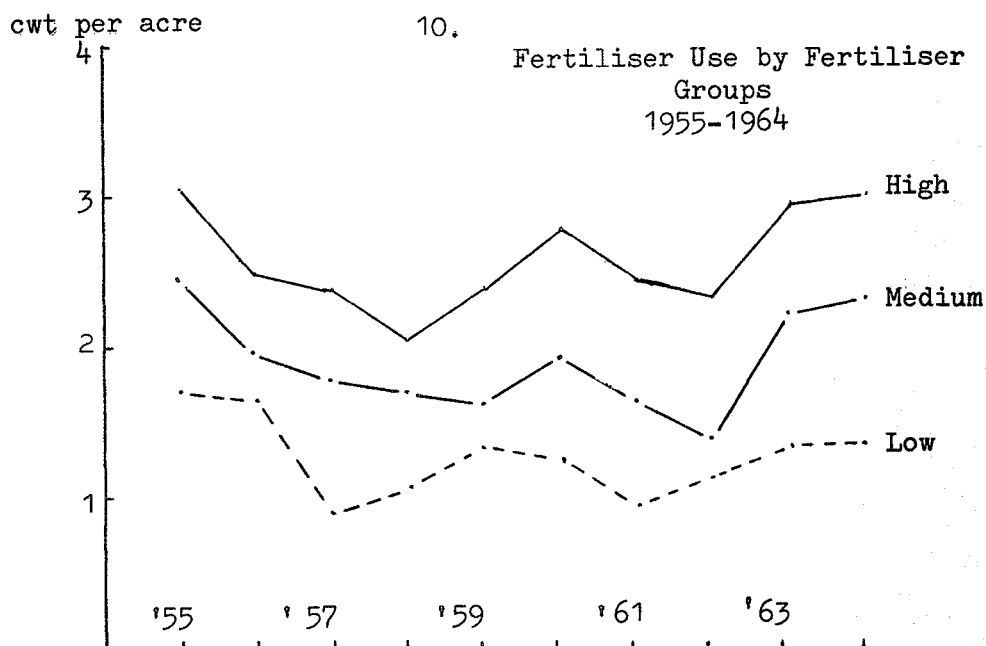
(a) Pairing significantly different at 10% level

(b) Pairing significantly different at 20% level

(indicating that there are only 10 chances in 100 that the High and Low groups could have been drawn as random samples, on the basis of farm size, from the total population, and 20 chances in 100 that the High and Medium groups would be similarly drawn.)

These figures suggest that the high fertiliser use farms are probably the smaller farms. However, attempts to obtain some correlation between fertiliser use and farm sizes were not successful.

Figure IV



As an alternative approach, the farms were stratified, according to farm size, into three groups most likely to represent farm types. First, small farms (less than 200 acres) considered by many to be of less than a "comfortable economic size" and therefore demanding high intensity farming, and where it might reasonably be expected that fertiliser use per acre would be at its highest; second, medium size farms, 200-280 acres, a modal group which would illustrate the more common farm size and third, the large farms of over 280 acres which might be thought to represent the farms where less intensive development is necessary to reach acceptable income levels.

Fertiliser use associated with each of these groups was:-

<u>Farm Size</u> (acres)	<u>Fertiliser Use</u> (cwt. per acre)
Small (less than 200 acres)	2.21 (a)
Medium (200-280 acres)	1.87
Large (more than 280 acres)	1.74 (a)

(a) This pair of means are significantly different at 10% level.

Available data on intensive farms did not assist in a more substantial examination of the relationship between fertiliser use and farm size. However, two postulates may be advanced to explain the apparent association between higher rates of fertiliser applied per acre and smaller farms.

- (1) That higher rates of fertiliser use on small farms are indicative of more intensive methods, necessary to obtain some desired production and income figures. Larger farms, on the other hand, provide an acceptable income level with less intensive development, and the lower fertiliser applications reflect farmers' satisfaction with present levels of production.
- (2) That larger farms have been developed more slowly due to lower initial supplies of labour and machinery capital per acre, and consequently have not attained the intensity of development of the smaller farms.

Both of these postulates have been advanced to the authors - the first largely from organisations and institutions servicing farms in the area and from some farmers who have attained high stock concentrations and production figures, and the second mainly from farmers on a lower development plane. While the relevance of fertiliser use figures is limited to perhaps a symptomatic role in the discussion, it is important to clarify which of the two postulates, which are not mutually exclusive, indicates the greatest barrier to increased production. Each postulate calls for quite a different policy approach to facilitate increased production.

Stocking Rates

Figure 2 shows that whole-farm stocking rates have increased on the sample farms, from an average of 4.67 to 5.52 ewe equivalents per acre - an increase of 18.0 per cent. Areas devoted to cash-cropping appear to have doubled on Southland intensive farms over the period 1953/4 to 1964/5 - consequently effective stocking rates for the survey farms have actually increased from 4.84 to 5.78 ewe equivalents per acre, an increase of nearly 20 per cent.

The trends and the variations evident in the whole-farm stocking rates obviously reflect similar trends and situations in total sheep numbers in New Zealand, which may influence, and in turn be influenced by, lamb and wool prices. It would appear that, while farmers on intensive farms in Southland have increased stocking rates as a long-term aim, short-term adjustments are made according to meat and wool price trends. Areas devoted to cash cropping, while increasing generally, also fluctuate on a short-term basis, increasing faster when downward adjustments in stocking were made and decreasing when stock numbers increase. The compensating effect of variable cash cropping acreages is not complete however, since the effective stocking rate curve in Figure II is not uniformly increasing.

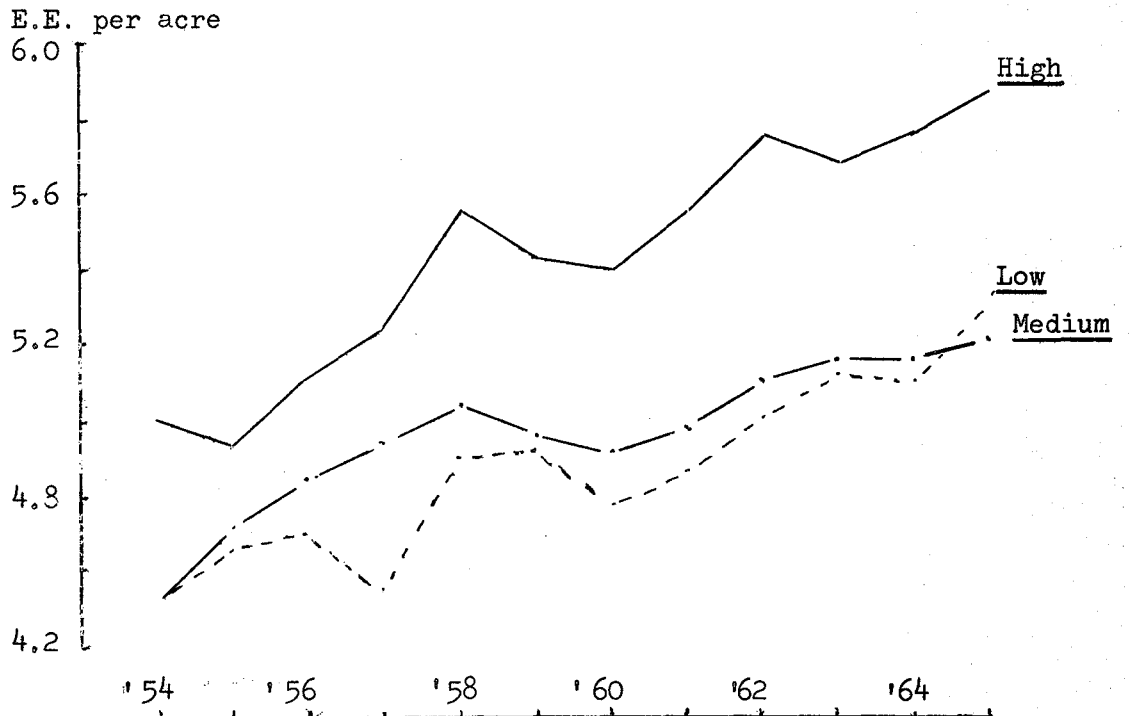
It could reasonably be expected that higher rates of fertiliser use over the period would enable farmers to increase stocking rates faster, and that this would be demonstrated by data from the survey farms. Figure V indicates that only the high fertiliser use group has a significantly higher stocking rate, and that the medium fertiliser use group have not increased stocking rates as much as might have been expected. Stocking rates on the three groups of farms show similar variations over the 12 year period; the levels of stocking at the beginning and the end of the period are shown in Table 3. Taking the mean of the average stocking rate for the whole 11 years in each group shows that only the "high" groups were stocking at rates consistently higher than the other two groups.

TABLE 3

<u>Fertiliser Group</u>	<u>Stocking Rates</u> (Ewe equivalents per Acre)		<u>Percentage Increase over 12 years</u>	<u>Average 1953/4-1964/5</u>
	<u>1953/4</u>	<u>1964/5</u>		
High	5.00	5.87	17.4	5.47 (a) (b)
Medium	4.51	5.21	15.5	4.97 (b)
Low	4.51	5.31	17.7	4.86 (a)

(a) (b) Pairings indicated by respective letter are significantly different at 1% level.

It has not been possible to calculate effective stocking rates for each group of farms, since no data exists to show how increased cropping in Southland has been distributed between the three groups of farms. It is quite feasible to expect that the medium fertiliser use group, which are in general larger and less intensive farms than the "high" group, has contributed relatively more to the cropping area. There appears to be no simple explanation for the degree of uniformity of stocking rates between the "medium" and "low" group, except that farmers do not feel that stocking rates should be increased until higher levels of fertiliser application are reached. One result is that the "medium" group farmers achieve much higher production per e.e. than the "low" group. This is discussed below. Nevertheless, each group has increased stocking rates over the period 1953/4 to 1964/5 by a similar percentage.

Figure VStocking Rates by Fertiliser GroupsProduction per Ewe Equivalent

It is often inferred that increases in stocking rate per se are desirable, and provide a yardstick against which farm development can be measured. This inference is likely to mislead both farmers and those who are concerned with measuring the profitability of farm investment, since production per ewe equivalent may show considerable variation. Figure VI indicates that significant differences do exist between output per ewe equivalent on the three groups of intensive farms, apart from year to year fluctuations.

Figure VI and Table 4 were prepared from physical records of annual meat and wool production on the survey farms, both converted to money terms, assuming constant prices of 42d per lb. for wool and 20d per lb. for meat. Over the whole period, the two upper fertiliser groups tended to have higher production per ewe equivalent than the low group.

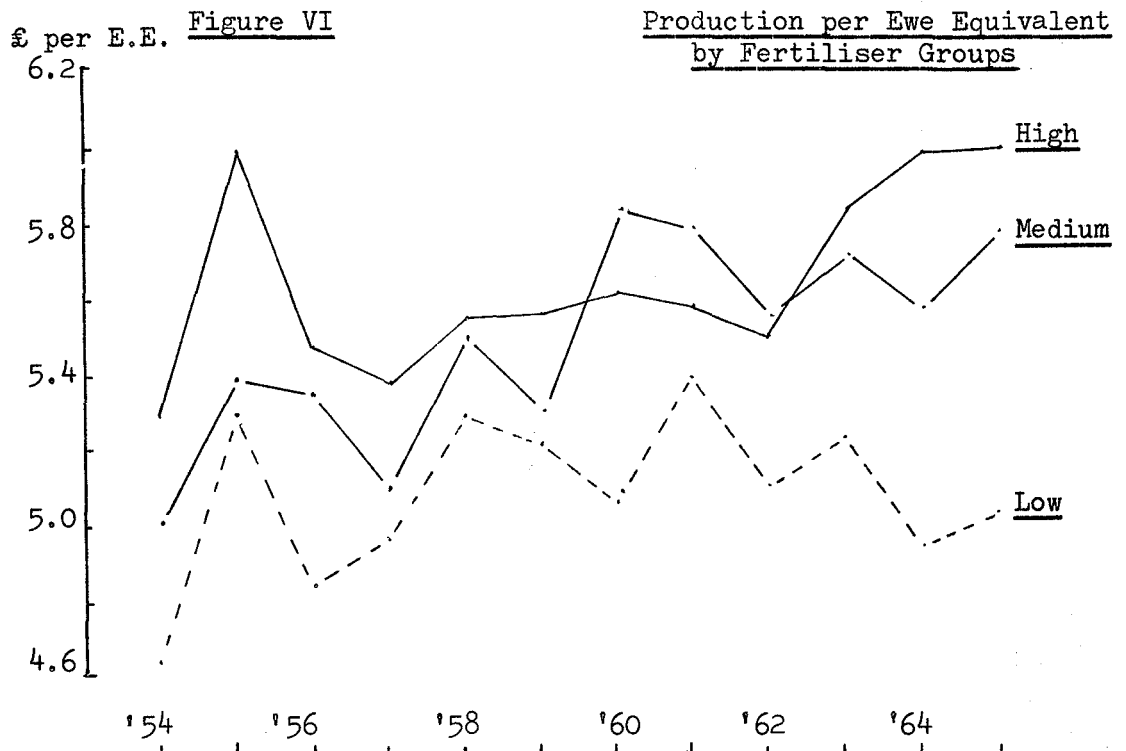


TABLE 4

Fertiliser Use and Production per Ewe Equivalent

<u>Group</u>	<u>1953/4</u>	<u>1964/5</u>	<u>Percentage Increase</u>	<u>Average 1953/4-1964/5</u>
High	5.30	6.00	13.2	5.69 (a) (c)
Medium	5.01	5.77	15.2	5.49 (b) (c)
Low	4.64	5.02	8.2	5.08 (a) (b)

- (a) Pairing significantly different at 0.1% level
 (b) Pairing significantly different at 1% level
 (c) Pairing significantly different at 30% level

Mean production per ewe equivalent from the "high" and "medium" groups are respectively about 12 per cent and 11 per cent above that of the "low" group. Further, although production per ewe equivalent was higher on the "high" and "medium" farms in 1953/4, the percentage increase over the twelve year period was considerably higher than that of the "low" group.

The very important relationship between stocking rate and production per ewe equivalent which explains the fluctuations shown in Figure VI is discussed below when farm production of the three groups of farms is considered.

Production per Acre

Gross farm production per acre estimates for the three groups of farms are shown in Figure VII and summarised in Table 5. Production is in value terms at constant prices (meat 20d per lb., and wool 42d per lb.).

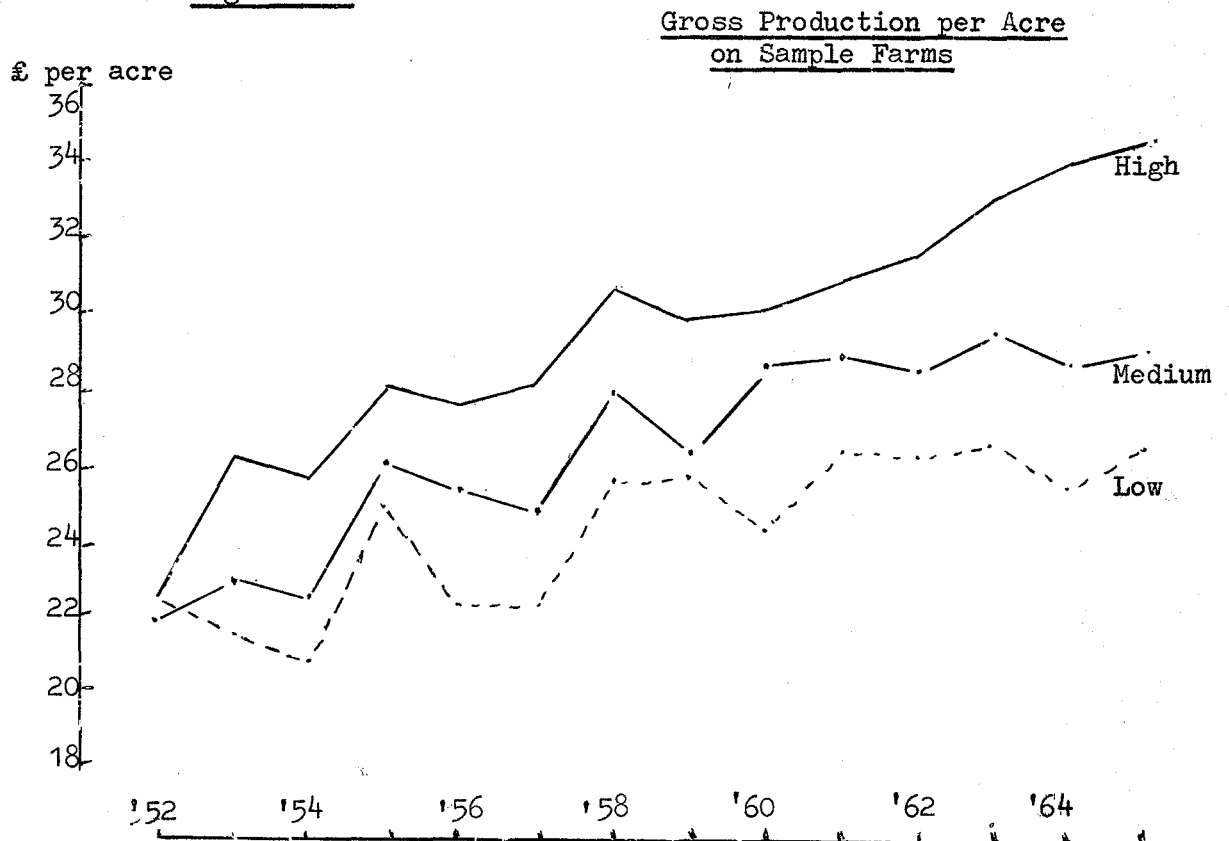
Both Table 5 and Figure VII show the considerable differences in production per acre between the three groups of farms. The "high" groups, averaged £31 per acre from meat and wool over the 12 year period and reflect the standard of performance of the more highly developed farms in the area. Since there is no apparent reason why if developed to the same stage the "medium" and "low" groups cannot match this high output figure, Table 5 offers some indication of the minimum potential increases in production which are known to be possible. This means, in effect, that the "low" group could increase production per acre by over 30 per cent and the "medium" group by nearly 19 per cent to reach the 1964/5 average level of operation of the "high" group. In the long run, each fertiliser group had a distinct and identifiable level of production per acre.

TABLE 5Fertiliser Use and Farm Production per Acre

<u>Group</u>	<u>1953/4</u>	<u>1964/5</u>	<u>Percentage Increase</u>	<u>Average 1953/4-1964/5</u>
High	25.56	34.56	35.2	30.81 (a) (b)
Medium	22.43	29.09	29.7	27.33 (a) (c)
Low	20.62	26.55	28.8	24.87 (b) (c)

- (a) Pairing significantly different at 2.0% level
 (b) Pairing significantly different at 0.1% level
 (c) Pairing significantly different at 5% level

It will be noticed from Figure VII that the three groups of farms were operating at similar production levels in 1951/2, i.e. about £22 per acre. Although the sample contains fewer farms in this year, casting some doubt on the reliability of the estimates, calculated increases in production per acre over the longer

Figure VII

period from 1951/2 to 1964/5, at constant prices, are as follows:

High	55%
Medium	33%
Low	19%

It is important, however, to consider the relationship between the factors which have influenced the production figures and which have led to the disparities evident in Table 5.

It has been mentioned that the division of the sample into three groups on the basis of fertiliser use, should not imply that subsequently demonstrated inter-group differences can be imputed to fertiliser use. Factors such as higher management levels, motivation, and closer subdivision, presumably associated with fertiliser use, will contribute in no small measure to increased production. However, it is feasible to impute a reasonable proportion of increased production to fertiliser use, as suggested below.

The farm characteristics, stocking rate, production per ewe equivalent and farm production per acre, are drawn together into table 6. In 1953/4 the "high" and "medium" groups showed generally higher stocking rates, production per ewe equivalent, and production per acre.

The percentage increase shown therefore under-estimates somewhat the relative performance of these two groups of farms, because of their higher initial development level.

TABLE 6
Fertiliser Use and Farm Characteristics³
(1953/4 to 1964/5)

<u>Farm</u> <u>Characteristic</u>	<u>High</u>	<u>Fertiliser Use Group</u> <u>Medium</u>	<u>Low</u>
Stocking Rate:- (E.E. per acre)			
Mean 1953-64	5.47	4.97	4.86
Percentage Increase	17.4	15.35	17.7
Production per Ewe equivalent (£):-			
Mean 1953-64	5.69	5.49	5.08
Percentage Increase	13.2	15.2	8.2
Farm Production (£ per acre):-			
Mean 1953-64	30.81	27.33	24.87
Percentage Increase	35.2	29.7	28.8

Over the period 1953/4 to 1964/5 the "high" fertiliser use group have achieved an increase of 35 per cent in production per acre by increasing stocking rates by over 17 per cent and production per ewe equivalent by 13 per cent. Referring to Figures 5, 6, and 7 it will be noticed that this increase in

³ It will be noted that stocking rate multiplied by production per stock unit does not necessarily equal production per acre. The reason for this lies in the method of averaging the observations over time and between farms. The extent of the difference depends on the statistical relationship between stocking rate and production per stock unit.

production per acre has been fairly consistent and that it has been achieved by similar upward trends in both production per ewe equivalent and in stocking rate. There would appear to be some inverse relationship between the stocking rate and production per ewe equivalent, indicating that even minor increases in stocking rate are associated with decreased production per ewe equivalent.

The "medium" group have increased production per E.E. faster than the "high" group. But they have increased stocking rate slower, and the total effect for the medium group is a slower increase in farm production.

The "low" group has increased stocking rate faster than either of the other groups. This has been done at the expense of production per ewe equivalent.

The slower increase in production per E.E. for the "low" group is expressed in slower increase in farm production compared to the "high" group, but yet roughly similar to the "medium" group. Trends in production per acre on the "low" group in Figure VI show a general increase until 1960/1, followed by a decrease. While the increase in production per acre has again been fairly consistent, the decrease in production per ewe equivalent in recent years (Figure VI) has been associated with a fairly sharp increase in stocking rate (Figure V). It would appear that attempts in later years by the "low" group to increase stocking rates, presumably without fertiliser and other associated development expenditure, have led to fairly substantial decreases in production per ewe equivalent, which are not evident in the "high" and "medium" groups.

The relationship between production per acre, stocking rate, and production per ewe equivalent is at present under further study.

Only a general comment is possible at this early stage of analysis. It would appear that many farmers, particularly on high producing farms, consider that any decrease in fleece weights or lambing percentages is a sign of over-stocking, and consequently take steps to relieve grazing pressure. In practice, of course, this will not be the case, and some optimum stocking rate will exist where fleece weights are below the maximum. One extension worker in the Southland area contends that stocking rate should be increased if wool weights rise above 11.5 lbs per head - a claim which would be difficult to dispute with our existing state of knowledge.

Gross Income per Acre

Estimates of gross income for the three groups of farms are shown in Figure VIII, and are summarised in Table 7. Gross income is calculated from records of physical production of wool and meat, and from records of "other income" from the records of the Meat & Wool Boards' Economic Service. Some confusion associated with the use of the term in an accounting sense is thereby avoided. Two assumptions have been made in these calculations - that all farms received identical prices for meat and wool sold, and that the prices received were the average prices operating in Invercargill in the relevant year. Actual prices used in the calculations are listed in Appendix 1. These assumptions remove the effect of chance inter-farm differences in wool prices, but introduce the effect of year-to-year price fluctuations of meat and wool.

TABLE 7Fertiliser Use and Gross Income per Acre

<u>Group</u>	<u>£</u>		<u>Percentage Increase</u>	<u>Average 1953/4-1964/5</u>
	<u>1953/4</u>	<u>1964/5</u>		
High	26.45	39.61	49.8	32.22 (a) (b)
Medium	23.97	32.66	36.3	28.35 (b) (c)
Low	22.99	26.94	17.2	24.30 (a) (c)

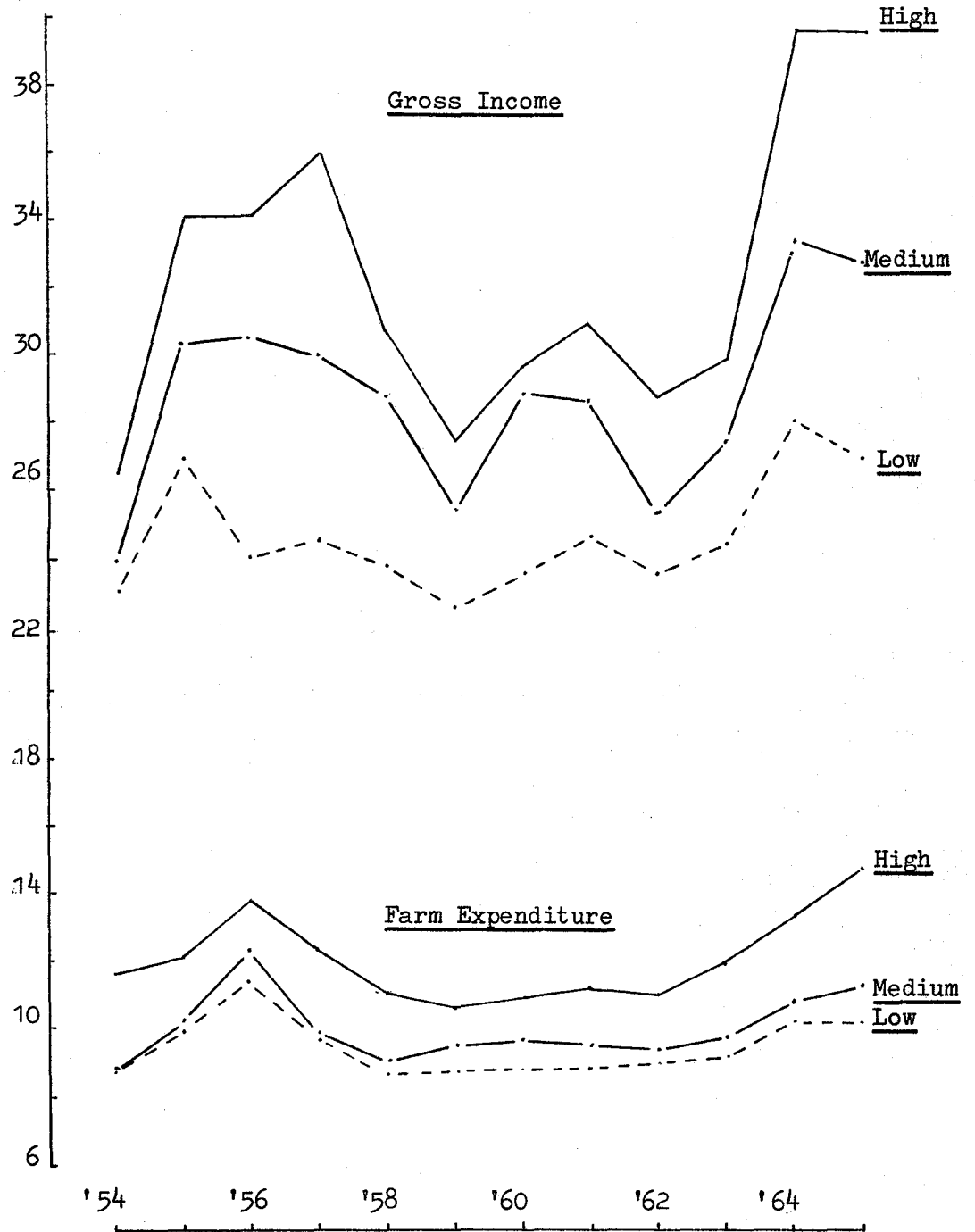
- (a) Pairing significantly different at 0.1% level
 (b) Pairing significantly different at 2% level
 (c) Pairing significantly different at 2% level

There are marked differences in gross income per acre between the three groups. Farms in the "high" group were earning in 1964/5 gross income of over £32 per acre, which is more than 21 per cent and 47 per cent higher than gross incomes earned on the "medium" and "low" groups respectively. Over the period 1953/4 to 1964/5, gross income per acre for the "high" groups rose by almost 50 per cent. Under the same price regime, gross income for the "medium" and "low" farms, rose by proportionately lower amounts. Figure VI demonstrates the self-evident, but often overlooked fact, that the variation in the gross incomes of the "high" group (higher producing farms) will be larger because a larger volume of production is exposed to a given price change. The disparity in gross incomes between the three

Figure VIII

Gross Farm Income and Expenditure per Acre

£ per acre



groups in any year apparently reflects changing price levels more than other factors. Expressed in another way, higher producing farms gain proportionately more gross income during a phase of higher prices.

Farm Expenditure per Acre

Since no physical information was available for the calculation of farm expenditure, accounting figures have been used. The term "farm expenditure" is a fusion of running expenses and a portion of farm development expenses. It includes wages and rations, farm requisites, fertiliser lime and seeds, truck and tractor expenses, feed and grazing, contract work, repairs and maintenance, rail and cartage, general expenses, insurance, and rates and land taxes, but excludes interest, rent, depreciation and manager's salary. The latter are omitted to remove variations in equity and residence conditions, to arrive at comparable levels of farm expenditure. Several of the included categories will contain both routine running expenses and elements of what could be correctly classified as development expenditure. In particular, contract work, wages, fertiliser lime and seeds, and repairs and maintenance, and farm requisites, will be likely to contain such expenditure. If it can be assumed that "true" running expenses per acre are fairly constant or steadily increasing, and this seems a reasonable assumption, then the variations in farm expenditure per acre reflect to some extent, the amount of farm investment which has taken place. Trends in farm expenditure are illustrated in Figure VIII, and are summarised in Table 8.

TABLE 8

Fertiliser Use and Farm Expenditure per Acre

<u>Group</u>	<u>1953/4</u>	<u>1964/5</u>	<u>Percentage Increase</u>	<u>Farm Expenditure p/ac.</u>
	<u>£</u>			
High	10.88	14.74	35.5	12.05 (a) (b)
Medium	8.78	11.19	27.4	9.96 (b) (c)
Low	8.77	10.28	17.22	9.24 (a) (c)

- (a) Pairing significantly different at 0.1% level
 (b) Pairing significantly different at 1% level
 (c) Pairing significantly different at 30% level

Farm expenditure is significantly higher for the "high" group than for the "medium" group. This probably reflects both higher running costs and higher development expenditure. Farm expenditure for the "low" group increased by slightly more than 17 per cent, compared with an increase of over 19 per cent⁵ in the index of prices paid for goods and services over the same period for New Zealand sheep farmers. This suggests that little if any increase in the volume of purchases of fertiliser, subdivision, drainage, stock expenses etc., has occurred. The slow rate of increase of farm production (p. 16) tends to reinforce this suggestion.

There is clearly some relationship between farm expenditure and gross income - in years where higher prices for wool and/or meat have caused gross incomes to rise, corresponding increases have occurred in farm expenditure. Doubtless, some of the variation is due to running expenses which vary with output, e.g. shearing expenses. However, close examination of the data reveals that most of the variation in farm expenditure originates from variation in expenditure on fertiliser, and what could be termed development expenditure. It will be noticed that levels of fertiliser use (Figure 3) correspond closely with the level of farm costs in Figure VIII.⁶

Net Income per Acre

Net income figures are derived simply as the difference between gross income and farm costs, and are shown in Table 9 and Figure IX.

-
5. Calculated from (6) p. 41 and (5)
6. Campbell's "residual funds" hypothesis (2), developed in the Australian environment, suggests that agricultural investment is likely to be higher on farms with widely fluctuating incomes and consequently lead to a higher rate of capital formation over time, than on farms where income is relatively stable. The arguments above simply claim that the effect of higher prices will be magnified on higher producing farms and must result in higher variance of gross income, and in higher aggregate income. On the Southland farms at least, it would appear that higher aggregate income, and not higher income variance sets the stage for increased investment.

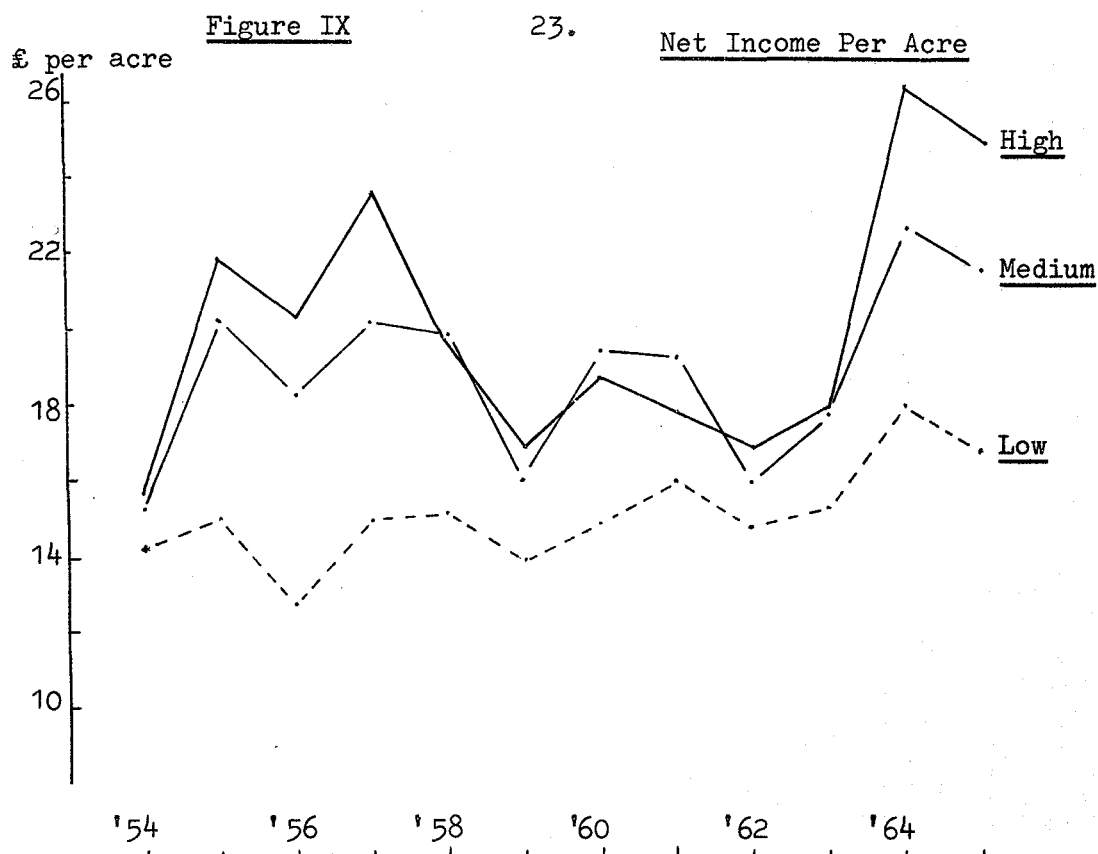


TABLE 9

Fertiliser Use and Net Income per Acre

<u>Group</u>	<u>£</u>		<u>Percentage Increase</u>	<u>Average 1953/4-1964/5</u>
	<u>1953/4</u>	<u>1964/5</u>		
High	15.58	24.87	59.6	20.18 (a) (b)
Medium	15.19	21.47	41.3	18.40 (b) (c)
Low	14.22	16.66	17.2	15.06 (a) (c)

- (a) Pairing significantly different at 1% level
 (b) Pairing significantly different at 30% level
 (c) Pairing significantly different at 1% level

Net income figures for the "low" group have increased at a much slower rate than the higher groups, to reach only £16.7 per acre in 1964/5. At the same time the "high" group earned a net income of almost £25 per acre, an increase of 50 per cent over the "low" group, and 16 per cent over the "medium" group.

These figures actually understate the differences in net income, as used in the traditional sense, between the groups. It will be remembered that farm costs are expected to contain a high proportion of development expenditure. The net income figures will therefore represent the surplus available after most of the investment in fertiliser, subdivision and drainage etc., has been carried out. Figure IX therefore probably reflects the acceptable level of personal income that was desired before re-investment in the farm took place. A slightly rising level should be expected as price changes on the expenditure side have all been upwards.

A Closer Look at Fertiliser Use and Stocking Rate

On intensive farms in Southland high fertiliser use has been associated with high production. It has already been suggested that this high production may come from the extra pasture growth promoted by the extra fertiliser and from better management methods, higher stocking rate and a higher level of farm development.

To facilitate a closer examination of the effect of different levels of fertiliser use and stocking rates, the sample of farms was divided into categories, four of which were selected for further study:

- | | | | |
|-----|-----------------|----------------------|------------|
| (a) | High fertiliser | - high stocking rate | (HH group) |
| (b) | High fertiliser | - low stocking rate | (HL group) |
| (c) | Low fertiliser | - high stocking rate | (LH group) |
| (d) | Low fertiliser | - low stocking rate | (LL group) |

where "high" and "low" fertiliser have the same limits as previously outlined and "medium" is omitted. The upper and lower groups for stocking rate were derived from the following classifications:

High stocking rate - above 5.43 ewe equivalents per acre, i.e. the top third on stocking rate classification.

Medium - between 5.43 and 4.85 ewe equivalents.

Low - below 4.85 ewe equivalents per acre - the lowest third.

The number of farms that fell into the four categories was:

HH group	10 farms
LH group	4 farms
HL group	2 farms
LL group	8 farms

As might well be expected, the LH and HL groups contained only a small number of farms. There is therefore a greater risk that these farms are not as representative of similar farms in Southland as the larger group of HH and LL farms would be. The statistical tests take account of this.

TABLE 10

Production Characteristics of Farms Classified
on Fertiliser Use & Stocking Rates

	<u>Fertiliser Use</u> (cwt/acre).	<u>Stocking Rate</u> EE/acre	<u>Prodn per EE</u> £/EE	<u>Prodn per acre</u> £/acre
HH	2.7	5.8	5.7 (e) (f)	32.9 (a)(b)(c)
LH	1.2	5.6	5.0 (f) (h)	27.7 (b)(d)
HL	2.7	4.6	5.7 (h) (i)	26.1 (c)(g)
LL	1.2	4.4	5.0 (e) (i)	21.9 (d)(a)(g)

- (a) Pairing significantly different at 0.1% level
 (b)(c) Pairing significantly different at 2% level
 (d)(e) Pairing significantly different at 5% level
 (f) Pairing significantly different at 20% level
 (g)(h)(i) Pairing significantly different at 20% level

The first two columns in Table 10 present the group averages for fertiliser use and stocking rate; the bases on which the farms were grouped. The third and fourth columns give the production per ewe equivalent and per acre, associated with the various groups of farms.

Table 10 allows some interesting comparisons. The "fertiliser effect" can be isolated by comparing the HH and LH groups, and the HL and LL groups respectively, and by the quite reasonable assumption that all other factors such as management ability, and technological competence, are substantially the same if stocking rates are comparable. The fertiliser effect should, however, be interpreted in its wider meaning, i.e. as part of an overall programme of pasture improvement; which can lead to greater stocking-carrying capacity.

The HH and LH groups have substantially the same stocking rates, but the farmer produces an additional £5.2 per acre. This is clearly due to an additional £0.7 earned by each ewe equivalent on HH farms. Similarly, HL farms' production of £4.2 per acre more than LL farms, is due to an additional £0.7 production from each ewe equivalent. In both cases then, an increase in fertiliser use of about 1.5 cwt/acre and a marginal increase in stocking rate is associated with a better stock

performance of the order of £0.7 per ewe equivalent, and consequent higher production levels per acre.

The stocking rate effect can be seen by comparing the HH and HL groups and the LH and LL groups. It is likely that higher stocking rates are associated with greater management ability, and with drainage and subdivision expenditure, although this is not necessarily the case. The table shows no evidence of lower stock performance accompanying an increase in stocking rate, at constant levels of fertiliser use. This suggests that the stocking rate level at which production per ewe equivalent starts to fall is much higher than many farmers expect it to be. On the information given it would appear to be above 5.7 ewe equivalents per acre. Higher stocking rates, whether at "low" fertiliser use levels (LH), or at "high" fertiliser use levels (HH), have in large measure contributed to 26% more production.

If fertiliser and stocking rate are studied together, some interesting points emerge. It has been established that increased stocking rates are not associated with lower stock performance, suggesting inefficient use of pastures at lower stocking rates. However, at low stocking rates, an increase in fertiliser use, which presumably boosts pasture production, is associated with an increase in stock performance. Two possible explanations for this apparent contradiction can be noted. First, it is likely that the farms with higher stocking rates have higher management ability, enabling more efficient use of pastures. Secondly, it may be that high levels of fertiliser use result in better quality pastures, enabling higher stock performance even at low stocking rates.

It must be mentioned that although the averages used in discussion are helpful, and indicate levels of farm performance, the statistical tests used give evidence of the existence, rather than the extent of differences in production.

It has been established that when high levels of fertiliser use and high stocking rates have been used, this combination is associated with high levels of production in most circumstances. The figures given in Table 10 merely verify the wisdom of balanced development. Some increase in production may be achieved by either increased fertiliser use or increased stocking rate, but there are clearly limits to the level of either which should be reached in isolation. Between year effects will be analysed in a later paper.

Finally, Table 10 illustrates the potential improvements in production per acre which could be expected in the Southland area if farmers were intent on achieving the HH level of operation (5.8 ewe equivalents/acre and 2.7 cwt fertiliser per acre). By following appropriate development patterns the expected increases in production per acre would be:-

LL group	-	£11.0 per acre
HL group	-	£ 6.8 per acre
LH group	-	£ 5.2 per acre.

Conclusions

This study of data collected by the Meat & Wool Boards' Economic Service from intensive sheep farms in Southland for the period 1953/4 to 1964/5 suggests that although fertiliser must be considered as only one input in a list of farm inputs essential to farm development, higher levels of fertiliser use per acre are associated significantly with:-

1. Smaller farms
2. Higher stocking rates
3. Higher production per ewe equivalent
4. Higher production per acre
5. Higher farm expenditure and gross incomes per acre
6. Higher net incomes per acre.

The average level of fertiliser use in Southland does not appear to have increased significantly since 1951, but there has been a significant increase in the amount of potash applied. Fertiliser application by farmers appears to vary with meat or wool prices and economic conditions generally.

On this historical evidence, significant increases in production per acre are possible in Southland, both by increased fertiliser use and by increased stocking rates. There is a close involvement between fertiliser, management, additional stock and other physical inputs in meat and wool production.

APPENDIX 1

Invercargill average prices incorporated into calculation of gross income.

<u>Year</u>	<u>Wool</u> ^(d)	<u>Lamb Prices</u> ^(a) (pence per lb)	<u>Ewes</u> ^(b) (pence per lb)	<u>Beef</u> ^(c) (shillings per 100 lb.)
1951/2	37.48	16.416	5.917	88.0
1952/3	47.37	19.063	6.161	97.5
1953/4	50.22	20.000	7.208	101.0
1954/5	51.38	23.917	6.625	120.0
1955/6	47.39	25.625	7.500	110.0
1956/7	57.23	23.500	7.875	60.0
1957/8	39.98	21.625	6.500	80.0
1958/9	37.19	19.500	5.125	120.0
1959/60	44.88	18.750	2.750	125.0
1960/1	41.19	17.250	4.750	120.0
1961/2	39.49	12.625	4.000	112.5
1962/3	41.93	17.000	4.750	110.0
1963/4	56.07	19.875	4.750	120.0
1964/5	42.14	23.500	9.750	145.0

- (a) January average Woolly Lambs 36 lbs and under
- (b) February & March average price for ewes
- (c) October average price per heifer G.A.Q.
- (d) Average wool price, Invercargill Sales - Dept. of Statistics.

APPENDIX II

Some Comments on the Sample

Records of Meat and Wool Boards' Economic Service show that at 5/11/65 there were 50 Southland fattening farms in their survey (group 4 Si). The sample of farms analysed in this paper was made up of 48 farms. Of these, 4 were no longer in the survey in the last year of analysis, 1964/5. Six of the fifty survey farms were excluded because records were not available for at least 4 years (the minimum acceptable period), and 4 others which had dropped out by 1964/5 were included.

In the first year of analysis, 1953/4, 32 of the survey farms were used. Of these 29 remained in the survey for the whole of the period and could thus be used for all years. Sixteen were included after 1953/4 and one of these withdrew before 1964/5.

Number of Farms in the Sample

<u>Year</u>	<u>Group</u>			<u>Total</u>
	<u>High</u>	<u>Medium</u>	<u>Low</u>	
1953/4	9	12	11	32
1954/5	10	14	11	35
1955/6	13	14	11	38
1956/7	14	14	11	39
1957/8	14	14	13	41
1958/9	15	14	14	43
1959/60	15	14	14	43
1960/1	15	13	14	42
1961/2	16	15	16	47
1962/3	16	15	14	45
1963/4	16	15	14	45
1964/5	16	14	14	44

The Effect of the Changing Sample on the Yearly Averages

If the farms are selected randomly the growing sample size will serve only to narrow the confidence interval band that can be imposed on the graphed attributes. Calculations were carried out to examine the extent of the change in the group average in any year caused by the withdrawal or inclusion of farms. They did not show any marked shift in the main attributes.

APPENDIX II (cont'd)

The Effect of the Changing Sample on the Farm Averages (e.g. mean output of one farm for the years 1953/4 to 1964/5)

Because the attributes stocking rate, production per ewe equivalent, and production per acre are increasing over time, the increasing sample size will almost certainly cause bias in the estimates. Farms are included for which there are no observations for the early years. As the averages are the means for twelve years and there are more farms in the last half of the period than the first half, the group means will be disproportionately weighted at the top. It so happens that of the 5 farms introduced in the last 4 years, 1 is in the "high" group, 2 are in the "medium" group and 2 are in the "low" group. This would weight the attributes in favour of the "low" and "medium" groups and hence the calculated difference between these and the "high" group is likely to be smaller than actual difference. The fact that there were only 9 farms in the "high" group in the first year will work the other way. It is to be hoped that these effects are compensating. More-over it is the difference in the levels that is important rather than the levels themselves. As long as the bias is in the same direction in each group the bias in the differences remains unimportant.

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