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THE PROFITABILITY OF BEEF PRODUCTION ON SOME NEW ZEALAND SHEEP FARMS

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C O N T E N T S

CHAPTER ONE

I N T R O D U C T I O N

New Zealand sheep farmers are currently receiving product prices which, when considered in relation to their farm costs, are the lowest they have been for many years. Wool prices appear unlikely to recover to levels experienced ten years ago and many sheep farmers are still relying on wool as a major source of farm income.

There is an increasing awareness that beef animals can no longer be regarded as aids to good sheep husbandry and instead, must make a direct contribution to farm income. The increasing acceptance of animals of dairy origin as beef-producers, and continued confidence in the long-term market for beef, have helped provide a climate for large-scale moves toward beef-production on many New Zealand sheep farms.

As a consequence, there has been a rapid increase in demand for economic information on all aspects of beef production and particularly with relation to established sheep enterprises. It is intended that this thesis should go some way towards meeting this demand.

1.1 THE SCOPE OF THIS THESIS

It would be impossible in a study of this nature to attempt a detailed investigation of all possible beef-production methods over a wide range of farm environments. For this reason, the investigation will be directed toward sheep farms which could fulfil the following conditions:

(a) The farm environment should be conducive to intensive sheep-farming in breeding-ewes, with a winter carrying capacity of about five ewes per acre, 100 per cent lambing, and all lambs fattened.

(b) The farm environment should enable an intensive beef-production system to be successfully implemented. Beef-animal carcass weights of the order of 400 lb should be possible at 18 - 20 months of age.

These conditions do not require that previous animal performances have reached the levels suggested, merely that they are feasible. The results of this study then, will be relevant to an audience which includes most New Zealand fat-lamb farmers, but excludes dry-sheep farmers and those whose climate or contour would not allow the production levels considered in this study.

The study is further limited by excluding consideration of all beef-breeding policies. It was felt that for the audience outlined above, fattening rather than breeding policies would be of interest. The inclusion of breeding policies would complicate the analysis and lessen the attention which could be given to close examination of beef-fattening policies.

1.2 THE PRESENT BEEF INDUSTRY

The beef industry in New Zealand has been described and documented by many workers, (36, 39 and 50). Comments by these workers highlight the fact that prior to the mid-1950's, cattle were regarded essentially as implements for pasture management and roughage control and beef production was merely an ancillary to the financially more attractive specialised industries of sheep farming and dairying.

Since 1948, a noticeable growth in female breeding stock has been observed, together with a decline in the importance of older, heavier beef cattle. In 1950, steers two years old and over made up 21.8 per cent of the national beef herd, with steers under two years representing 20.7 per cent. By 1969 the proportions had changed to 10.8 per cent for steers over two years and 27.8 per cent for steers below this age. The increased retention of dairy-bred animals for slaughter would have contributed towards this change.

The general trend, particularly within the last five years, has been towards slaughter at an earlier age. This is in keeping with the changing role of beef animals associated with recognition of their potential profitability as meat-producers.

Johnson (36) assessed likely future trends in beef production, and considers that expansion in the beef industry will be at the maximum biological rate, (i.e. a seven per cent long-term growth-rate of the beef breeding herd), with only moderate increases in sheep numbers. Animals from the National Dairy Herd have also been projected to play a major role in the New Zealand Beef Industry.

McClatchey (50) considers there is no reason why, at some time in the future, much more of New Zealand's pastured land could not be devoted to beef production if changes in relative market prices for the various alternative products were to warrant such a change in output proportions.

1.3 BEEF RESEARCH REQUIREMENTS

Research into the economics of beef production prior to the 1950's was almost neglected. The recent increase in demand for economic information on all aspects of beef production in relation to the established sheep and dairy enterprises has revealed a lack of physical information on the subject.

Joblin (35) points out some of the research work required, and mentions

(a) detailed research on the feed requirements of the various classes of cattle at various production levels;

(b) a more thorough investigation of our feed resources, including possible yields and feeding values of grass, crops or fodders in various environments;

(c) an investigation based on (a) and (b) of a wide range of possible management systems.

The information problems encountered in this study indicate that Joblin has accurately pinpointed the critical gaps in our present knowledge of beef production.

1.4 REASONS FOR THIS STUDY

As a Farm Advisory Officer with the Department of Agriculture the author was in contact with an ever increasing number of sheep farmers looking to beef production as a means of combatting falling sheep returns and rising farm costs.

Many of these sheep farmers occupy farms part or all of which would be suitable for beef production. It is perhaps ironic that in many areas such as the fertile Manawatu river-flats, the initial decision to adopt a breeding-ewe and fat-lamb enterprise rather than dairying on some farms was made solely because the farm area was large enough to make this type of sheep farming economic. Smaller farms, perhaps next door, became dairy enterprises because of the higher pre-acre returns. With falling sheep returns and the currently attractive dairy returns, dairy farms are more profitable than the larger sheep farms. It is these farmers, ideally suited in terms of farm environment and economic climate, who could quickly and successfully adopt an intensive beef production system.

The lack of physical and economic data on beef production and the wide variety of cattle performances resulting from the various systems adopted by farmers highlighted the need for a thorough investigation into beef-production systems.

1.5 AIMS OF THE STUDY

The aims of this study are two-fold

(a) to investigate various aspects of beef-producing systems and find which system is likely to return most net profit to the farmer;

(b) to compare beef-production systems with sheep-farming on a profitability basis.

The results will apply to any farm where beef cattle performances described in this study are feasible. The beef policies examined will be those where animals are purchased as weaners or 18-month cattle, and sold for slaughter.

1.6 METHODS OF APPROACH TO THE STUDY

Initially, a budgeting technique was considered, as the aim was to conduct an analysis readily understood by farmers. However, it soon became apparent that budgeting techniques were inadequate and that linear programming was quite capable of giving results easily translated so as to be accepted by a farmer audience.

Any analysis is limited in reliability according to the physical information on which it is based. Much of the time spent in this study was used to find or compile the required physical information. To this end, information was gathered from farmers, research stations and the literature from New Zealand and overseas. Throughout this thesis, a constant theme is "feed-budgeting" or the science of matching feed requirements and feed availability to maximise returns on the farm.

Two Case Farms will be examined in detail. These two were purposively selected to represent different farm conditions. The fact that both analyses gave the same broad guide-lines for an optimum beef system reinforces the view that the results are applicable to a wide variety of farms.

CHAPTER TWO

TECHNICAL CONSIDERATIONS RELATING TO BEEF PRODUCTION

2.1 INTRODUCTION

This chapter outlines the information required for this study and describes the sources of information for farm management studies. Information gathered from discussion with farmers, small farm experiments and the literature is presented.

Animal characteristics of possible importance to a beef-producer together with the problems inherent in comparing two or more breeds, are discussed.

2.2 INFORMATION REQUIRED FOR THIS STUDY

The physical and financial information required so that the aims of this study could be met may be considered separately.

2.2.1 Physical Information

The construction of a linear programming model requires the analyst to define input-output relationships and any on-farm limitations appropriate to the system being considered. The model must be able to take account of these limitations and relationships at any production level, and for any mix of enterprises which may be of interest.

The information required thus includes not only the inputs and outputs for a farm running all sheep or all beef animals, but any combination of these two enterprises. The impact of changes in these enterprises on feed, labour and other possible inputs must be estimated, along with the production levels which would result. Complementary, supplementary or competitive relationships between enterprises for any farm resource must be defined.

2.2.2 Financial Information

The on-farm costs and prices for any production situation of interest must be known. Any relationship between per-animal cost and scale of enterprise must also be defined.

2.3 THE AVAILABLE SOURCES OF INFORMATION

Information for the solution of farm management problems may be gathered from scientific literature, small farm experiments or farm surveys (18). The usefulness of any one of these methods depends on the particular problem under consideration.

In the case of beef production on sheep farms, the following points may first be noted:

(a) The New Zealand beef industry is expanding rapidly. Physical and financial information available from farmers is thus relevant to a growing industry, and not a static situation.

(b) Only in recent years have farmers adopted intensive methods of beef production on a large scale. Few farmers have achieved a stable beef system.

(c) Only in the last few years have Research Stations attempted to provide experimental data on intensive beef production.

(d) Financial information is a lesser problem than physical information as a relatively small number of inputs and outputs are normally involved.

For these reasons, it was found that lack of physical information on intensive beef production was a real limitation to the study. To overcome this, all possible sources of information were considered and to some extent used in the study.

2.4 INFORMATION FROM FARMERS

In addition to farmers encountered by the author while employed by the Department of Agriculture, a purposive sample of twelve farmers in the Manawatu and Waikato were interviewed. These farmers were selected because they had evolved something approaching a stable system of beef production, had changed from sheep to beef production, or had adopted some other management aspect of particular interest to this study. In only two cases, however, had farmers been operating an all-beef system for more than three years, and both of these farmers had made the change for motives other than profit.

It soon became apparent that while information gained during discussion with these farmers proved of general interest and illustrated the diversity of possible beef enterprises, limited factual information on the physical aspects of beef production could be obtained.

No set interview questionnaire was used, and the following discussion is based on points raised in general conversation with the farmers.

2.4.1 Stock Purchases

Most farmers could readily provide information on the number of stock purchased, date of purchase and price paid. However, the price paid for an animal is an unreliable guide as to its size or weight. Some farmers are more successful stock-buyers than others and are able to obtain better stock for the same cash outlay. Farmers were prepared in some cases to pay substantial premiums for a certain class of cattle and did not regard live-weight as an acceptable measure of value.

The practice of buying and selling on a live-weight basis would enable more accurate estimates of the live-stock input. However, this is being done only on a very small scale at the present time.

Farmers who owned cattle-weighing scales usually weighed cattle at the time of purchase. Apart from these farmers, a reliable basis for estimating the amount of beef produced on the farm was not available.

2.4.2 Stock Sales

Where stock are sold for slaughter, carcass weights are usually available. These give an accurate guide to meat sold off the farm. Most farmers however, sell at least some stock "on the hoof" and in these cases it cannot always be assumed that selling price reflects the weight of the animal.

2.4.3 Feed Consumed

The amount of feed consumed by beef animals is difficult to assess at Research Stations and accurate estimates are impossible on the farm. It soon became clear that the use of substitution rates between beef and other animals based on farm records or farmer observations could lead to very large errors.

Given a specific area of land, a farmer can at best supply the number of animals which the area supported in any one season. Generally, the amount of feed present when grazing commenced is not available and any supplementary feed such as hay may not have been recorded.

Good stock and pasture management often involves different classes of stock being shifted within the farm. Grazing a number of beef animals on a specific area for long periods was rarely practiced on the farms inspected. Simple stocking-rate figures are thus an unreliable guide to feed ingested by any class of animals on the farm. In any case, the pattern of growth, the amount, or quality of feed produced on any farm area would seldom be known.

2.4.4 Supplementary Feed

Some farmers had carefully recorded the amount of hay or silage fed to their beef animals and the dates on which it was fed. There is no guide however, as to the quality of this feed, nor the wastage involved in feeding it. Few farmers knew when a feed surplus had occurred which enabled supplementary feed to be conserved, most having simply "made enough to winter the animals", In some cases farmers had a fixed policy of conserving a certain area each year, others used a yard-stick based on the number of animals to be wintered.

Hay was generally preferred to silage, mainly because of easier feeding. However, in a few cases self-fed silage had been used with apparent success. Few farmers purchased supplementary feed as a general policy, with an apparent preference for self-sufficiency in feed supplies.

2.4.5 Grazing Management

The systems of grazing management varied widely from rotations of various length, to set-stocking. A rotational system was the most popular and seemed to allow farmers to match feed availability and feed requirements most successfully through easier recognition of feed surpluses.

Farmers running large numbers of bulls, and those where lack of labour or paddock numbers did not allow rotational grazing, were forced to adopt a set-stocking system. It was impossible to estimate how much, if any, production was lost because of this.

2.4.6 Other Stock

Where non-beef animals shared pastures with beef animals, estimating the proportion of feed consumed by each class of stock became impossible.

It was particularly noticeable however, that beef animals were poor competitors for pasture when grazed simultaneously with sheep. Growth rates of beef animals were noticeably poorer in all cases where sheep and beef animals were grazed together.

To a lesser extent, this comment was also true of beef animals on dairy farms. Invariably, a dairy farmer attempting to fatten beef animals consciously or unconsciously gave first preference for feed to his milking cows. In most cases, beef animals were fed on a basis similar to herd replacements, and the two were frequently run together.

If fast growth rates are desirable, there would seem to be a clear case from these observations for running beef animals on an area independent of either sheep or milking cows. The farmers who did this achieved the fastest growth rates.

2.4.7 Veterinary Costs

In all cases the veterinary costs associated with a beef enterprise arose almost entirely from worm-drenching and lice-spraying. These costs were highest with young animals and generally low for older mature animals.

Drenching and spraying programmes varied markedly from farm to farm. Some farmers involved themselves in considerable expense as a precaution against lice and worms in their beef stock, while others spent almost nothing. Some farmers waited until the offending parasites appeared while others took preventative measures regardless of previous infestation levels.

Veterinary requirements would seem to be a field in which farmers are particularly ill-informed. When asked why a particular drenching or spraying programme had been chosen, farmers were invariably vague and obviously had little or no factual basis to work on. There would appear to be a big need for independent research and extension work in this field.

For worm-drenching, a typical programme chosen was two drenches in the 3 - 6 month age range, and another two between 6 and 15 months. The materials used were often a specific gut-worm drench alternated with a broad-spectrum drench to control lung-worm. For lice control, animals were frequently given a double spray at 4 - 5 months of age and again at 8 - 9 months.

In some years, considerably more doses than this would be required, depending on the presence of parasites. For farmers who did not take precautions against parasites at all, stock in some cases appeared quite healthy, while in other cases preventative measures would have been beneficial.

2.4.8 Labour Requirements

The requirement for labour is perhaps the most difficult input to assess for a beef enterprise. For the farms inspected, the labour input varied widely and no conclusions could be drawn as to the optimum labour input for any beef system.

The wide variety of beef systems available to a farmer all have differing labour requirements. However it was generally accepted by farmers that one man could successfully manage a larger area with beef animals than either sheep or dairy cows. This may not be true for a combination of two or more classes of stock such as sheep and beef cattle, due to the extra management problems involved.

The ability to save labour costs was a reason many farmers gave for increasing beef numbers at the expense of sheep or dairy cows. Many of these farmers commented, however, that the savings was not as great as they had anticipated. Where a rotational system of grazing was practiced with adequate attention to animal health and supplementary feeding, a considerable amount of time was spent with the stock. Some farmers who changed to beef farming in the hope of increasing their free time found that this did not always eventuate.

The difficulties in estimating labour requirements were demonstrated by one farmer who had kept a record for a full season, of hours spent by farm staff on the cattle, sheep and cropping enterprises. Although detailed and accurate the results depended on circumstances peculiar to that year such as the incidence of facial eczema in the ewes, weeds in the crop or bloat in the cattle. Results also gave no information as to how much extra labour would be required by increased cattle numbers or how much would be released by a decrease in the size of the ewe flock. Nor did the results suggest whether the allotment of time was, in fact, optimal.

Labour requirements are thus difficult to estimate for a beef-producing system. It may be generally accepted however, that they are lower than for equivalent stock numbers in sheep or dairy cows.

2.4.9 Managerial Ability

Differences in managerial ability of farmers were reflected in marked differences in stock performance and profitability. In particular, for successful beef farming the skills required are firstly, successful purchasing i.e. buying the right animals at a good price and secondly, skillful feed-budgeting i.e. matching feed requirements to feed availability.

Purchasing skill also requires experience, frequent visits to sale yards and constant surveilance of stock prices. Farmers frequently confessed that much of their profit margin had been eroded by lack of skill in this field. For these farmers a beef system involving a minimum of buying and selling transactions would be advisable.

The skill required for successful feed-budgeting is again obtained by experience and the realisation by farmers that feed requirements of beef animals are unlike that of either sheep or dairy animals. The farmers who had approached beef-farming as an entirely new farming system and had budgeted feed supplies to maintain growth rates, were invariably rewarded with heavier carcass weights.

Some of the farmers interviewed had changed from either sheep or milking cows to beef farming simply to allow themselves more free time. Motives other than profit tended to be reflected in lowered stock performance. This point highlights the effect standard of management can have on the profitability of an intensive beef system.

2.4.10 Animal Mortality

Animal losses were surprisingly low on the farms inspected. Farmers typically lost one or two animals each year, mainly through misadventure. An occasional outbreak of bloat on some farms was reported, which resulted in some deaths. None of the farmers, however, felt bloat prevention was justified.

Outbreaks of disease were not reported on any farms and it would appear that mortality is not a major cost in beef producing systems once animals have been successfully weaned.

2.4.11 Buildings, Fences and Yards

For the farms inspected, a change to beef production from either sheep or dairying had required very little expenditure on buildings, fences or yards. Two farmers had erected feeding platforms to enable easy wintering, both of these farms being on a particularly winter-wet soil-type. Other farmers on a similar soil-type considered this expenditure was not justified however, and believed similar results could be obtained with careful stock management during wet periods.

Cattle-yards were in existence on most farms prior to the increase in beef numbers. These could usually be made adequate for increased cattle numbers with little expenditure.

Sheep fences were usually more than adequate for control of beef stock, although in some cases further subdivision appeared desirable to facilitate grazing management. On dairy farms, fencing was generally adequate and no additional expenditure was required.

Both sheep and dairy farmers who had changed to beef production considered very little expenditure on building fences or yards was necessary. Most of the farmers interviewed had long-term plans for increasing subdivision, hay or silage-storing facilities and installing a cattle-weighing platform. These were regarded as being aids to management rather than necessities.

2.4.12 Other Costs

Other costs associated with a beef enterprise, such as cartage, depended on the locality of the farm and the particular beef system being operated.

Animals were bought through Stock Firms on a commission basis in some cases but most farmers preferred direct contact with the vendor. This eliminated the cost of commission and allowed farmers to choose the animals for themselves.

2.4.13 Capital Requirements in Stock

The question of capital requirements for an all-beef system was regarded by the farmers as being a problem with two separate aspects:

(a) the "working capital" aspect. A beef farmer is required to wait long periods before recovering his capital outlay on stock. The time period involved will depend on the policy adopted but in some cases a second crop of weaners may have to be purchased before animals from the first crop are ready for sale.

(b) the "additional capital" aspect. In most cases the sale of breeding ewes, and to a lesser extent dairy cattle, did not furnish enough capital to enable purchase of an equivalent stocking rate in beef animals. Of these two aspects, working capital appeared to worry farmers more than the additional capital requirements. Buying young animals, and even calves to be reared by hand, was a common method of obtaining sufficient beef cattle numbers with the capital available. The working capital problem then arose. The severity of this problem depended on the speed with which farmers increased beef cattle numbers. However, most farmers reported that financial problems had arisen, particularly in the period before the first crop of weaners was sold.

If farmers are to be encouraged into increased beef production, adequate provision of working capital should be made.

2.4.14 Specialist Markets

Some of the beef producers interviewed had gained access to beef markets other than by sale to export freezing works. Two farmers in particular were supplying beef directly to meat retailers for consumption in New Zealand. Prices received were generally \$2.00 - \$4.00 per 100 lb of meat above ruling schedule price.

These markets had a significant effect on profitability for these farmers, the only requirement being that animals had to be supplied for most of the year in prescribed numbers at prescribed times. Animals were also required to be within a defined range of carcass weights, although no breed preferences were reported.

2.4.15 General Comments on the Information gained from Farmers

The farmers interviewed were invariably willing and eager to discuss all aspects of beef production. They proved a valuable source of information on the on-farm problems likely to arise with an expanding beef enterprise. However, because of the recent nature of the changes and problems already discussed in putting reliable figures on many of the inputs and outputs, no reliable quantative data was obtained.

The main management problem encountered appeared to be where farmers had attempted to carry too many cattle. This resulted in low carcass weights and large numbers of animals held on the farm for up to two years. A second problem would appear to be lack of purchasing skill. Some farmers had paid very high prices to obtain a particular class of replacement cattle only to find that the premium was not reflected in price received at time of sale. Some farmers were adamant that Friesians were unacceptable as beef-producing animals, while others preferred them to any other breed.

2.5 SMALL FARM EXPERIMENTS

With the increasing availability of reliable cattle-weighing scales, it has become common for farmers and farm advisers to conduct small farm experiments on beef production.

Live-weight recording has provided a measure of meat production on the live animal, as reflected by live-weight gain. A set of Donald's portable scales were purchased by the Department of Agriculture for use in the Manawatu area. These were used by the author to assess, where possible, the impact of various management systems on the growth rate of beef cattle.

Groups of animals were weighed on five farms at two-monthly intervals. The number of animals in each group varied from 20 to 60. It became apparent, however, that attributing differences in growth rate to any one management system had several limitations.

(a) It was rarely possible for animals to be "emptied" before weighing to eliminate weight differences due to changes in gut-content. This would normally require animals to be denied access to feed and water for at least twelve hours before weighing, which would not be practical on most farms.

(b) The farmer had almost sole jurisdiction over his animals. Any attempt to standardise one aspect of management can be thwarted by a farmer whose motives are profit rather than experimentation.

(c) With on-farm recording of this type and no control-groups of animals, differences between farms could not be attributed to any one factor. Influence of breed, sex, environment and feeding regime are all interwoven and can be disguised by such unmeasurable factors such as managerial skill.

However, the weight recording did enable a picture of live-weight gains possible under Manawatu conditions to be defined. The wide range of growth rates recorded on farms under apparently similar conditions also illustrated the impact management differences can have on final carcass weight.

The advantages of being able to weigh beef cattle soon became apparent to the farmers involved, most of whom have now purchased scales of their own. In particular, live-weight recording enables more accurate dosage rates for worm-drenching to be calculated and enabled farmers to reliably forecast carcass weights. This latter point is particularly important where a premium is payable for carcass weights in a defined weight-range.

2.6 THE LITERATURE

During the last five years there has been a marked increase in research work carried out on beef cattle in New Zealand. With increasing awareness of beef farming as a profitable land-use, it became obvious that compared with more established enterprises such as sheep and dairy farming, very little factual information was available about beef production.

The pattern of beef research has been similar to that used to investigate sheep and dairy production. Firstly, an attempt was made to find what the potential production of beef per acre might be under a given set of conditions. Secondly, the management system most likely to exhibit this potential was evolved. Thirdly, and only recently, an attempt has been made to translate potential physical production into economic terms to find which system is likely to return most profit to the farmer.

The third stage in this process requires the feasibility and profitability of results from Research Stations to be examined on the farm. A comparison with other possible enterprises on a profitability basis is also implied and this thesis falls with this third stage.

Beef research work in New Zealand has been dominated by the emergence of the Friesian as a suitable beef-producing breed for the environment and markets of this country. It is intended to discuss the various beef-producing characters in turn, together with comments on any breed differences for these characters.

2.6.1 Growth Rate and Feed Conversion Efficiency

Nutritional aspects of beef production are considered in detail in Ch.3, where it is noted that feed requirements can be partitioned into

(a) a maintenance requirement

(b) a growth requirement

To maximise beef production, the aim must be to minimise the allotment of feed to maintenance and devote as much as possible of the available feed to growth. As the maintenance requirement is dictated by body-weight and is independent of growth rate, it follows that feed conversion efficiency as measured by the pounds of feed required per pound of live-weight produced, will increase with intake and growth rate.

Maintenance requirements represent the "overheads" in any ration. Once these overheads have been met, increasing growth rate decreases the proportion of total diet used for maintenance with a corresponding increase in feed-conversion efficiency.

Rate of growth is a character which has received a lot of attention from research workers. The factors likely to limit the rate of growth are:

(a) feed availability limitations

(b) the animial's ability to consume sufficient food energy to exhibit a fast rate of gain, i.e. intake limitations

(c) genetic factors

There is an increasing amount of evidence that given a restricted feed supply, animals of a similar live-weight will grow at the same rate regardless of breed. Joblin (33),using stall-fed cattle found that feed-conversion efficiency increased with dry-matter intake. Later work (34) showed little difference in the feed-conversion efficiency of Angus and Friesian steers compared at equal live-weights.

The consistently faster growth rate potential of Friesian over Jersey, Angus or Hereford cattle then, may be attributed to greater feed intake and not an inherently superior feed-conversion efficiency.

Unless Friesian animals are given the opportunity to express their fast growth-rate potential by feeding them to levels above the intake capacity for other breeds, breed differences are likely to be small. However, if animals are fed to appetite, the Friesian will eat most, grow fastest and in this way exhibit the highest overall feed conversion efficiency.

2.6.2. The Growth Habits of Beef Animals

The growth habits of beef animals are dictated mainly by the quality and quantity of feed consumed. Compensatory growth, or the ability of an animal to recover live-weight after a period of feed shortage, would seem to be of doubtful relevance to grazing animals. Joblin (35) concludes from a series of trials that only small live-weight differences in weaner cattle are likely to be completely recovered by compensatory growth and that even this is doubtful when animals are in competition for pasture.

Pasture has consistently proven to be the most successful ration for growing beef animals. Nicol and Coop (53), have commented that

> "a consistent finding in both the North and South Islands in work on winter nutrition is the remarkable response to grass as a substantial portion of the winter ration."

Grass of reasonable quality is an entirely adequate diet for growing beef animals, provided it is in sufficient quantity.

Because growth habits of beef cattle are related to the quantity and quality of feed consumed, growth habits are largely within the control of the farmer.

2.6.3 Breeding Cows and Milking Ability

The significance of milking ability as a productive character in any breed will depend on the role female animals are expected to fulfil. Mature females may be required to perform one or more of the following functions:

(a) aid grazing management on the farm by "cleaning-up" rough pastures
(b) produce a calf each year
(c) suckle one or more calves satisfactorily each year
(d) after calves are weaned, be acceptable in a dairy herd for milk production.

Beef breeding cows on the sheep farm have traditionally been required to clean up pastures and to successfully rear one calf each year. Cows tended to be grazed hard for much of the year, frequently in competition with sheep. With the increasing value of weaned calves, it is desirable where possible to rear more than one calf on each cow. This requires more careful cow management and has led many farmers to consider the Friesian breed for increased milking ability.

For many farmers, adequate feeding of their present breeding cows during critical periods could lead to an increased number, and heavier weaners. Hight (27) showed that pre-natal nutrition of the dam had a greater bearing on total meat production from calves at 18 months of age than did post-natal nutrition during the suckling period. In other words, careful breeding-cow management before calving can have appreciable long-term benefits.

Measuring the milking ability of grazing Angus and Hereford cows is difficult and shows great variability (8). From Hight's comments however, it would appear that Angus and Hereford Cows may have a considerable unrealised milking potential.

Where more than one calf is to be suckled per cow, or cows are to be returned to a milking herd, there are several advantages in choosing the Friesian breed. Hight (27) has demonstrated that Friesians can perform satisfactorily on hill country and the breed is certainly an acceptable milk producer.

There are three points which should be considered before the Friesian breed is adopted,

(a) increased milk production will make the cow more susceptible to magnesium and other mineral deficiencies

(b) milk production beyond that required for satisfactory calf-rearing can lead to over-consumption and nutritional scours in calves. If excessive milk is not consumed, mastitis in the cows can result

(c) it is more efficient in terms of pounds of meat produced/pound of grass consumed to feed grass directly to a growing animal, than via a cow to be made available to a growing animal as milk (21).

The introduction of Friesian blood into traditional breeding herds has some advantages, particularly where additional calves can be mothered on or where cows can be returned to a dairy herd. Where this is not possible, however, best results may be obtained by retaining traditional breeds and improving management. This would avoid health problems which may arise and could be more efficient in terms of beef production from the available feed supply.

2.6.4 Age at Maturity

The onset of maturity in beef animals is typified by an increased deposition of fat in the body. From birth, bone growth constitutes a major component of live-weight gain, followed by a period of muscle development when weight-gain is mostly in the form of red meat. This process continues until the onset of maturity. For the beef markets New Zealand supplies at present, and is likely to supply in the future, the character of major importance is the production of red meat.

The onset of maturity is marked by a big fall in feed-conversion efficiency. Joblin (34) estimates that the production of one pound of fat requires four to five times as much feed as the production of the same weight of red meat. The age at which an animal matures has been found to differ between breeds (23, 31) with the Friesian maturing 2 - 3 months later than Jersey, Hereford or Angus breeds.

Friesian animals, because of later maturity, thus have more scope for red-meat production. They will continue to produce meat rather than fat, for two or three months longer than animals of Hereford, Angus or Jersey breeds.

The importance of this character to a farmer will depend on the age at which animals are slaughtered. If animals are to be kept beyond 18 months of age the Friesian is likely to return the greatest weight of red meat from the available feed supply, but if animals are to be slaughtered at 14 - 15 months of age, the character loses importance.

Some farmers may consider it desirable to "finish" cattle by attaining a cover of fat on the carcass. The Angus, Hereford and Jersey will achieve this aim at an earlier age than the Friesian, and may be considered to have an advantage under these circumstances.

2.6.5 Meat Characteristics

The eating quality of meat produced by various breeds has been much publicised and some retailers have claimed consumer resistance to meat of dairy animal origin, or "dairy-beef". However, differences are small if they exist and it would appear that consumer preference is based on emotion rather than fact.

A considerable research effort has been aimed at investigating meat quality. The comment is made (24) that

> "many of the earlier experiments lacked statistical treatment and in some cases very few or only one sire was used per breed. Only in recent experiments have detailed carcass measurements on a reasonable number of animals been obtained. However the general conclusion can be drawn that all breeds and crosses studied produce satisfactory beef although the yellow fat of the Jersey gives certain marketing problems".

It would seem from these comments that there is no scientific evidence for breed differences in meat quality. Dr Kirton (41) takes this a stage further when he points out that to date, no marketing problems have been encountered with dairy beef.

> "I believe that the differences observed are not likely to be due to the origin but to the methods of management and that similar management would produce similar types of carcasses".

Differences, if they exist, are due to different weights of carcass or different management systems on the farm and there is at the moment no evidence to suggest that animals of any breed will cause problems in meat marketing. All breeds can produce acceptable meat but meat quality can be influenced by management of the live animal, and weight of the animal at time of slaughter.

2.6.6 Animal Performance with Limited Feed Supply

The ability of animals to maintain body weight or growth rate under adverse feeding conditions is a point frequently raised by farmers who tend to attribute any differences in individual animal performance to breed differences. The very fact that farmers are divided in their opinion of the merits of various breeds highlights the subjective nature of this assessment.

Any breed differences in performance with restricted feed supply are considered by Joblin (34) to be attributable to differences in body weight and resultant maintenance requirement. With restricted feed supplies, the largest animals will have the poorest growth rates because more of their ration is required for maintenance.

In a herd containing Angus and Friesian cattle, the former would be expected to show the greatest weight-gain during the period of feed shortage, since they would usually be lighter animals. This explanation implies, however, that each animal eats an equal share of the available feed supply. In practice, larger animals are likely to consume more feed at the expense of smaller animals.

Any difference in performance on a restricted feed supply may therefore be largely attributed to differences in live-weight. Maintenance of live-weight, and any live-weight gain, will depend on feed intake. Differences in growth rate of small and large animals grazing together may therefore be attributed largely to their ability to compete for the available feed supply.

2.6.7 <u>Calf Live-Weight and Mortality</u>

The greater live-weight birth of Friesian calves over those of Angus, Hereford or Jersey breeds can be an important character where a harsh climate is possible at the time when calves are born.

It should be remembered, however, that nutrition of the dam also has a big effect on calf live-weight. For difficult climates careful nutrition of the pregnant cow would be required, regardless of breed.

2.7 A DEFINITION OF THE "BEST BREED"

Confusion which frequently arises durihg breed comparison discussions may be attributed to a failure to define precisely what criteria should be used for judgement.

From an economic point of view the breed which performs most successfully for the farmer will be that which returns the highest net profit from his available feed supply. If the relative merits of available beef-producing breeds are compared on this basis, many apparently conflicting views from trial work may be resolved.

2.8 THE IMPORTANT BREED CHARACTERS

Many characters which can differ between breeds have been discussed. It is now intended to isolate the breed differences which could affect net profit from the available feed supply.

2.8.1 <u>Growth Rate</u>

Major differences will only be evident when animals are fed at levels approaching intake capacity. However, where fast growth rate to achieve a target carcass weight within a restricted time period is important, Friesian animals will have an advantage over Hereford, Angus or

Jerseys. For example, a farmer wishing to achieve a 375 pound carcass weight for bulls before their second winter, would be more likely to succeed with Friesians than Angus, Herefords or Jerseys.

2.8.2 Feed Conversion Efficiency

Feed conversion efficiency increases with feed intake. From a fixed feed supply, maintenance rations should be minimised and productive rations maximised. To this end, intake must be as high as possible per animal. The Friesian, because of its greater intake capacity, thus gives the farmer more opportunity to produce beef from the available feed supply.

2.8.3 Age at Maturity

Because the Friesian matures later than the Jersey, Hereford or Angus breeds it has the ability to produce the greatest amount of red meat. This product is more efficiently produced than fat and more desired by the market. The importance of this character to a farmer will depend on the age of animals at slaughter.

2.8.4 Milking Ability and Calf-Rearing

Milking ability is an important character where cows are returned to a dairy herd after calves are weaned, or where more than one calf can be reared per cow. However, it is biologically inefficient to feed large quantities of milk to beef-producing animals.

For hill country farmers, the potential calf-rearing ability of Hereford and Angus cows has probably not been realised. Gains may be better made here with management, rather than the introduction of Friesian blood.

2.8.5 Summary

A farmer aiming to maximise net profit from his available feed supply, should give particular attention to three breed characters. Fast growth rate will enable him to increase feed conversion efficiency at high feeding levels, and more easily attain target carcass-weights. Later maturity will give him more opportunity for red-meat production. Increased milking ability can lead to more calves reared, better weaning weights, or more milk sold. Other breed differences are unlikely to have a great impact on profit levels to the farmer. However, all three of the characteristics mentioned tend to be associated with the Friesians having faster growth rate, greater age of maturity and greater milk yield than Hereford, Angus or Jersey animals.

2.9 DIFFICULTIES IN MAKING BREED COMPARISONS

The main difficulty in making breed comparisons lies in the selection of parameters for measurement. It has been suggested that from an economic viewpoint, net profit to the farmer from his available feed supply is likely to be the most applicable measurement. This estimate, however, would include costs and prices for a wide range of commodities. Any estimate would therefore be relevant only to the circumstances and year in which it was made. An economic analysis should be the final aim, however, and research work on breed comparisons should be aimed at making estimates on this basis as accurate as possible.

A further difficulty in comparing breeds is the selection of stocking rates. It can be argued that because animals of some breeds consume more feed than others, animals should not be compared on a one-to-one basis. Indeed, it has been suggested that under some circumstances slow-growing animals such as the Jersey may have some advantage over the faster-growing breeds. (42)

> "There is general agreement that Friesians have the highest growth rate both under low-land and hill conditions and that Jerseys have the lowest. Whilst more evidence is needed before the other breeds and crosses can be accurately ranked for growth, there is also the need for growth and development studies with cattle at the optimum rate for a given breed, particularly in environments where there is a seasonal shortage in feed supply. Butterfield (1966) has suggested that the attributes of lighter and earlier maturihg breeds might be advantageous in this latter situation."

The optimum stocking rate is difficult to define and would be related to the farm circumstances being considered. There would, however, be many on-farm environments where a seasonal shortage in feed supply existed. It has been estimated (23) that of total variation in meat production between animals only five per cent could be attributed to differences in breed. These measurements were made on farms, with no allowance made for the greater intake of faster-growing animals. It may well be that differences would be much less than the five per cent reported, if an intake adjustment was made. It could confidently be said that breed effects are far outweighed by those of environment and management.

The extent to which a farmer should pay a premium for a Friesian animal is therefore a difficult question, and can only be resolved with reference to a particular set of circumstances. If differences in animal size are to be recognised and an adjustment made to stocking rate for comparison purposes, several problems arise

(a) Young beef-producing animals are not a static size; they are growing. If total animal live-weight is to be used as a parameter for recommending stocking at a particular rate, any differences in live-weight gain will mean that comparative stocking rates should change through an animal's lifetime.

(b) Breeds such as the Angus and Jersey have an advantage over the Friesian in periods of feed shortage due to reduced maintenance requirement. In periods when feed is abundant however, the Friesian with its greater size and appetite can utilise more feed and thus increase its total efficiency at this stage. The two factors would tend to balance out, the effect of each depending on feed availability in relation to stock numbers, and likely fluctuations in feed supply.

(c) A breed comparison based on animal live-weight rather than animal numbers, when translated into economic terms, must recognise which costs which may be incurred on a per-animal, or a total live-weight basis. These may be considered as follows.

<u>CAPITAL</u>: Capital costs for each breed will be related to the price paid for replacements. If a stocking-rate ratio is derived on a live-weight basis, and replacement animals are purchased at a fixed price per pound live-weight, breed differences would effectively be cancelled out. Replacement costs on a per-acre basis would thus tend towards equality and differences would be small.

LABOUR: The additional labour requirements of a larger number of animals may not be great. Day-to-day management such as rotational grazing would require little more labour for 100 animals than for 90. The labour required for drenching, spraying, marking and weighing may be related to number of animals rather than size. However, the disadvantages of a larger number of animals must be considered against the advantage of small animals which would normally be easier to handle.

YARDS, FENCES, PASTURES: Small animals are less likely to damage yards and fences, and are likely to reduce pasture damage on wet soils. However, differences are unlikely to be great and again must be balanced against the effect of greater numbers.

VETERINARY: Most veterinary expenses arise from worm-drenching and lice-spraying. Dosage rates for drenching, and material for lice-spraying, are both calculated on animal live-weight. Breed differences on a total live-weight basis are therefore likely to be small.

KILLING: Killing charges paid by a farmer are not calculated on a per-animal basis. The Freezing Industry is concerned (8) over declining carcass weights because costs of boning meat tend to be independent of carcass size. For as long as farmers receive a net price per pound for meat, however, there is no incentive to supply heavier carcasses. Killing costs to the farmer are not related to animal numbers but animal carcass weight, which is again determined in the main by total animal live-weight.

CONCLUSIONS:

There can be no simple answer to the question, which is the best breed? Comparing breeds on a total live-weight basis overcomes some criticisms and it appears that most costs are related to total live-weight, rather than number of animals.

Breeds must be compared on the basis of net profit to the farmer. However, for those farmers not producing bull beef, not requiring high levels of milk production, and not keeping animals after 15 - 16 months of age, a premium for Friesian animals may not be justified.

2.10 BREEDING AND SELECTION

The Angus and Hereford breeds have for centuries been selected for apparently desirable characters such as "compactness." It can only be regarded as a failure of past selection criteria that the Friesian, which has been selected for milk yield, is now widely preferred to the Angus and Hereford as a beef-producing breed.

The gains to be made from selection for beef-producing characters within any breed are likely to be small, at least in the short term. Carter (17) is conducting long-term trials in the Waikato, utilising large numbers of Angus cows available from the Lands and Survey Department. These trials are essentially exploratory, aimed at determining the best selection criteria. Carter, using Friesian bulls, has found a small positive association between artificial breeding "proof rating" calculated by the Dairy Board and final live-weight of animals. This may indicate deficiencies within the method for estimating these ratings, as sires with fast-growing offspring would have more mature daughters at the time of first lactation.

Carter is also examining the extent of heterosis between Angus and Hereford cattle, but results so far indicate that only small gains are possible.

If appreciable gains are to be made by selection and breeding, the first requirement is to clarify the characters of economic significance, and then assess their heritability. However, in the short term at least, the biggest gains are to be made by cross-breeding to introduce, rather than select for, economically desirable characters.

2.11 SUMMARY

The physical and financial information required for this study is not readily available as the Beef Industry has only come into prominence within the last few years. It has therefore received little attention from research workers and few farmers have evolved a stable beef-production system.

Discussion with farmers illustrated the diversity of possible beef enterprises and exposed some of the problems farmers encounter when expanding their beef enterprise. However, little reliable information on the physical relationships involved in beef production could be obtained from farmers.

Small farm experiments provided useful back-ground information on the growth performances possible in the Manawatu, but again could not reliably provide information on the physical relationships involved.

The literature in New Zealand has been devoted in the main to assessing the Friesian as a beef-producing animal. Breed differences of significance to the farmer are growth-rate, age at maturity and milking ability. The Friesian would appear to have obvious advantages in these respects, but these are dependant entirely on the beef system envisaged. Situations where other breeds would have an advantage can be conceived.

Breeds may better be compared on total live-weight than on numbers, as many costs are related to animal live-weight. If this is done many apparent breed differences disappear.

Selection and breeding of beef animals has little to offer, at least in the short term. Establishing which characters are of economic significance and assessing their heritability would need to be the first steps taken in this direction.

CHAPTER THREE

THE NUTRITIONAL REQUIREMENTS OF GROWING BEEF ANIMALS

3.1 INTRODUCTION

This chapter introduces the subject of "feed-budgeting", which is a method of matching feed requirements and feed available to maximise returns on the farm. Substition rates and the "ewe equivalent" system are discussed and evaluated. The effect of different stock classes and grazing systems on pasture yields is noted.

Possible sources of feed availability information are discussed together with the deficiencies of these measurements. A method of estimating feed requirements based on live weights and growth rates of beef animals, is derived.

3.2 FEED-BUDGETING

One of the most critical resources available to any live-stock farmer is the feed supply. This resource largely dictates which live-stock systems are possible and which of these is the most profitable on any farm. For the New Zealand pastoral farmer, feed supply is represented in the main by grass production. The quality, quantity, and pattern of grass growth are essential points to consider in the management process.

A knowledge of feed requirements for any possible live-stock system, together with a knowledge of feed available, will allow the farmer to adopt a "feed-budgeting" approach to farm management. Feed budgeting may simply be defined as the science of matching feed availability to feed-consuming enterprises on the farm. When the farmer finds the most profitable method of achieving this end, he has maximised returns from what will often be his most critical resource, feed-supply.

It will be seen later in this thesis that feed-budgeting is the basic approach which has been used in the linear programming analysis. Feed availability, as reflected by grass growth on the farm, is assumed to be the limiting resource to all systems which are considered.

This approach has been used by American workers in areas of the United States where pasture is the chief live-stock diet. Raleigh (55) comments that

> "optimum range live-stock production can be achieved only through compatible live-stock and forage management. The first requirement in developing a range live-stock and forage management programme is a quantative and qualitative inventory of forage resources .....Only after the relative seasonal availability of nutrients is known, can live-stock be managed to obtain a maximum return from the available forage resources.."

Raleigh concludes his paper by saying

> "results.....indicate that it is feasible to manipulate live-stock management, based on the knowledge of forage quality relative to live-stock performance, for increased live-stock production",

These comments apply equally well to the New Zealand system of all-grass farming. New Zealand agronomists however, have failed to provide us with a "quantative and qualitative inventory" of our grass resources.

3.3 SUBSTITUTION RATES AND THE EWE EQUIVALENT SYSTEM

When comparing two live-stock systems such as sheep and beef farming, it is necessary to make some estimate of the way in which these animals compete for the limiting resource. This is usually accepted as being feed supply, and on this basis substitution rates are derived.

The basic unit for comparison is usually the breeding ewe, and other live-stock classes are related, in terms of feed requirements, to this basic unit. The most sophisticated system used in New Zealand would be the Ewe Equivalent (E.E.) system. Coop (19) points out that while the E.E. system has its limitations, it is a very useful concept, easily calculated and understood.

The comment by Coop that the E.E. system represents not production per acre, but the stock carried per acre, or carrying capacity, is very pertinent. He then points out what may be the greatest use for the E.E. system when he says that while it may not be a measure of what animals produce, it is a reasonable measure of grass which they harvest. In other words, previous carrying capacity of a farm, expressed in E.E., is a good guide to pasture produced by that farm, and made available for grazing.

A comparative budgeting study between sheep and cattle, based on substitution rates such as the E.E. system however, is subject to possible error. Sheep and beef animals are very different in the way their feed demands change between seasons. They should not be compared on an annual "stock-unit basis". Coop (19) readily concedes this point when he comments that as far as cattle are concerned the errors in comparing an all-sheep with an all-cattle farm could be considerable.

Profitability comparisons on a stock-unit basis overlook any supplementary or complementary relationship between live-stock classes. They take no account of relative flexibility in feed requirements, and while the growth pattern of beef cattle is necessarily described to enable their computation, this growth pattern may not be the most profitable one for the farmer.

Stock-unit systems thus tend to over-simplify a live-stock comparison study, with errors arising from the assumptions made. It will be noted that with the feed-budgeting approach used in this study, substitution rates in the form of stock-units are not required. Indeed, having arrived at the most profitable live-stock system, substitution rates may then be calculated as a result of the analysis.

3.4 GRASS PRODUCTION WITH SHEEP AND BEEF ANIMALS

One difficulty in estimating pasture availability is that, as Joyce (38) points out from his stocking-rate trial at Ruakura,

> "the effect of type and level of stocking had marked effects on the level of pasture production."

Joyce estimated that cattle areas, on average, produced eight per cent more pasture than under a ewe grazing system and 22 per cent more than under a wether grazing system. Similarly, lower stocked areas produced five to ten per cent more pasture than under high stocking-rate conditions. Cattle pastures tended to be more open than sheep areas.

When comparing live-stock systems such as sheep and beef cattle then, some cognisance should be taken of the fact that the latter would lead to a greater total pasture production. For breeding ewes and fattening beef cattle, the difference would appear to be of the order of eight per cent. Estimating this factor however could lead to the following difficulties:

(a) The type and standard of management may be critical, e.g.

the grazing pattern adopted by a farmer may influence any increase in pasture production.

(b) The time of the year when an increase occurred would be difficult to ascertain, i.e. any increase may not occur over a full year's grass production, but only in some seasons.

(c) The soil type, pasture species, and general climate may influence the increase. Joyce (38) commented that with a beef system pastures tended to be more open than under sheep. Under some farm conditions this may lead to a decrease in pasture production.

(d) The extent to which any increased pasture growth led to future increases in fertiliser or other requirements would be difficult to assess.

For the purpose of this study then, it will be assumed that pasture production under breeding ewes will be the same as that for a beef production system. It should be recognised however, that on the available evidence this assumption would appear to underestimate the returns possible from all-beef system, when compared with breeding ewes.

3.5 THE EFFECT OF GRAZING MANAGEMENT ON PASTURE PRODUCTION

Agronomists for many years have discussed grazing systems and their effect on pasture production. The fact that they have failed to make any clear-cut decisions on which system produces most pasture, would seem to indicate that differences, if any, are small.

In particular, the merits of rotational grazing versus set-stocking have been often mentioned. Brougham (11) has achieved high meat outputs of beef per acre using a length of rotation ranging from 20 days in the Spring to 60 days in the Summer and Autumn.

Comments by American workers (28) would support the contention that rotational grazing has some advantages

> "the species of plant used and the type of animal may influence the results. However there is evidence that at high stocking rates rotational may be advantageous over continual grazing."

New Zealand work (10, 62) supports this contention.

However, there are some circumstances in which a rotational system on the farm is not feasible. This is often due to lack of paddock numbers or staff to shift temporary fences, but in some cases farmers have found difficulties in shifting uncastrated male beef animals at some periods of the year. The extent to which these farmers are losing pasture production is difficult to estimate.

Joyce (38) measured increased pasture production of five to ten per cent in favour of 1½ cattle beasts per acre as against 2¼. The extent to which this is a reflection of grazing method is difficult to assess. It may be that the lower stocking rate allowed a more flexible approach to pasture management. American work supports these observations by Joyce, and Van Keuren (60) comments that

> "despite high fertility and rotational grazing to provide periodic recovery from grazing, overstocking with resultant overgrazing was shown to markedly reduce forage production."

He adds emphasis to this statement by saying

> "maximising beef cattle production from pastures required first of all maximising forage production."

Maximum pasture production could therefore be expected at lighter stocking rates using a rotational grazing system. Light stocking rates may not be the most profitable, however, and rotational grazing is not always feasible on the farm.

It cannot be doubted that correct pasture management is an essential feature of any successful live-stock operation. Some of the advantages of rotational grazing may in fact stem from more easily recognised surpluses and deficits by the farmer. This would facilitate feed-budgeting and increase live-stock performance. This effect would be particularly noticeable at high stocking rates.

3.6 EFFICIENCY OF ANIMAL HARVESTING

The efficiency of animal harvesting may be defined as the percentage of pasture grown which is consumed by animals. This percentage is likely to vary widely depending on stocking rate, class of stock, type of pasture, pasture management, rain-fall, contour and soil type.

Grass lost by animal trampling can be very high on some soil types in wet conditions. Losses in these circumstances are likely to be higher with beef animals than sheep. If pasture availability figures are based on previous sheep numbers, some allowance would have to be made for feed loss in wet periods on pastures prone to treading, if beef animals are being considered.

Generally, however, the efficiency with which animals harvest grass is related to managerial efficiency and stocking rate. Coop (20) points out that high stocking rate generally leads to more feed being harvested. This observation should be balanced against an earlier comment by Joyce (38) that as stocking rate increases, pasture production decreases under an all-beef system. It may be that these two opposing factors cancel one another out, as stocking rate increases i.e. while more is grown, it is less efficiently harvested at low stocking rates.

3.7 ESTIMATING FEED AVAILABILITY

There are two alternative ways in which the pattern, quantity, and quality of pasture production on a farm could be estimated

(a) by harvesting grass mechanically and measuring quantity and quality produced over a number of seasons;

(b) by making an indirect estimate based on previous stock performances on the farm. The pattern of feed requirements for animals such as breeding ewes has been measured at Research Stations. Given previous stock numbers and performance, and adjusting for any feed sales or transfers customary on the farm it is possible to estimate the feed which has been produced for consumption by stock on the farm.

3.7.1 Cutting and Harvesting

Cutting and harvesting techniques have several limitations which should be noted;

(a) results tend to vary with the harvesting technique used. Taylor (58) comments that techniques of measuring herbage are difficult and often unsuitable;

(b) frequency of harvesting is a problem. Ideally, this should be done at the same interval and in the same way as with grazing animals. This may not always be practicable.

(c) Harvested dry matter may be a poor indication of effective feed availability. This figure would need to be corrected for digestibility of the harvested material. The inclusion of foreign matter such as soil in the harvested sample is difficult to avoid and can lead to serious errors in yield estimation.

(d) Estimates of feed availability by mechanical harvesting are usually only available at Research Centres, and a limited number of locations in New Zealand. The usefulness of any measurement decreases with distance from the measuring site.

3.7.2 Indirect Estimates

An indirect method based on previous stock performance overcomes some difficulties but also has many limitations:

(a) The estimate does not take account of short-term feed surpluses and deficits. Normal day to day feed transfers which are a part of any live-stock system disguise these.

(b) The quantity and pattern of feed consumed by an animal such as a breeding ewe will depend on whether replacements are reared on the farm, twinning rate and weight of lambs at slaughter. Some adjustment can be made for these factors, but estimates tend to be subjective and open to possible error.

(c) Estimates of variation in feed consumed between seasons are difficult. Increases or decreases on the sheep farm would normally have their effect through rises or falls in wool clip, lambing percentage and lamb weight. Relating these parameters to a figure for feed consumed can be difficult and often inaccurate.

3.7.3 The Method Used

In this thesis pasture availability figures will be derived using a combination of the two techniques mentioned. In this way the limitations of each technique can, to some extent, be avoided. The procedure for the Case Farms will be -

(a) select farms of a soil type and locality where pasture growth measurements have been made for a number of years;

(b) use previous stock numbers and performance to estimate feed available for live-stock consumption;

(c) use the mechanical measurements to give a picture of within and between-year variations in pasture production.

3.8 FEEDING STANDARDS

The feeding value of various feed-stuffs may be expressed in one or all of the following terms;

M.E.	Metabolisable energy
D.E.	Digestible energy
T.D.N.	Total digestible nutrients
D.O.M.	Digestible organic matter

which are measures of energy available to the animal after taking account of such factors as the undigested fraction or faeces.

N.E. Net Energy

S.E. Starch Equivalent

are measures of productive energy or the amount of energy which can be converted into growth, fattening, etc. and allow for the heat energy wasted on converting available into stored energy.

For maintenance, animals can utilise available energy from different types of feed with almost equal efficiency irrespective of the type of food eaten. For growth and fattening, however, the available energy from concentrates is used more efficiently than that from roughages. Conversely, for growth and fattening the productive energy systems are superior to available energy systems because the productive energy is used with equal efficiency irrespective of the type of feed (19).

Thus, available energy systems are better than productive energy systems for maintenance but not for growth and fattening.

This means that no one system will meet all situations. The American feeding standards are expressed in terms of T.D.N. (available energy) whereas United Kingdom and European standards are in S.E. (productive energy). These are the standards available, and as has been pointed out, both have their weaknesses.

The system most applicable in New Zealand is one of the measures of available energy. In dealing with a grazing animal under New Zealand conditions, the proportion of total annual feed represented by maintenance is high, estimated by Coop to be approximately 80 per cent for sheep, 70 per cent for beef cattle and 60 per cent for dairy cattle.

Of the four available energy expressions outlined, D.O.M. is the easiest to measure. In addition, the feeds normally provided for grazing animals in New Zealand and even for stall-fed, do not warrant more complex estimates.

In a country of predominately free-grazing animals, the loss in accuracy by using D.O.M. is more than offset by its simplicity. It is thus intended to express feeds and feed requirements in terms of D.O.M. in this thesis.

DEFINITION OF D.O.M: Digestible Organic Matter (D.O.M.) may be defined as the number of pounds of organic matter digested per 100 lb. of feed organic matter eaten. Organic matter is the weight of dry matter less the weight of ash.

Organic matter is used rather than dry matter to overcome differences in soil contamination of the feedstuffs and because minerals are not a source of energy to the animal.

3.9 FEED REQUIREMENTS FOR GROWING BEEF CATTLE

The feed requirements for growing beef cattle depend on the physiological status of the animal and whether the feed energy is being utilised for maintenance or weight gain.

For practical purposes, feed requirements can be partitioned between maintenance and production. Thus for growing or fattening cattle

D.O.M. consumed = D.O.M. for maintenance
plus D.O.M. for live-weight gain.

3.9.1 Factors Affecting Maintenance

The maintenance requirements of an animal can be defined as the amount of feed energy required to maintain the physiological status of body tissues, and for practical purposes in a non-producing adult animal can be referred to as the amount of feed energy required to maintain live-weight. However, for young animals in which growth normally occurs, if live-weight is kept constant, it is probable that changes in body composition, i.e. ratio of bone; muscle; fat, will occur.

The energy required for maintenance can be affected by the following factors:

(a) Size of animal: the requirement for maintenance varies with "metabolic weight", which is live-weight raised to the power of 0.75 (25, 62).

(b) Muscular activity: energy expenditure due to walking and grazing affects maintenance requirements. The stall-fed animal thus has a lower requirement than the same animal under grazing conditions.

(c) Climate: climatic factors, by affecting the heat loss of an animal can have an effect on the energy required for maintenance. Environmental stresses mean a greater proportion of feed intake is used for maintenance which is then unavailable for production.

Other factors such as availability of shelter, or coat length can have some effect on maintenance requirement. However, body weight and grazing environment are the two main influences.

3.9.2 Production Requirements

For production, as represented in the beef animal by growth and fattening, feeding levels must be considerably above a maintenance ration.

Different levels of live-weight gain require different levels of feeding to sustain them. In general, higher levels of production are associated with higher efficiencies of food utilisation. (48, 63).

The final composition, as well as the total amount of product, can influence markedly the feed energy required for productive purposes. As the calorific value of fat is approximately four times that of protein, considerably more feed energy is required to lay down a given amount of fat than is required to lay down the same amount of protein.

For older animals there is proportionally more fat contained in any live-weight gain, so the feed requirement per pound of gain is greater in older fattening animals than in young growing animals.

3.9.3 Methods of Estimating Requirements

The estimation of feed requirements for grazing beef cattle in New Zealand is a topic about which very little factual information is available. In the works of Nicol and Coop (53)

> "in the absence until recently of controlled feeding facilities for beef cattle in New Zealand little precise nutritional work has been undertaken .....this is a reflection of the relatively insignificant place the nutrition of beef cattle has had in New Zealand to date."

Estimates made with stall-fed animals have a limitation pointed out by Wallace (63) in his work with dairy cows

> "it is very doubtful how far standards for maintenance and production established under stall-feeding conditions can be applied to grazing animals."

Wallace derived equations describing the feed requirements of milking cows. He is generally sceptical of feeding standards (62), and states

> "it must be appreciated that the feeding standards themselves rest upon an experimental basis of some slenderness, and that no claim is made that the statement of requirements are accurate or precise."

They may be regarded merely as "guides to feeding practise".

In addition to the limitations mentioned by Wallace, the use of recommendations for dairy cows to estimate the requirements of growing beef cattle can lead to serios errors -

(a) measurements for the dairy cow were made with a mature animal. Any weight gain would be almost wholly fat, and for the smaller growing animal the energy content of any weight gain could be entirely different;

(b) measurements were made over a very limited live-weight range of heavy mature animals. Recommendations would have very little relevance to small animals.

Even where estimates are made on beef animals, further problems seem to be encountered. New Zealand workers (34) discovered a wide range in the feed conversion efficiencies of individual animals. American workers (25) found that digestibility of dietary energy varies with plan of nutrition, while British workers (1) found that the efficiency of utilisation of metabolisable enrgy varies much more widely with the concentration of the diet when fattening than it does at maintenance levels.

Notwithstanding these limitations, an estimate of feed requirements of beef cattle over a range of live-weights and growth rates was found to be an essential pre-requisite for a satisfactory analysis. The best estimate possible, with the information available, had to be made. The basis for this estimate was as follows:

(a) American work, which appeared to be most relevant to the growing beef animal, was used as a basis for estimating feed requirements.

(b) The American recommendations were adjusted to grazing conditions in New Zealand using the "pieces" of information available in New Zealand, particularly from the work of Brougham (11), Joyce (37) and Joblin (32, 33, 34).

The results of these estimates proved more reliable and consistent than was expected, considering the suggested problems outlined previously by nutrition workers in this field. The results also demonstrated the inadequacy and inaccuracy for New Zealand conditions of earlier work such as that done by Morrison (52) which is frequently used as the basis for current stock-unit tables.

3.9.4 An Estimate of Feed Requirements For Growing Beef Animals

Attempts by some American workers (25) to formulate a set of equations which would describe dietary requirements over a range of live-weights and growth rates gave varying results. Later work (45) resulted in a series of tabulated feed requirements which separated requirements for live-weight gain from those for maintenance. These recommendations have been tested under various conditions in commercial feed-lots and their adaptability to practice has been demonstrated.

These workers report however, that data is needed on the effect of environment on net energy requirements. This comment highlights the need to make some adjustment for the increased maintenance requirement of a grazing animal as compared with a stall-fed animal.

However, the recommendations seem to have been widely accepted, and in conclusion the authors report that the system is adaptable to practice and overcomes common criticisms that net energy values do not apply under maintenance conditions and vary with feed intake.

The table of feed requirements as shown in Table 3.1 is presented in units of megacalories per day (meg.cal./day) net energy. These units must be converted to D.O.M. and and adjustment made for the increased maintenance requirement of animals grazing in New Zealand conditions. In both cases, figures used were those recommended by Mackintosh and Davies (47). The increase in maintenance requirement was chosen somewhat arbitrarily as 30 per cent. The resultant figures expressed in lb D.O.M./day are shown in Table 3.2.

Having arrived at what appear to be suitable recommendations for growing beef animals, it is possible to test their accuracy by comparing them with measurements made in the field in New Zealand. These measurements must include -

Table 3.1

The Feed Requirements of Growing Beef Animals (Megacalories Net Energy Per Day)

Daily Gain (Kg)	BODYWEIGHT (KILOGRAMS)														
	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500
0	3.3	3.7	4.1	4.5	4.8	5.2	5.6	5.9	6.2	6.6	6.9	7.2	7.5	7.8	8.1
0.1	3.5	4.0	4.3	4.8	5.1	5.5	5.9	6.3	6.7	7.0	7.4	7.7	8.0	8.3	8.6
0.2	3.8	4.2	4.7	5.1	5.5	5.9	6.3	6.8	7.1	7.5	7.9	8.2	8.6	8.9	9.3
0.3	4.0	4.5	5.0	5.3	5.8	6.3	6.7	7.2	7.6	8.0	8.4	8.7	9.1	9.5	9.8
0.4	4.3	4.8	5.3	5.7	6.2	6.8	7.1	7.6	8.0	8.5	8.9	9.2	9.7	10.1	10.4
0.5	4.5	5.1	5.6	6.1	6.6	7.1	7.6	8.1	8.5	9.0	9.4	9.8	10.2	10.6	11.0
0.6	4.8	5.3	5.9	6.5	6.9	7.5	8.0	8.5	8.9	9.5	10.0	10.4	10.8	11.3	11.7
0.7	5.0	5.6	6.2	6.8	7.3	7.9	8.4	9.0	9.5	10.0	10.5	10.9	11.4	11.9	12.4
0.8	5.3	5.9	6.5	7.1	7.7	8.4	8.9	9.5	10.0	10.6	11.1	11.5	12.0	12.5	13.0
0.9	5.6	6.2	6.9	7.5	8.1	8.8	9.3	10.1	10.5	11.1	11.6	12.1	12.7	13.2	13.7
1.0	5.9	6.5	7.3	7.9	8.5	9.2	9.8	10.5	11.0	11.7	12.2	12.7	13.3	13.9	14.4
1.1	6.2	6.9	7.6	8.5	9.0	9.7	10.2	11.0	11.6	12.3	12.8	13.4	14.0	14.5	15.1
1.2	6.4	7.2	7.9	8.8	9.4	10.1	10.7	11.5	12.1	12.8	13.4	14.0	14.7	15.2	15.8
1.3	6.7	7.6	8.3	9.1	9.8	10.6	11.3	12.1	12.7	13.4	14.1	14.7	15.3	15.9	16.5
1.4	7.0	7.9	8.7	9.5	10.3	11.1	11.8	12.6	13.3	14.0	14.7	15.3	16.0	16.7	17.3
1.5	7.3	8.2	9.1	10.0	10.8	11.5	12.3	13.1	13.9	14.6	15.4	16.0	16.7	17.4	18.0

Source: Reference (45). Journal of Animal Science 27 (3) : 801.

Table 3.2

The Feed Requirements of Growing Beef Animals (Pounds of Digestible Organic Matter Per Day)

DAILY GAIN (POUNDS)	BODYWEIGHT (POUNDS)														
	330	385	440	495	550	605	660	715	770	825	880	935	990	1045	1100
0	4.4	4.8	5.4	5.8	6.5	6.9	7.3	7.8	8.2	8.6	9.2	9.5	10.0	10.3	10.8
0.22	4.5	5.1	5.7	6.1	6.8	7.3	7.7	8.3	8.8	9.2	9.7	10.1	10.5	10.9	11.4
0.44	4.8	5.4	6.0	6.4	7.0	7.6	8.1	8.7	9.1	9.6	10.0	10.6	11.0	11.5	12.0
0.66	4.9	5.6	6.1	6.8	7.4	8.0	8.5	9.1	9.6	10.0	10.6	11.1	11.6	12.0	12.5
0.88	5.3	6.0	6.6	7.1	7.8	8.4	8.9	9.6	10.1	10.5	11.1	11.7	12.2	12.6	13.1
1.10	5.5	6.3	6.8	7.5	8.2	8.8	9.4	10.0	10.5	11.0	11.6	12.2	12.8	13.2	13.8
1.32	5.8	6.6	7.3	7.8	8.6	9.2	9.8	10.5	11.0	11.6	12.1	12.8	13.3	13.8	14.5
1.54	6.0	6.9	7.6	8.2	9.0	9.7	10.3	10.9	11.5	12.1	12.6	13.4	13.9	14.4	15.1
1.76	6.5	7.2	7.9	8.5	9.4	10.1	10.7	11.3	12.1	12.6	13.2	13.9	14.6	15.2	15.8
1.98	6.6	7.5	8.2	8.8	9.8	10.5	11.2	11.9	12.6	13.2	13.8	14.6	15.2	15.8	16.5
2.20	6.9	7.8	8.6	9.3	10.1	10.9	11.6	12.4	13.1	13.7	14.3	15.2	15.8	16.5	17.1
2.42	7.2	8.1	9.0	9.7	10.6	11.4	12.1	12.9	13.7	14.3	15.1	15.8	16.5	17.1	17.9
2.64	7.4	8.5	9.3	10.1	11.0	11.9	12.6	13.5	14.3	14.9	15.5	16.5	17.3	17.9	18.6
2.86	7.8	8.8	9.8	10.5	11.5	12.4	13.1	14.0	14.8	15.5	16.1	17.1	17.9	18.6	19.4
3.08	8.1	9.1	10.1	10.9	12.0	12.8	13.7	14.6	15.3	16.2	16.7	17.8	18.6	19.4	20.0
3.30	8.4	9.5	10.5	11.3	12.4	13.4	14.3	15.1	16.0	16.8	17.7	18.5	19.4	20.0	21.0

(a) animal live-weight

(b) animal live-weight gain per day

(c) food intake.

The limited number of measurements made could largely be attributed to problems in measuring the food intake of grazing animals. However, using figures supplied by Brougham (11), Joyce (37) and Joblin (33, 34), it was possible to check the values over a considerable range of growth-rates and live-weights. In all cases, only relatively minor differences between derived and observed figures were noted.

On this basis, the feed requirements as shown in Table 3.2 were accepted as reasonable recommendations for the growing beef animal under New Zealand grazing conditions.

3.9.5 Limitations in Animal Intake

Table 3.3 gives the same recommendations as Table 3.2 but converted from pounds D.O.M. to pounds of dry matter per day. A conversion ratio of

1 lb Dry Matter = 0.62 lb D.O.M.

is assumed.

If these recommendations are used to construct a graph of feed requirements based on animal live-weight and daily live-weight gain, Figure 3.1 results. This figure highlights the effect limitations in animal intake can have on live-weight gain. Animals are unlikely to consume more than $2\frac{1}{2}$ - 3 per cent of their body weight as dry matter each day. If digestibility of feed is low, effective energy untake will be insufficient to support fast growth-rates.

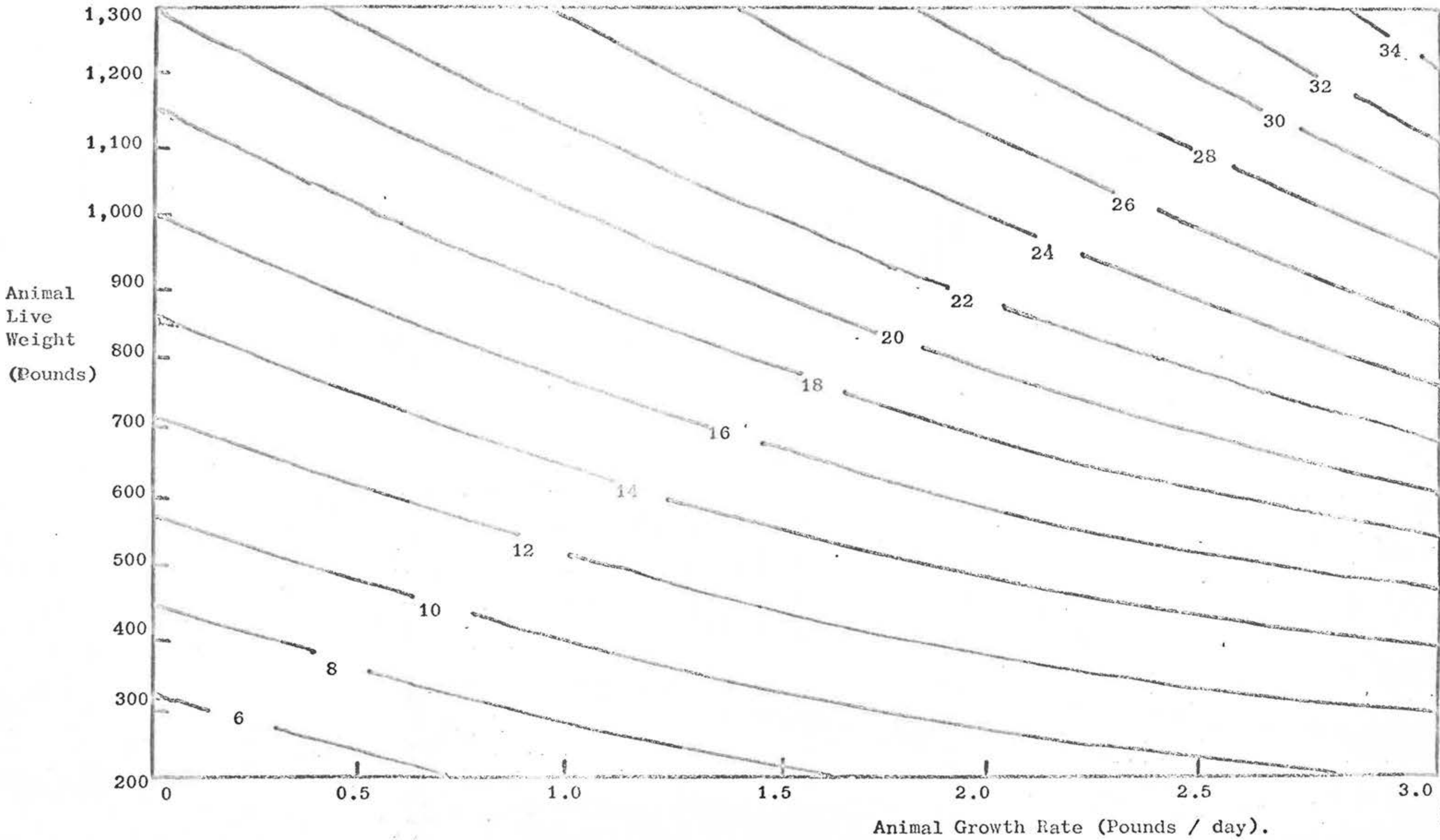
Table 3.3

The Feed Requirements of Growing Beef Animals (Pounds of Dry Matter Per Day)

Daily Gain (Pounds)	BODYWEIGHT (POUNDS)														
	330	385	440	495	550	605	660	715	770	825	880	935	990	1045	1100
0	6.9	7.9	8.7	9.3	10.3	11.1	11.8	12.6	13.3	13.9	14.8	15.4	16.1	16.7	17.4
0.22	7.3	8.3	9.2	9.8	10.9	11.7	12.4	13.3	14.1	14.7	15.6	16.2	16.9	17.6	18.3
0.44	7.7	8.7	9.6	10.3	11.4	12.3	13.1	14.0	14.7	15.4	16.2	17.1	17.8	18.5	19.3
0.66	8.0	9.2	10.1	10.9	12.0	12.9	13.7	14.6	15.5	16.2	17.1	17.9	18.7	19.4	20.2
0.88	8.5	9.7	10.6	11.4	12.6	13.6	14.4	15.4	16.3	17.0	17.9	18.8	19.7	20.4	21.2
1.10	8.9	10.2	11.1	12.0	13.2	14.2	15.1	16.1	17.0	17.8	18.7	19.7	20.6	21.4	22.3
1.32	9.3	10.6	11.7	12.5	13.8	14.9	15.8	16.9	17.8	18.7	19.6	20.6	21.5	22.3	23.3
1.54	9.7	11.1	12.2	13.1	14.5	15.6	16.6	17.6	18.6	19.5	20.4	21.6	22.5	23.3	24.4
1.76	10.2	11.6	12.7	13.7	15.1	16.3	17.3	18.3	19.5	20.4	21.3	22.5	23.5	24.5	25.5
1.98	10.6	12.1	13.3	14.3	15.8	17.0	18.0	19.3	20.3	21.3	22.2	23.5	24.6	25.5	26.6
2.20	11.1	12.6	13.9	15.0	16.4	17.6	18.8	20.1	21.2	22.2	23.1	24.5	25.6	26.6	27.7
2.42	11.5	13.1	14.5	15.6	17.1	18.4	19.6	20.9	22.1	23.1	24.5	25.6	26.7	27.7	28.9
2.64	12.0	13.7	15.0	16.3	17.8	19.2	20.4	21.8	23.0	24.1	25.0	26.6	27.8	28.9	30.1
2.86	12.5	14.2	15.7	16.9	18.6	20.0	21.2	22.6	23.9	25.1	26.0	27.7	28.9	30.1	31.3
3.08	13.0	14.7	16.3	17.6	19.3	20.7	22.1	23.6	24.7	26.1	27.0	28.8	30.1	31.2	32.5
3.30	13.5	15.3	16.9	18.3	20.00	21.6	23.0	24.4	25.8	27.1	28.7	29.9	31.2	32.4	33.8

FIGURE 3.1

THE FEED REQUIREMENTS OF GROWING BEEF ANIMALS.
(POUNDS OF DRY MATTER PER DAY.)



(X) Represents The Feed Requirements / animal / day.

This situation is commonly noticed on beef farms, especially when animals are reaching mature weights and require appreciable energy intake just to meet maintenance requirements. The situation is worsened during periods when grass digestibility drops, such as in dry summers.

Intake limitations mean that if fast growth rates are desirable, feed quality can be as critical as feed quantity.

3.9.6 Variations in Feed Requirement

The feed requirement recommendations as presented have proven reliable (11, 37), almost regardless of animal breed, sex, and previous nutritional levels.

This observation supports comments made in Chapter Two that any major differences in feed conversion efficiency of beef-producing animals are related almost entirely to intake limitations. Also, because the feed required to produce any live-weight gain is independent of previous nutritional levels, compensatory growth has little or no relevance to a grazing beef animal over the weight-gains normally encountered on farms.

The feed requirements, as calculated, are therefore acceptable since only minor variations would be expected. They will form the basis for the "feed-budgeting" analysis on which this thesis is based.

3.10 SUMMARY

A live-stock farmer's feed supply is usually his most critical resource, and to maximise profits he must allocate feed by the most profitable means available.

The ewe equivalent system has some uses, but is inadequate for a detailed comparison between sheep and beef enterprises. Low stocking rates and rotational grazing would appear best suited for maximum pasture growth, but may not be practical on the farm. Increased pasture production with a change to beef animals from sheep has been recorded.

Digestible organic matter is an appropriate feeding standard for New Zealand conditions and on this basis, the feed requirements for growing beef cattle are calculated. American estimates are used, scaled to New Zealand grazing conditions using the pieces of information available in this country. When daily dry-matter requirements are presented graphically, growth-rate limits caused by intake limitations become apparent. Feed requirements appear to be almost independent of breed, sex and previous nutritional levels.

CHAPTER FOUR

BUDGETING AND LINEAR PROGRAMMING TECHNIQUES

4.1 INTRODUCTION

In this chapter budgeting and linear programming techniques are discussed. The reasons why linear programming was chosen as an analytical technique for this thesis are outlined.

Parametric budgeting techniques are discussed and a beef/sheep parametric budget is presented. Parametric linear programming methods are briefly described, followed by the way in which price maps may be drawn using this technique.

4.2 POSSIBLE METHODS OF ANALYSIS

As outlined in Chapter 1, the aims of this study are to compare sheep and beef farming on a profitability basis and to define what the most profitable beef system might be for a given set of farm circumstances and conditions. Where possible, the sensitivity of any recommendation to changing sheep and beef prices 1/ will also be considered.

The availability of information will dictate to some extent the choice of technique. However, it is clear that to meet the broad aims of this thesis, the analytical technique chosen must be capable of profit maximisation. The two techniques which may be considered are:-

(a) Budgeting - with the possible use of parametric budgeting.

(b) Linear programming.

1/ In the context of this thesis, sheep price represents the revenue from sales of lamb and wool less the direct costs such as shearing and veterinary costs which may be attributed to one breeding ewe.

Beef price is synonomous with the beef export schedule price in $/100 lb of carcass weight.

In addition to the requirement for profit maximisation, any technique chosen should also meet the following requirements:-

(a) To determine the most profitable mix of enterprises for any given set of farm conditions.

(b) To take account of on-farm limitations or restraints such as land, capital and labour.

(c) To consider a large number of possibly diverse farm enterprises.

(d) To maximise profit over a wide range of product prices, and give an estimate of the sensitivity of any recommended farm plan to a change in product prices.

(e) To carry out steps (a) to (d) with a minimum of computational effort, and enable presentation of results in a readily understood fashion.

4.3 THE ADVANTAGES AND LIMITATIONS OF BUDGETING

The usefulness of a budget will depend on the task it is being used for. Candler (14) mentions several advantages budgeting may have over a more sophisticated technique such as linear programming:

(a) budgets will always produce sensible results;

(b) budgets are easily understood and can be done by farmers rather than for them;

(c) a simple budget can be done quickly and requires little or no computational assistance such as a computer

(d) using a parametric budgeting technique, a problem can be simplified in mathematical terms to highlight the sensitivity of any outcome to the assumptions made.

These advantages, however, are only valid for situations where a more sophisticated technique is not justified. A real limitation of budgeting is that it cannot explicitly take account of on-farm restrictions such as land, labour, and capital without considerable complication of results. A further limitation recognised by Kingma (39) is that budgeting would normally require quite highly subjective judgement of the alternatives available to the farmer.

This point is further stressed by Candler (14) when he comments that

> "by nominating the alternatives to be examined, budgeting can beg the question."

In other words, by nominating which possibilities are to be considered two important features may be overlooked -

(a) a budget may gloss over gaps in our present knowledge;

(b) alternatives which may not appear worth budgeting may in fact be highly profitable.

Lewis (44) used a budgeting procedure to compare dairying with beef production on a profitability basis, and mentions five factors which could affect the relative profitability of these two:-

(a) the substitution rate between beef animals and dairy cows;

(b) the butterfat price;

(c) the beef schedule price;

(d) production levels possible for dairying;

(e) beef carcass weights at slaughter.

Lewis then considers each of these critical variables over a range of values and presents the results in the form of graphs and tables in an attempt to make the budget applicable to a wide audience. Lewis concedes, however, that only one possible beef policy has been compared with one dairy policy. It may well be that these policies are not optimum for any farm being considered. The budget in this case does not fully achieve the aim of profit maximisation.

A further deficiency of the budgeting technique when applied to complex problems is highlighted by the five critical factors mentioned by Lewis. These factors could be expected to be interrelated, e.g. substitution rate chosen will affect beef carcass weights and dairy production levels. These relationships may be critical to an assessment of relative profitability yet their inclusion in an analysis using a simple budgeting technique may be difficult or impossible.

Lewis points out that restrictions other than feed supply, such as labour and capital, have not been recognised in the analysis. Again, this would have been difficult with a simple budgeting technique.

The advantages and limitations of a budgeting technique are thus very much related to the complexity of the problem, and the number of alternatives available. For a simple problem, the advantages mentioned by Candler become apparent, while for a more complex problem limitations of the budgeting technique point to the need for a more sophisticated approach if the full range of production possibilities are to be explored, with restrictions and relationships recognised.

4.4 PARAMETRIC BUDGETING

Candler (14) considers parametric budgeting and points out that the principles are extremely simple:

(a) decide which assumptions (or parameters) should be varied;

(b) give each of these parameters a letter;

(c) compute the budget in the normal way, except that each time a parameter enters the budget use the corresponding letter rather than a specific numerical value.

This approach has been used by the author (46) when comparing returns from beef and butterfat. Similarly, parameters could easily be assigned to the five key factors mentioned by Lewis (4.3) which affect the relative profitability of these two enterprises.

A major advantage of parametric budgeting is that having isolated key parameters such as substitution rate and carcass weight, any relationship between parameters becomes more apparent. For example, the substitution rate between dairy cows and beef animals will bear some relationship to eventual carcass weight of the beef animals. It may be possible then, to further simplify the analysis by substituting a single parameter weighted according to the relationship between substitution rate and carcass weight.

Parametric budgeting not only makes the analysis more flexible as regards key prices and assumptions, but also serves to pinpoint any relationship between these key parameters which may have not been apparent with a normal budgeting procedure.

Results may be presented in the form of a graph, nomogram or pro forma budget (14). These are designed to show the revenue corresponding to any set of values for the parameters which may be of interest. However, the revenue in each case will be related to the underlying assumptions in the budget.

4.5 A BEEF/SHEEP PARAMETRIC BUDGET

A parametric budget can readily be prepared to compare profit margins between breeding ewes and fattening beef animals. The key parameters likely to affect relative profitability may be listed as follows:-

A : The gross margin 1/ per breeding ewe ($)

S : The schedule price for beef ($/100 lb carcass weight)

C : Variable costs 2/ per head for beef animals plus the cost of a replacement animal

X : The substitution rate as defined by the number of breeding ewes replaced by one beef animal

B : The carcass weight of beef animals at the time of sale after allowance is made for deaths 3/ (100 lb)

The parametric budget thus becomes

$$P = \left(\frac{B\,S - C}{X} \right)$$

1/ The gross margin for a breeding ewe is represented by the income which it earns from meat and wool sales, less the variable costs 2/ attributed to that breeding ewe, and in this thesis has the same meaning as "sheep price".

2/ Variable costs include such items as veterinary and cartage which may be attributed directly to any animal. They do not include fixed farm costs such as rates and fertiliser.

3/ Allowance may be made for deaths on a per animal basis by multiplying carcass weight at sale by percentage of animals lost, e.g. for animals of carcass weight 400 lb with five per cent losses, 20 lb of meat per animal would, on average, be unavailable for sale.

where P = the gross margin returned to the farmer for each breeding ewe replaced by beef animals. A comparison between P and the present ewe gross margin, A, will be an indication of the relative profitability of breeding ewes or beef production. Several points should be noted however, when using a budget of this nature:-

(a) The substitution rate of breeding ewes for beef animals may not be constant either within or between farms. A particular farm may be ideally suited in terms of pattern of feed production to breeding ewes, while another may be better suited to beef production. Within a farm, substitution of beef animals for a portion of a ewe flock may involve a different substitution rate than that which may be involved if all of the ewe flock is replaced.

(b) No fixed costs are included. The basic assumption is that all costs not included during calculation of the ewe gross margin or the direct costs for beef animals, are the same for both livestock systems.

(c) No restrictions other than those implied in nomination of a substitution rate, are included.

Provided these limitations are recognised, the parametric budget does enable a quick estimate to be made of relative profitabilities. By using a range of values for critical parameters, the sensitivity of outcome to underlying assumptions can easily be assessed.

Relationships between parameters become apparent when presented in the form of a parametric budget, and in this case allow further simplification. In this example, the number of breeding ewes replaced by a beef animal dictates the feed made available to that animal. This figure can then be used as a basis for calculating carcass weight. If the feed consumed by five breeding ewes allows a carcass weight of 400 lb to be attained, the parametric budget becomes -

$$P = \frac{4S - C}{5}$$

EXAMPLE: A farmer considers that five breeding ewes consume the same amount of feed as a beef animal purchased as a weaner and reaching a carcass weight of 400 lb net of losses at 18 months of age. He is able to purchase weaners at $40/head and estimates other direct costs for the beef enterprise to total $10/head. He wishes to compare his present ewe gross margin of $7.00 with possible beef returns at beef schedule prices of $16.00, $20.00 and $24.00/100 lb respectively.

$$P = \frac{4S - C}{5}$$

where S = $16.00, $20.00 and $24.00

C = (40 + 10) = $50.00

P = $2.80, $6.00 and $9.20 respectively.

For beef schedule prices over $20/100 lb, this farmer could thus consider replacing breeding ewes with beef animals, in which case a more detailed analysis may be justified.

This example illustrates how parametric budgeting can extend the usefulness of the budgeting process and lends itself well to a simple comparison of possible sheep and beef cattle returns.

This technique is well suited to extension work, particularly where advisers are able to make reliable estimations of substitution rates, costs and prices for a particular farm.

4.6 LINEAR PROGRAMMING

Over the last ten years the simplex method for solving linear programming problems has gained wide acceptance by agricultural economists as a research tool for the solution of certain classes of farm management problems.

Linear programming can broadly be defined as a procedure which maximises profit from a set of enterprise possibilities, subject to any constraints imposed. In this study, the enterprise possibilities include various beef and sheep systems. The constraints represent on-farm limitations such as feed-supply.

The mathematical basis for linear programming and its application to various agricultural problems has been described by Heady and Candler (26) and Rae (54). The technique has previously been applied to an investigation involving beef cattle by Kingma (39) and Lattimore (43).

Linear programming enables a simultaneous comparison of production possibilities within the beef enterprise, with a variety of sheep and cropping policies. The technique thus has the ability to meet both aims (1.3) of this thesis simultaneously.

Construction of a linear programming model 1/ requires the analyst to define all of the pertinent input/output relationships.

1/ In this text, the term "model" is used as an abbreviation for "linear programming model" unless otherwise indicated.

This can be a time-consuming process as was the case in this study where it was found that many of the important relationships had not previously been described. The considerable data requirements for construction of a model has been cited as a disadvantage of linear programming. It may be said however, that

> "perhaps as much as any other tool, linear programming forces the investigator to set down a systematic model ....,which is a functional account of the relationships between relevant variables." (26).

In this way, the model forces the analyst to consider critical relationships which may otherwise have been ignored.

Kingma (39) and Lattimore (43) both found that linear programming was suited to explore a farm management problem involving a number of possible farm enterprises competing for a limited feed-supply, Townsley (50) supports this view and comments that an obvious pre-requisite for the use of linear programming is that the decision-maker be faced with a number of alternative courses of action.

McIvor (49), when considering methods available to an agricultural economist comments that

> " when several activities are possible and where these compete for fixed resources such as land, capital, labour and feed, linear programming can realistically be applied."

In this study linear programming proved to be a particularly useful technique for allotting feed supplies on a farm to feed-consuming enterprises in the most profitable way. A relatively simple model was constructed, and it was found that simplicity, rather than detracting from its usefulness, enabled an easy check to be made that the on-farm system was being accurately simulated. A simple model also has the advantage that computing time is minimised, and adjustments are easily made so that the sensitivity of results to any critical assumption may easily be assessed.

4.7 BUDGETING AND LINEAR PROGRAMMING

Many of the advantages and disadvantages of budgeting and linear programming have been considered. However, the complimentarity of the two techniques should be emphasised (14).

The limitations of budgeting become apparent with increasing problem complexity, while for simple problems budgeting has obvious advantages over a more sophisticated technique. Linear programming on the other hand, is well equipped to handle farm-management problems involving a large number of possible enterprises and restrictions, but should not be used where a simpler technique would suffice.

There would thus seem to be a two-step process required:

(a) linear programming at the research level to fully explore relationships and production possibilities;

(b) budgeting at the extension level based on information derived by linear programming.

In this way, the advantages of each technique could be attained. The increasing availability of computer facilities and the recognised need (15) for computer programmes, designed specifically at helping to make better decisions in the field will lead to much wider usage of techniques such as linear programming. Budgeting may be the final tool for farmer acceptance, but the research worker and the adviser will need more sophisticated analytical techniques as the diversity and complexity of possible farm enterprises increases.

4.8 DATA REQUIREMENTS FOR LINEAR PROGRAMMING

As will become apparent in this study, linear programming can be very demanding in terms of data requirements. However, it should be recognised that a comprehensive budgeting approach would require similar information.

Any analysis is only as reliable as the information on which it was based. Data used in the construction of the model for this thesis was gathered from what the author believed to be the most reliable sources. Where possible, the sensitivity of any recommendation to the accuracy of underlying assumptions has been assessed. For the two most important variables, sheep and beef prices, a parametric analysis has been carried out.

In the last few years, two workers (39, 43) have used linear programming to examine beef-production systems in New Zealand. Both of these workers comment that reliable information on this subject is not only scarce, but that which is available often does not enable construction of production functions, or any reliable economic analysis.

McIvor (49) recognises this problem also, and mentions

> "lack of adequate data on monthly pasture production, variations in pasture nutritive values, cattle growth rates, feed requirements, and market price fluctuations."

Overseas workers, however, consider that problems peculiar to the beef industry exist (4),

> "It is recognised that the development of input/output relationships and production functions for beef was not as simple as most other agricultural commodities",

problems mentioned are that some inputs are by-products of the National Dairy Herd, animals can change hands a number of times in their life-time, and that beef farming is often only a secondary or opportunist enterprise on the farm.

4.9 PARAMETRIC LINEAR PROGRAMMING

There would be little merit in comparing returns from sheep and beef farming unless a range of returns from these two enterprises was considered. To this end, a parametric linear programming approach will be used.

The procedure for "variable-price" programming is explained by Candler (13) in mathematical terms. However, the procedure may be summarised as follows:-

(a) The problem must be formulated so that a price change in the enterprise of interest can be easily made.

(b) The model must take account of any relationships affected by the price change, e.g. a change in beef price will necessitate a change in the purchase price of a replacement animal, if these two factors are related.

(d) Having arrived at an optimum 1/ farm plan for a given set of prices, the model must show the price range over which this plan is optimum.

(d) By altering a price to a point just beyond that over which the first plan was optimum, the model should derive a new optimum plan relevant to the new prices. Again, the price ranges over which this new plan is optimum will automatically be calculated.

The procedure is to take successive "steps" over the price range of interest 2/. The minimum price of interest will give

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1/ The term "optimum" describes a situation where profit has been maximised from the resources and enterprises available.

2/ A more detailed account of the procedure used in this study may be obtained from the author.

an initial optimum plan, together with the price increase required for a change in plan to become necessary for optimality. Altering the price to a point just beyond the stability range for the initial plan will give rise to a second optimum plan. This procedure is continued until the whole price range of interest is covered.

It should be noted however, that while optimum plans change abruptly at a certain price level, profit margins will alter continuously with price changes. Thus, for example, the optimum plan may include 10 beef animals and 100 breeding ewes for beef schedule prices between $20.00 and $30.00 per 100 lb, if sheep price is held constant. Profit margins will be higher at $30.00 than at $20.00, however, even though the same farm plan is optimum.

4.10 PRICE-MAPPING

An extension of the parametric linear programming procedure outlined leads to the preparation of price maps. These may be defined as the graphical representation of optimal plans over prescribed price ranges.

For the purpose of this study the two prices of specific interest are those for sheep and beef cattle. The parametric technique is simply used to plot "borders", or lines which define the price ratios for sheep and beef cattle at which new plans become optimum.

The technique is explained in detail by Candler (13, 26). In this thesis, the parametric technique is used to define the optimum farm plan for any sheep and beef price of interest. Since price ranges over which this plan <u>is</u> stable are also defined, each plan will be represented by an "area" on the price map.

The price-mapping technique has three major advantages -

(a) it allows a more orderly analysis and ensures that all combinations of prices within the price ranges of interest are examined. Deriving a series of optimum plans by taking discreet steps over ranges of price combinations would not ensure that all farm plans of possible interest had been described;

(b) it allows a much clearer and simpler presentation of results, and avoids the need for comprehensive tables;

(c) the stability of any plan is represented by an area on the map and becomes immediately obvious. The stability range would be more difficult to assess from a series of tables.

4.11 SUMMARY

The uses of budgeting and linear programming are discussed. The conclusion is reached that while budgeting has several advantages for simple problems, linear programming is better equipped to deal with situations where several enterprises must be considered. The complementarity of the two techniques is emphasised, and the expanded usage of sophisticated analytical techniques for extension work is forecast.

Parametric budgeting is a useful extension of the budgeting technique, and provided a possible method of comparing beef and sheep returns. This technique however, was considered to be too superficial for the present analysis.

The parametric linear programming technique improves the versatility of the linear programming approach, and may be used to prepare price-maps which have major advantages in the computation and presentation of programming results.

CHAPTER FIVE

THE CONSTRUCTION OF A LINEAR PROGRAMMING MODEL FOR CASE FARM 1

5.1 INTRODUCTION

In this chapter, the application of a linear programming analysis to Case Farm 1 is described. The alternatives available to the farmer, on-farm restrictions, and relevant costs and prices, are outlined. The enterprises which may be of interest to the farmer are discussed in detail, together with the way in which these are incorporated into the linear programming model.

The way in which a parametric beef schedule price is incorporated into the model, and cognisance taken of correlation between the beef schedule price and the cost of replacement beef stock is described.

5.2 CASE FARM 1

The grazeable area is 235 acres of Puke Puke Black Sand Complex. This soil type is typical of the low-lying sand country in this area, and because of a high water-table severe summer or autumn droughts are unusual. Pasture production is discussed in <u>5.3.2</u>.

The farm is well fenced and subdivided with a good woolshed, water supply and cattle yards. The contour is generally flat with some sandy ridges.

5.2.1 <u>Reasons for Selection</u>

Case Farm 1 was purposively selected for detailed study for three main reasons:-

(a) The farm is in the same locality and has a similar environment and soil-type to the Department of Agriculture's Field Research Station (Flock House), near Bulls, where pasture production measurements have been made.

(b) The farmer has recently commenced to convert his farm from an all-sheep to an all-beef enterprise.

(c) The farmer is keenly interested in research work, is a very observant and able stockman, and proved invaluable when the practicability and feasibility of results were assessed.

5.2.2 Present Farm Circumstances

The farmer initially became interested in beef production as a means of reducing labour requirements. He employs no labour, has no dependent children, and considered more leisure time a legitimate reason for decreasing the size of his ewe flock.

The change to beef is being made by hand-rearing on re-constituted milk, about 150 Friesian calves purchased each spring from dairy farmers in the district. This operation has been successful with negligible losses, but in future the aim is to purchase weaned "dairy-beef" type steers from dairy farmers. Again, the aim is to reduce labour requirements by eliminating the calf-rearing operation.

Until the 1969/70 season about 1,000 ewes were mated annually, but the ewe flock has now been reduced in size to accommodate the increased numbers of beef animals.

5.2.3 Farm Production Figures

Lambing percentages up to 130 per cent have been recorded from the ewe flock on this farm.

In recent years 200 hoggets have been mated annually and 60 per cent of these have produced lambs. Total wool production has been consistently around 75 - 80 lb. per acre. Beef animals on the farm in the past have been few in number with about 40 - 60 head of 18 month cattle purchased each spring for fattening. The number purchased was dictated by the price of these animals and the feed situation on the farm.

The farm has been included in the Meat and Wool Board's Economic Survey for eight seasons and gross returns per ewe wintered from sales of meat and wool have been calculated as follows

Season	Ewes Wintered	Gross Return/Ewe
1961/62	1005	$ 7.15
1962/63	1008	$ 8.14
1963/64	975	$11.14
1964/65	1010	$10.35
1965/66	1009	$10.23
1966/67	1045	$ 8.15
1967/68	1043	$ 8.32
1968/69	1048	$ 9.67

While averages over time can be misleading due to influences such as inflation and devaluation, it may be noted that for the seasons shown gross return per ewe averaged in excess of $9.00 which is particularly high (36, 64).

The direct costs attributed by the farmer to his ewe flock are taken from the 1969/70 farm accounts and may be summarised as follows:-

Shearing	$0.54/ewe
Veterinary	$0.31/ewe
Interest ($7.00 at 6%)	$0.42/ewe
Total direct costs	$1.27/ewe

If the same costs are accepted for the 1968/69 season, the gross margin, or gross return less direct costs, for each ewe was -

Gross return	$9.67
Less direct costs	$1.27
Gross margin 1/	$8.40/ewe wintered.

5.3 THE LINEAR PROGRAMMING ANALYSIS FOR CASE FARM 1

The construction of a linear programming model according to Stewart (56), requires the following steps to be taken:-

(a) Decide upon the alternatives available.

(b) Consider the restraints which should be imposed.

(c) Decide what units will be used.

(d) Derive the input/output coefficients.

(e) Decide which prices or net revenues should be used.

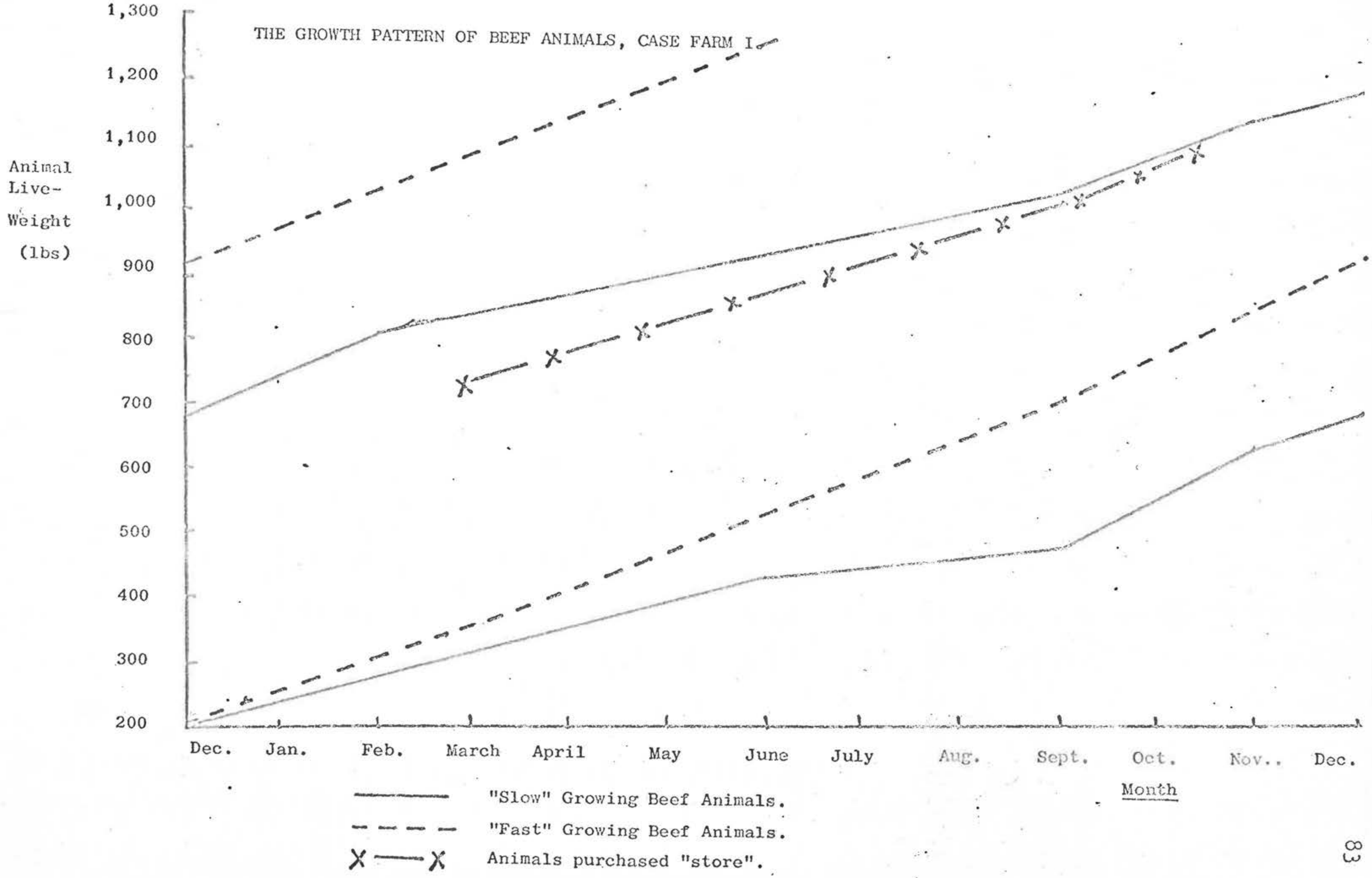
5.3.1 The Alternatives Available

The farm has demonstrated its capacity as an all-sheep farm , and fast growth rates in beef-cattle have been obtained as shown in Fig. 5.1. The climate is considered unsuitable for wheat production. However, barley is grown on some farms in the district. In some years store-lambs are fattened, or surplus feed is made into hay for sale.

1/ The gross margin per ewe wintered calculated in this way represents the "sheep price" which is referred to later in this text.

FIGURE 5.1

THE GROWTH PATTERN OF BEEF ANIMALS, CASE FARM I.



The enterprises available on this farm therefore include breeding ewes producing meat and wool, beef-production, barley production, lamb fattening and hay selling.

5.3.2 The Restraints Imposed

Restrictions or restraints in the model ensure that the availability of any resource is not exceeded. Labour requirements for beef production are considered by the farmer to be lower than for the equivalent stock numbers in breeding-ewes. The capital requirements for any of the alternatives which are considered are not a limiting factor for this farmer, although interest will be charged at six per cent per annum for all capital invested in livestock.

The resource which restricts the size of any enterprise chosen will thus be feed-supply. Blackmore (3, 9) reports that in a year of "normal" rainfall 1/, the following distribution of pasture dry-matter production was recorded:

spring	32.1%
summer	28.4%
autumn	30.3%
winter	9.2%
	100.0%

It should be noted that the seasons as described in Department of Agriculture's Field Research Reports divide the year as follows:

1/ Blackmore considers that for this locality, a 30% reduction in pasture production in summer or autumn because of low rainfall constitutes a drought and that a drought of this nature may be expected to occur, on average, one year in five.

September October November	)	spring
December January February	)	summer
March April May	)	autumn
June July August	)	winter

It is estimated by the farmer that 1250 breeding ewes with a 120 per cent lambing could be adequately fed under an all-sheep system on this farm. Using Coop's (19) ewe-equivalent system, this equates closely with present stock on the farm, as shown in Table 5.1.

Table 5.1

Case Farm 1 - Ewe Equivalents

Present Stock	E.E./head	Total E.E.
200 Hoggets	0.6	120
50 18-month cattle 1/	2.5	125
1000 ewes	1.0	1000
	Farm Total	1245

The seasonal availability of feed on this farm is then derived as follows:-

(a) The feed available is distributed between seasons according to measurements made by Blackmore (3, 9).

1/ These animals are only held on the farm for part of the year and E.E. are estimated at 2.5/head.

(b) The total availability of feed is scaled so that 1250 ewes with 120 per cent lambing may be included in an all-sheep plan[1/].

The seasonal availability of feed on this farm is estimated in this way to be

spring	4670	lb	feed	units	available (100's lb D.O.M.)
summer	3930	"	"	"	"
autumn	4400	"	"	"	"
winter	1360	"	"	"	"
Total	14360	"	"	"	"

These figures represent pasture actually utilised by animals, so that wastage and conservation losses must be added if a figure of total grass growth is desired. The figures as presented are on a whole-farm basis. The total production for a year is estimated to be 1,436,000 lb D.O.M. and assuming a conversion ratio of -

1 lb dry matter = 0.62 lb D.O.M. (61)

the dry matter consumed by animals each year is 9,900 pounds per acre.

5.3.3 Units and Input/[illegible] [illegible]efficients

One feed unit represents one hundred pounds of Digestible Organic Matter supplied or demanded in any season. Any feed-consuming enterprise such as a breeding ewe will demand a specified amount of feed in each season. The inclusion

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1/ Since feed requirements for breeding ewes are those described by Coop (19), the same figures are used to scale feed availability - i.e. feed required by 1250 ewes is the feed available.

of one breeding ewe in the final plan will therefore remove from the D.O.M. available on the farm in any season, an amount described by its input/output co-efficients.

5.3.4 The Costs and Prices Used

The costs and prices will be discussed in detail as each enterprise is considered. However, it must be emphasised that a "gross margin" or "enterprise net revenue" approach has been used and to enable the analysis to cover variable sheep and beef returns, costs must be defined as follows:-

(a) Fixed Farm Costs: These are costs which are fixed for the farm regardless of which enterprises are chosen and regardless of sheep and beef returns. Included in this definition are overhead costs (principal repayments, rates, insurance, etc.), and the costs common to breeding-ewes, beef animals or cash crops (fertilizer, repairs and maintenance, vehicle expenses, etc.).

(b) Fixed Enterprise Costs: These are costs which may be attributed directly to an enterprise, and are independent of changes in beef or sheep returns, e.g. veterinary expenses.

(c) Variable Enterprise Costs: These costs may also be attributed directly to an enterprise, but may be affected by any change in sheep or beef returns. For example, the purchase price of beef animals as discussed in 5.7 includes some cost which is related to the beef schedule price and may be described in the context of this thesis as a variable enterprise cost.

To calculate enterprise net revenues, both fixed and variable enterprise[1] costs are subtracted from the total revenue earned by the enterprise. Fixed farm costs are not included in the model and may be subtracted from the total net revenue obtained by the linear programme after computation to calculate tax-paid profit to the farmer.

5.4 THE MODEL FOR CASE FARM 1

The linear programming model for Case Farm 1 is presented in Table 5.2. In total, 47 activities are included, 34 of these being beef-producing activities.

For activities other than those producing beef, the value represents the income as a result of including one unit of that activity in the farm plan. For beef-producing activities, a negative number indicates that only the fixed enterprise costs are included, and revenue from beef sales is gained by supplying beef, as indicated by a negative sign in the beef-selling row, to the beef-selling activity.

Positive numbers within the model indicate resource requirement, while negative numbers indicate supply of the appropriate resource in that row. For example P_{38}, a hay-making activity, consumes or removes 1.0 feed units from the spring feed supply and supplies 0.56 feed units to winter-feed resources. This operation involves a cost, denoted by a negative value, of $0.50.

1/ The way in which variable enterprise costs for beef-producing activities are included in the model is discussed in 5.8.

TABLE 5.2 - THE LINEAR PROGRAMMING MODEL FOR CASE FARM 1

Feed Available	Activity No.	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}
	Value	-17.79	-17.86	-17.94	-18.01	-18.08	-18.15	-18.22	-11.85	-11.90	-11.95	-12.00
4670 :	Spring	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
3930 :	Summer	4.5	8.0	11.7	14.9	14.9	14.9	14.9	-	3.5	7.3	10.4
4400 :	Autumn	5.7	5.7	5.7	5.7	9.1	12.5	16.2	4.0	4.0	4.0	4.0
1360 :	Winter	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
	Beef Sell	-2.10	-2.40	-2.73	-2.89	-3.05	-3.21	-3.38	-1.32	-1.63	-1.95	-2.11

Activity No	P_{12}	P_{13}	P_{14}	P_{15}	P_{16}	P_{17}	P_{18}	P_{19}	P_{20}	P_{21}	P_{22}	P_{23}
Value	-12.05	-12.10	-12.15	-18.59	-18.66	-12.40	-12.45	-17.79	-17.86	-17.94	-18.01	-18.08
Spring	9.6	9.6	9.6	19.2	23.7	19.2	23.7	12.4	12.4	12.4	12.4	12.4
Summer	10.4	10.4	10.4	14.9	14.9	10.4	10.4	4.5	8.8	13.2	17.9	17.9
Autumn	7.4	10.9	16.2	16.2	16.2	14.5	14.5	7.2	7.2	7.2	7.2	12.2
Winter	5.7	5.7	5.7	16.9	16.9	16.9	16.9	9.5	9.5	9.5	9.5	9.5
Beef Sell	-2.27	-2.42	-2.58	-4.56	-4.81	-3.77	-4.01	-3.30	-3.63	-3.98	-4.33	-4.69

Activity No.	P_{24}	P_{25}	P_{26}	P_{27}	P_{28}	P_{29}	P_{30}	P_{31}	P_{32}	P_{33}	P_{34}	P_{35}
Value	-18.15	-18.22	-11.85	-11.90	-11.95	-12.00	-12.05	-12.10	-12.15	-2.05	-2.06	10.0
Spring	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	9.0	13.4	-
Summer	17.9	17.9	-	4.3	8.8	13.4	13.4	13.4	13.4	-	-	-
Autumn	17.3	22.9	5.1	5.1	5.1	5.1	10.1	15.2	20.8	9.5	9.5	-
Winter	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	10.3	10.3	-
Beef Sell	-5.05	-5.43	-2.53	-2.87	-3.21	-3.57	-3.92	-4.29	-4.66	-1.50	-1.73	1.0

Activity No.	P_{36}	P_{37}	P_{38}	P_{39}	P_{40}	P_{41}	P_{42}	P_{43}	P_{44}	P_{45}	P_{46}	P_{47}
Value	5.0	-	-0.5	-0.5	-0.5	-4.5	-4.5	-4.5	-4.5	34.0	0.9	0.9
Spring	3.37	-	1.0	-	-	-1.0	-	-	-	19.8	-	-
Summer	1.62	-	-	1.0	-	-	1.0	-	-	16.7	1.0	-
Autumn	1.45	1.0	-	-	1.0	-	-	-1.0	-	14.0	-	1.0
Winter	2.10	-1.0	-0.56	-0.56	-0.56	-	-	-	-1.0	2.9	-	-
Beef Sell	-	-	-	-	-	-	-	-	-	-	-	-

The beef-selling row includes only one positive number, under P_{35}, the beef-selling activity. The 34 beef-producing activities, which have negative numbers in the beef-selling row must, therefore, supply beef to P_{35} for "consumption", or sale at the value placed on P_{35}. The value of P_{35}, i.e. the revenue earned from sale of 100 lb of carcass meat, represents the beef schedule price. Changing the value of P_{35} therefore effectively changes the revenue obtained from all beef-producing activities.

> <u>Example</u>: P_1 represents an animal which consumes 9.6 units of feed in spring, 4.5 units in summer, 5.7 units in autumn and 5.7 units in the winter. It supplies 210 lb of meat for sale at the schedule price of interest as denoted by the value placed on P_{35}, and each unit of activity P_1, or each animal, incurs fixed enterprise costs of $17.79.

5.5 BEEF-PRODUCING ACTIVITIES

One unit of any beef-producing activity represents the purchase of one beef animal. The main variables with any beef-producing activity are -

(a) age, live-weight, and date of purchase;

(b) age, live-weight, and date of sale;

(c) growth pattern for the time the animal is on the farm, i.e. between date of purchase and date of sale.

For Case Farm 1, 34 different beef activities are included in the matrix as shown in Table 5.2. Differences among these activities are almost entirely due to different dates of purchase and sale, and different animal growth patterns.

Purchase Date: Three purchase dates are considered as being the starting point for three main cattle policies -

(a) weaners may be purchased on 1st December at 10 - 12 weeks of age and 200 lb live-weight. Although no breed distinctions are made, these would usually be from a dairy herd;

(b) weaners may be purchased at 6 - 8 months of age on 1st April. These animals would weigh 360 - 400 lb live-weight and would usually be of Angus or Hereford breeds since farmers with herds of breeding cows normally wean their calves at this time.

(c) 18 - 20 month "store" 1/ cattle purchased in the autumn. These animals could be of any breed.

Selling Date: Three main selling periods are considered in the programme, representing selling policies available to this farmer -

(a) animals purchased as weaners may be sold before their second winter, at 15 - 20 months of age;

(b) animals purchased as weaners may be kept for a second winter for sale the following spring at approximately two years of age;

(c) animals purchased "store" in the autumn may be sold the following spring at approximately two years of age.

Growth Rates: To enable the calculation of feed requirements for beef animals, growth rates must be stipulated.

1/ "Store" animals are those which may be old enough for slaughter, but could gain more weight if feed is available. The definition therefore includes any animals old enough for slaughter.

For each beef activity the monthly growth-rate of an animal is described. Three general growth patterns are included -

(a) a "slow" growth pattern which would result if animals were fed well below appetite for most of their life on the farm. This is a growth pattern witnessed on several of the farms visited and will be used as a basis for estimating the desirability of faster growth rates. The growth pattern is illustrated in Fig. 5.1.

(b) a "fast" growth pattern where animals are given a much higher plane of nutrition, particularly over the winter period. For the two Case Farms considered, the "fast" growth pattern will be based on weight recording previously carried out on the farm, using the fastest growth rates which have been observed. This growth pattern for Case Farm 1 is shown in Fig. 5.1.

(c) the growth pattern after 18 months of age for animals purchased as weaners is again based on previous figures attained on the farm being examined. For animals purchased "store" and taken through a second winter, a similar growth pattern is assumed, as shown in Fig. 5.1.

5.5.1 Costs and Prices for Beef-Producing Activities

The costs and prices for beef-producing activities will be considered in detail in 5.8 where adjustment will be made for those costs and prices which vary with the beef schedule price.

5.5.2 Beef Producing Activities in the Model

The beef-producing activities in the model for Case Farm 1 are summarised in Table 5.3 where purchase and sale dates, age and live-weight at sale, are noted. Carcass weights at sale are calculated from dressing-out percentages 1/.

Activities $P_1 - P_7$ represent "slow" growth-rate animals purchased in December at 200 lb live-weight and sold before their second winter in seven drafts at monthly intervals from 1st December to 1st June. Animals represented by activity P_1 are sold on 1 December, P_2 on 1st January, and so on with P_7 being sold on the 1st June.

Activities $P_8 - P_{14}$ also represent "slow"growth-rate animals, but differ from $P_1 - P_7$ in that they are purchased at 360 lb live-weight on 1st April. Selling dates are again at one-monthly intervals with animals represented by activity P_8 sold on 1st December, P_2 on 1st January, and P_{14} on 1st June.

Activities $P_{15} - P_{18}$ represent "slow" growth-rate animals but these are not sold until the spring following their second winter. Animals represented by activities P_{15} and P_{16} are purchased as weaners on 1st December at 200 lb live-weight, while those represented by activities P_{17} and P_{18} are purchased at 360 lb live-weight on 1st April. Animals

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1/ Dressing-out percentages are derived in Appendix 1 but may be defined here as the percentage of animal live-weight at time of slaughter which is represented by frozen carcass weight, i.e. the weight used as a basis for payment after slaughter.

Table 5.3

Case Farm 1 - Summary of Beef-Producing Activities

Activity No.	Month Bought	Live-Weight Purchase (lb)	Month Sold	Age Sold (Months)	Months on Farm	Live-Weight Sale (lb)
P_1	Dec.	200	Dec.	15	12	690
P_2	Dec.	200	Jan	16	13	750
P_3	Dec.	200	Feb.	17	14	810
P_4	Dec.	200	March	18	15	840
P_5	Dec.	200	April	19	16	870
P_6	Dec.	200	May	20	17	900
P_7	Dec.	200	June	21	18	930
P_8	April	360	Dec.	15	8	690
P_9	April	360	Jan.	16	9	750
P_{10}	April	360	Feb.	17	10	810
P_{11}	April	360	March	18	11	840
P_{12}	April	360	April	19	12	870
P_{13}	April	360	May	20	13	900
P_{14}	April	360	June	21	14	930
P_{15}	Dec.	200	Nov.	26	23	1140
P_{16}	Dec.	200	Dec.	27	24	1180
P_{17}	April	360	Nov.	26	19	1140
P_{18}	April	360	Dec.	27	20	1180
P_{19}	Dec.	200	Dec.	15	12	910
P_{20}	Dec.	200	Jan.	16	13	970
P_{21}	Dec.	200	Feb.	17	14	1030
P_{22}	Dec.	200	March	18	15	1080
P_{23}	Dec.	200	April	19	16	1150
P_{24}	Dec.	200	May	20	17	1210
P_{25}	Dec.	200	June	21	18	1270
P_{26}	April	360	Dec.	15	8	910
P_{27}	April	360	Jan.	16	9	970
P_{28}	April	360	Feb.	17	10	1030
P_{29}	April	360	March	18	11	1080
P_{30}	April	360	April	19	12	1150
P_{31}	April	360	May	20	13	1210
P_{32}	April	360	June	21	14	1270
P_{33}	March	730	Sept.	26	8	1040
P_{34}	March	730	Oct.	27	9	1080

represented by activities P_{15} and P_{17} are sold on 1st November, at about 26 months of age, while those represented by activities P_{16} and P_{18} are sold one month later on 1st December.

Activities P_{19} - P_{25} represent "fast" growth-rate animals purchased on 1st December at 200 lb live-weight. As with activities P_1 - P_{17}, these animals are sold in seven drafts at one-monthly intervals, with animals represented by activity P_{19} being sold on 1st December, P_{20} on 1st January, and so on with P_{25} animals being sold on 1st June.

Activities P_{26} - P_{32} also represent "fast" growth-rate animals except that all are purchased on 1st April at 360 lb live-weight. Selling dates are again at one-monthly intervals with animals represented by activity P_{26} being sold on 1st December, P_{20} on 1st January, and P_{32} on 1st June.

Activities P_{33} - P_{34} represent beef animals purchased at 18 months of age on 1st March, to be sold at about two years of age. Animals represented by activity P_{33} are sold on 1st September, while those represented by P_{34} are sold on 1st October.

The beef-producing activities are discussed in greater detail in 5.8. Feed requirements for each of these activities are calculated according to live-weight and growth-rate for the period the animal is on the farm. For example, the animal represented by activity P_1 has a summer feed requirement of 4.5 feed units or 450 lb D.O.M. For activity P_8 however, animals are not purchased until the 1st of April and are sold on the 1st of December, so the requirement for summer feed is zero.

Feed requirements for all animals are calculated on an annual basis. Animals which are present on the farm for more than twelve months thus have a double requirement in some months within the year. In this way total feed requirements in any month may include those for a young animal plus those for a similar animal twelve months older.

5.6 THE PARAMETRIC BEEF-SELLING ACTIVITY

To enable a range of beef schedule prices to be considered, it is necessary to include a procedure in the model which takes account of the relationship between the beef schedule price and the income from the various beef-producing activities of interest.

This is achieved by using a "beef-selling" activity", P_{35}. Any beef-producing activity in the model supplies beef to this selling activity which then sells it at the beef schedule price of interest. In this way, a price change for the selling activity will automatically mean a change in revenue for every beef-producing activity in the model.

The income from any beef-producing activity is in this way represented by the amount of meat or the carcass weight available to the beef-selling activity at the time of slaughter. Income is therefore directly related to the current price placed on the beef-selling activity. The Values included in the model for beef-producing activities therefore represent only the fixed enterprise costs for each, as defined in 5.3.4.

This parametric procedure is necessary because of the large number of beef-producing activities which are included in the model. The number of sheep activities included do not justify a similar procedure.

5.7 THE CORRELATION BETWEEN BEEF SCHEDULE PRICES AND REPLACEMENT COSTS OF BEEF ANIMALS

Because of the wide range of beef schedule prices which are considered, it is not realistic to assume a constant price for replacement cattle. It therefore becomes necessary for the model to take some account of the correlation between the beef schedule price and the cost of replacement beef animals.

The price a farmer is required to pay for replacement beef animals depends on a number of factors. In particular the following influences may be noted:-

(a) The current beef schedule price.

(b) Confidence in the beef market, especially during the expected lifetime of the animal being purchased.

(c) The availability of feed on the farms of possible vendors and purchasers.

(d) Confidence in markets other than beef, especially milk-products, fat lambs and wool.

(e) The availability of credit, i.e. the ease with which farmers can finance the purchase of capital stock.

(f) The current level of farm incomes. This effect is amplified by the present system of progressive income tax, so that in a high profit year farmers are prepared to pay considerably more for capital stock.

In attempting to estimate the impact of beef schedule prices on replacement costs, several problems emerge. Firstly, any estimate must necessarily be based on historical data, and because a wide variety of factors affect purchase price, the effect of any one factor is difficult to isolate. Also, with rapid expansion of the beef industry, information gathered within the last few years is not representative of a stable relationship, and information gathered before this time may no longer be relevant.

The problem is considerably simplified, however, if the following assumptions are made:-

(a) The current beef schedule price is directly related to confidence in the future market for beef.
(b) The availability of stock feed has the same impact on beef prices as on other possible farm enterprises.
(c) The future prospects for other possible farm enterprises do not vary.
(d) Finance is available at a fixed interest rate to purchase replacement stock, regardless of price.
(e) Taxation effects do not vary.

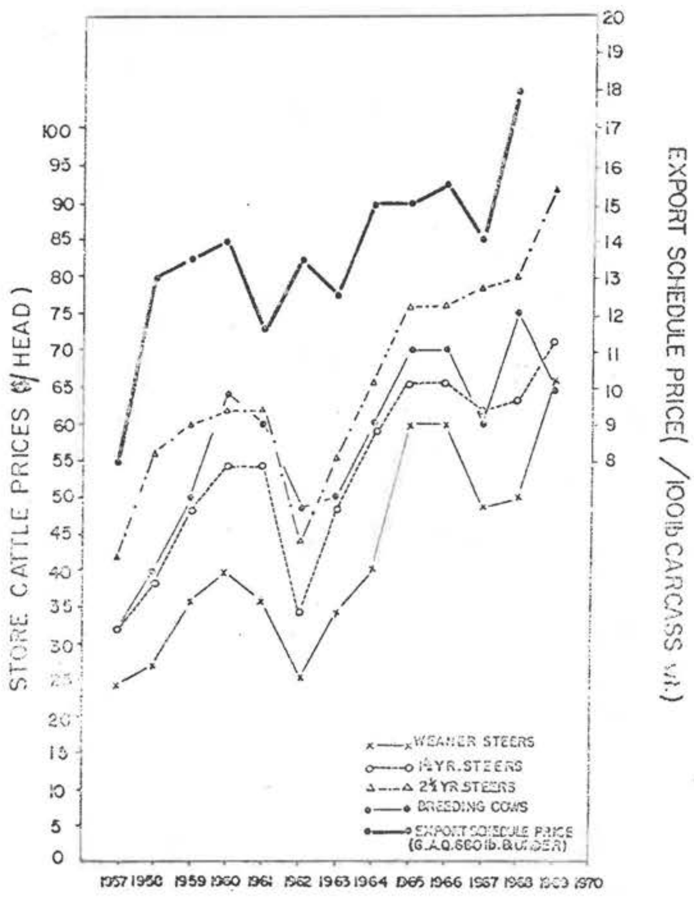
Under these assumptions, expected purchase price will be influenced by only one variable, the current beef schedule price. The validity of these assumptions would need to be investigated with regard to a given set of circumstances, and for a farmer purchasing replacement cattle the price he would be prepared to pay would almost certainly be influenced by such factors as current feed availability.

The South Auckland Beef Development Committee assembled information on beef schedule prices and replacement costs for the years 1957-69 (2), and this information is presented in Fig. 5.2. The comment is made in this publication that ...

> "store cattle prices fluctuate from year to year but are closely associated with the beef carcass export schedule prices."

<u>Fig. 5.2</u>

Store Cattle Prices and Export Beef Carcass Values (1957-70)



<u>Source:</u> South Auckland Beef Development Committee Publication (1970) - "Buying and Selling Policies".

For the purpose of this thesis, it is assumed that any fluctuation in the replacement costs of beef animals may be attributed entirely to changes in beef schedule prices.

Estimates are derived for animals purchased at three defined periods as follows:-

(a) A 200 lb live-weight animal purchased at weaning on 1st December. This animal would usually be reared on a dairy farm.

(b) A 360 lb live-weight animal purchased on 1st April, at about 6 - 7 months of age. This animal would usually be from a traditional beef-breed herd.

(b) A "forward store" animal purchased at 14 - 18 months of age which could have been slaughtered as a "boner" at the time of purchase.

To facilitate estimation, the purchase price may be partitioned into two parts -

(a) a part which will be independent of current beef schedule price.

(b) a part which will bear a direct relationship to current beef schedule price.

From observations made by Lattimore (43) and those presented in Fig. 5.2, it can be seen that purchase price is almost directly related to schedule price for animals which are killable as boner cattle, while for smaller animals a less direct relationship exists. In other words, the dependent part of purchase price is greatest for heavier animals, while for small animals such as weaners, the independent part of purchase price is greater. This may be explained as follows:

Lattimore (43) has estimated that the cost of rearing a calf is $14.50, and this is independent of the beef schedule price. The cost of a calf at birth is influenced by the demand for these animals which bears some relationship to the beef schedule price. The calf-rearers' profit margin is also likely to be influenced by beef schedule price. As an animal consumes feed and grows older and heavier, the influence of rearing cost is gradually replaced by the value of the meat which the animal carries. Finally, at the time of slaughter, an animal's value is dictated entirely by the value of its carcass. In this way the independent part of purchase price diminishes as an animal approaches slaughter weight while the dependent part increases.

A trial-and-error method was used to derive relationships between purchase prices and schedule prices for the three classes of animals defined above. The independent part of purchase price for a 200 lb weaner is estimated to be its rearing costs, $14.50, while this effect diminishes to $10.00 for the independent part of purchase price for a 360 lb weaner. The independent part for "forward-store" animals is the amount required to out-bid buyers purchasing on behalf of Freezing Works and is estimated to be $2.00/head.

The dependent part of purchase price approximates the current value of an animal's carcass weight as saleable meat. For a 200 lb live-weight weaner, the dependent part is represented by the value of 100 lb of carcass meat, while for a 360 lb animal the relevant figure is 180 lb of carcass meat. For "forward-store" animals which may be slaughtered, the variable portion of purchase price is represented by the carcass value.

The total purchase price may be expressed as follows where -

P = total purchase price ($)

B = current beef schedule price ($)

C = carcass weight in 100's lb at time of purchase

(a) a 200 lb live-weight weaner

P = \$14.50 + 1.0 B

(b) a 360 lb live-weight weaner

P = \$10.00 + 1.8 B

(c) a "forward-store" animal

P = \$2.00 + CB

Example: For the three beef schedule prices of \$15.00, \$20.00 and \$25.00, the following purchase prices could be expected for the three classes of beef animals defined above. The "forward-store" animal, (c), will be taken as 350 lb carcass weight for the purpose of this example.

Table 5.4

Some Examples of Calculated Purchase Prices

Schedule ($/100 lb)		$15.00	$20.00	$25.00
Purchase price ($)	(a)	29.50	34.50	39.50
" " ($)	(b)	37.00	46.00	55.00
" " ($)	(c)	54.50	72.00	89.50

These figures agree closely with those reported by Lattimore (43) and appear to reflect reasonably well, the impact of changing beef schedule on the market for replacement animals according to Watson (64), for the 1969/70 season. Adjustment may be required for particular circumstances in some seasons.

It will be seen later that these calculations have important implications in the programming matrix.

5.8 THE COSTS OF BEEF-PRODUCING ACTIVITIES

The inclusion of a "beef-selling" activity in the model allows an automatic adjustment to be made for any change in cost structure associated with change in beef schedule price. There are three costs which may be affected by the beef schedule price -

(a) the portion of replacement cost of beef animals as discussed in 5.7, which is directly related to beef schedule price;

(b) the interest charge is calculated on purchase price for the period the animal is on the farm. The interest cost on the dependent part of purchase price will thus be influenced by beef schedule price;

(c) the revenue loss due to mortalities is related to the beef schedule price at time of sale.

Any beef-producing activity earns income by making beef available for sale, at the schedule price of interest, through the beef-selling activity. Costs which vary with beef schedule price can therefore be simply represented by subtractions from the amount of beef made available for sale.

<u>Example</u>: A beast purchased as a weaner at 360 lb live-weight is held on the farm for 12 months and sold at a carcass weight of 400 lb. Deaths are estimated at four per cent of animals. The calculation would be as follows:-

(a) Carcass weight of live animals at the time of sale is 400 lb per beast.

(b) The portion of purchase cost of replacement which varies with beef schedule price is represented by 180 lb of meat 1/. (i)

(c) The interest rate on the variable portion of purchase cost is six per cent. The interest charge is therefore represented by -

$\left(\frac{6 \times 180}{100}\right) = 10.8$ lb meat (ii)

(d) Deaths are estimated at four per cent. The average amount of meat unavailable for sale, per animal is thus -

$\left(\frac{400 \times 4}{100}\right) = 16$ lb meat (iii)

(e) Total meat subtracted from carcass weight

180	(purchase)
10.8	(interest)
16	(deaths)
206.8 lb	

(f) Adjusted carcass weight for transfer to beef-selling activity -

400.0
- 206.8
193.2 lb

In this way, allowance has been made in the model for costs related to beef schedule price. Costs which are not influenced by beef schedule price, such as the independent part of purchase price, can simply be totalled and included as a fixed enterprise cost for each unti of activity, or each animal included in the farm plan. It should be noted that net carcass weight for

---

1/ This was discussed in 5.7. The 180 lb of meat subtracted has a value related to the beef schedule price of interest. This is the dependent portion of purchase price.

transfer to the beef-selling activity is calculated so as to represent revenue from meat sales after subtraction of those costs which vary with the beef schedule price. The net carcass weight is therefore not a measure of actual beef produced by the animal for sale. To arrive at actual physical meat production, subtractions to cover the variable portions of interest and purchase cost must be added back in.

The total costs of five beef-producing activities are presented in detail in Table 5.5. These are based on data gathered during discussion with farmers, except that in some instances figures particularly relevant to Case Farm 1 are noted.

The abbreviations in Table 5.5 are explained as follows:-

(a) Activity No. The activity number identifies each individual beef-producing activity or policy. Thus 14 units of P_4 in a farm plan represents the purchase of 14 beef animals in December to be grown at the "slow" growth rate for sale at 15 months of age in March at a live-weight of 840 lb.

(b) Bought: The date of purchase is stipulated and is taken at the first day of the month shown.

(c) Sold: The date of sale is also taken as the first day of the month shown. These sale dates are chosen as being representative of the time of the year when the farmer might consider sending beef animals for slaughter.

(d) Months On: The number of months spent on the farm by each animal is the time period between date of purchase and date of sale. This is the time period

Table 5.5

Details of Five Beef-Producing Activities

(a)	Activity No.	P_1	P_4	P_8	P_{10}	P_{15}
(b)	Bought	Dec.	Dec.	April	April	Dec.
(c)	Sold	Dec.	Mar.	Dec.	Feb.	Nov.
(d)	Months on	12	15	8	10	23
(e)	Age at Sale	15	18	15	17	26
(f)	Live-weight (purchase)	200	200	360	360	200
(g)	Live-weight (sale)	690	840	690	810	1140
(h)	Dressing-out %	46.9	48.4	46.9	48.1	51.4
(i)	Interest "rate"	6.0	7.5	4.0	5.0	11.5
(j)	Losses (%)	2.5	2.5	1.5	1.5	3.0
(k)	No. lice sprays	2	2	1	1	2
(l)	No. worm drenches	4	4	2	2	4
(m)	300 lb drench costs ($)	.72	.72	-	-	.72
(n)	500 lb drench costs ($)	1.20	1.20	1.20	1.20	1.20
(o)	Spray costs ($)	.50	.50	.25	.25	.50
(p)	Total veterinary ($)	2.42	2.42	1.45	1.45	2.42
(q)	Fixed interest cost ($)	.87	1.09	.40	.50	1.67
(r)	Fixed purchase cost ($)	14.50	14.50	10.00	10.00	14.50
(s)	Fixed Enterprise costs ($)	17.79	18.01	11.85	11.95	18.59
(t)	Meat loss (interest) (100's)	.06	.08	.07	.09	.12
(u)	Meat loss (purchase) (100's)	1.00	1.00	1.80	1.80	1.00
(v)	Meat loss (losses) (100's)	.08	.10	.05	.06	.18
(w)	Slaughter carcass wt. (100's)	3.24	4.07	3.24	3.90	5.86
(x)	Total meat loss (100's)	1.14	1.18	1.92	1.95	1.30
(y)	Net carcass wt. (100's)	2.10	2.89	1.32	1.95	4.56

over which feed is required and expenses are incurred by animals on the farm.

(e) Age at Sale: This is the total age, in months, of animals at time of slaughter. A birth date of 1st September is assumed for this estimate. For the purpose of this study however, animals are better described in terms of live-weight than age.

(f) Live-weight (purchase): Live-weight of animals at time of purchase is defined to enable calculation of purchase price and as a starting point for future growth on the farm. For weaners, live-weights of 200 lb at 12 weeks and 360 lb at 6 - 7 months are assumed. These are not suggested as being optimum weights and many farmers suggest that heavier weights are desirable. They are, however, the weights at which animals are usually offered for sale.

(g) Live-weight (sale): Live-weight at sale is the combined result of live-weight at purchase and weight gain on the farm. The growth pattern is described according to Fig. 5.1, and for any date of sale, a particular live-weight will have been reached.

(h) Dressing-out %: Dressing-out percentage is the percentage of an animal's live-weight which becomes saleable meat at time of slaughter. This percentage varies with live-weight, as described in Appendix 1.

(i) Interest "rate": This is the interest rate used to calculate the opportunity cost of capital invested in stock. An interest rate of six per cent per annum is used, adjusted on a monthly basis according to the time each animal spends on the farm, i.e. before purchase cost is recovered.

Thus activity P_1 which involves grazing animals on the farm for 12 months has an interest "rate" of six per cent, while animals which are present on the farm 15 months have an interest "rate" of 7½ per cent, charged on purchase price.

As purchase price is divided into an independent part and a part which varies with schedule price, it is considered in two parts under (q) and (t) in Table 5.5.

(j) Losses %: This is the percentage of animals lost by death for each activity during the period animals spend on the farm.

These estimates are based on farmer experience which has shown that most losses occur early in the animal's life. With P_1, for example, animals are purchased at 12 weeks of age and losses for the following 12 months on the farm are estimated to be 2.5%. For P_{15} animals are purchased at the same age but kept on the farm an additional 11 months and total losses are estimated at 3.0% of animals.

(k) No. Lice Sprays: The number of times animals are sprayed for external parasites is specified to enable calculation of veterinary costs. Animals on Case Farm 1, as on most farms encountered during farm visits, are sprayed in Dec./Jan. at 4 - 5 months of age and again 4 - 5 months later. Weaners purchased in December thus require two sprays while those purchased in April require one.

(l) <u>No. Worm Drenches</u>: This is the number of times animals would normally be drenched for internal parasites during their time on the farm. In some years considerably more drenching would be carried out, while in others fewer drenches would be required. The figures used however, are the usual drench requirements for this farm.

Two drenches per head are usually administered to weaners in the 3 - 6 months age range, with a further two after this time. It is not normal procedure to drench animals 18 months of age or over.

(m) <u>300 lb Drench Costs</u>: Drench costs are related to animal live-weight and using 1969/70 prices are estimated at 12 cents /100 lb live-weight. For weaners purchased in December the two drenches administered before April would be for a live-weight average of about 300 lb. Costs are therefore 36 cents/drench, or 72 cents for two, as shown for P_1.

(n) <u>500 lb Drench Costs</u>: These are included for animals drenched after April at an average live-weight of about 500 lb. Costs are therefore 60 cents/drench, or $1.20 for two as shown for P_1.

(o) <u>Spray Costs</u>: The cost of spraying for external parasites is estimated to be 25 cents/animal, again based on 1969/70 prices. Thus for P_1 which is sprayed twice, total cost is $0.50, while for P_8 which is purchased in April and only sprayed once the cost is \$0.25.

(p) Total Veterinary Costs: Total veterinary costs are derived from summation of spraying and drenching costs for each animal. From farmer experience on Case Farm 1 and discussions with other farmers, these two items represent almost the entire veterinary expenditure on beef animals.

(q) Fixed Interest Costs: This is the interest cost charged against the portion of purchase price, which is independent of schedule price for each enterprise. The interest "rate" used is that discussed under (i). Thus for P_1 the fixed portion of purchase price is \$14.50, the interest "rate" is six per cent and the fixed interest cost is \$0.87.

(r) Fixed Purchase Cost: Fixed purchase cost is the independent portion of an animal's purchase price which does not vary with beef schedule price, as discussed in 5.7.

(s) Total Fixed Enterprise Costs: Total fixed enterprise costs represent the summation of those costs incurred per animal, which are independent of schedule price, i.e. veterinary costs plus the independent part of interest and purchase costs.

(t) Meat Loss (interest): Takes account of the portion of interest cost which varies with schedule price, as discussed in 5.8.

(u) Meat Loss (purchase): Represents the variable portion of purchase price in terms of 100's lb. saleable meat, as outlined in 5.8.

(v) Meat Loss (losses): This figure represents carcass meat unavailable for sale through animal deaths, as discussed in 5.8. Thus for P_{15} with three per cent losses and carcass weight at slaughter of 586 lb, meat losses are (586 x 3/100), or, on average 18 lb of meat per animal.

(w) Slaughter Carcass Weight: This figure is simply derived from live-weight at slaughter (g), by the relevant dressing-out percentage, (h). This is the saleable meat available from each live animal at time of slaughter.

(x) Total Meat Loss: Total meat loss is the summation of (t), (u) and (v), and represents those costs which are related to schedule price for each beef animal on the farm.

(y) Net Carcass Weight: This figure is derived by subtracting total meat losses from the original carcass weight. Net carcass weight is calculated to represent revenue from meat sales after subtraction of those costs which vary with schedule price. To arrive at actual physical meat production (t) and (u), the meat subtractions to cover the dependent portion of purchase and interest costs must be added to net carcass weight.

5.9 THE BREEDING-EWE ACTIVITY

The main sheep enterprise on this property is represented by the breeding ewe activity, P_{36}. Each unit of sheep activity however, represents not only one breeding ewe but also its lamb and a proportion of a ram, and ewe replacement. The sheep activity on this farm represents a ewe flock producing wool and fat lambs for sale. Profitability could be increased by raising lambing percentage or wool production, which would not markedly increase feed consumption. Therefore, within reasonable limits the sheep returns can legitimately be varied without alteration to the feed requirements. In any event variation in sheep returns can be attributed largely to price fluctuations rather than increases or decreases in physical production. Since ewe replacements are reared on the farm, increased sheep returns would not mean increased replacement costs for this farmer.

The feed requirements for the sheep activity are those recommended by Coop (19). A breeding ewe with 120 per cent lambing consuming 890 lb D.O.M. annually as described by Coop will be assumed since these production figures agree closely with previous sheep performance on this farm. Feed requirements in the model thus become -

Spring	373 lb D.O.M.
Summer	162 lb D.O.M.
Autumn	145 lb D.O.M.
Winter	210 lb D.O.M.
Total	890 lb D.O.M.

The net revenue of the breeding-ewe enterprise P_{36}, has a value represented by a gross margin or "sheep price", as discussed in 5.2.3, for each breeding-ewe wintered.

5.10 THE CROPPING ACTIVITY

The crop which is considered for Case Farm 1 and represented by activity P_{45} is barley. Cash-crops can be considered to have a "feed requirement" since they make land unavailable for grass production. This requirement is from the time when land is first ploughed to the time when grass has been resown and is available for grazing.

For barley, land may be ploughed on 1st September with the crop being harvested the following January/February. Grass may be resown at the end of March and the farmer considers that new grass would produce 50 per cent of an established pasture for the winter following sowing. One acre of barley thus "consumes" the following proportions of grass normally produced by an acre in each season:-

Spring	100%	of	one	acre's	grass	production
Summer	100%	"	"	"	"	"
Autumn	75%	"	"	"	"	"
Winter	50%	"	"	"	"	"

Thus in the spring the barley crop makes one acre of land totally unavailable for grass production and subsequent stock consumption, while in the winter half of the normal production is available. The feed requirements for the model are calculated accordingly, e.g. Spring consumption is 100% of one acre. Each acre in the spring would normally produce 1980 lb D.O.M. One acre of crop thus has a spring "feed-requirement" of 19.8 feed units.

The net revenue for barley is estimated with all operations carried out on contract, since the farmer does not own the necessary machinery. Costs and yields are based on estimates by the farmer from experience gained by barley growers in the district.

cultivation and drilling	$ 8.00
seed (3 bushels at $1.50)	$ 4.50
fertilizer 1/	$ 2.50
weed spraying	$ 2.00
spray (army worm)	$ 1.50
harvesting	$ 8.00
sacks and twine	$ 1.50
freight	$ 5.50
cultivate and return to grass	$ 4.00
grass seed	$ 4.00
sundry	$ 0.50
	$42.00 per acre

For a crop of 80 bushels/acre which could be expected in this district the net revenue with a barley price of $0.95/ bushel would be $34.00/acre.

Apart from the barley-growing activity, P_{45}, no other cropping activity will be included in the model for Case Farm 1 as the farmer does not believe other cash-crops would be feasible and considers that fodder crops produce less feed than grass on this farm.

5.11 HAY AND SILAGE MAKING ACTIVITIES, P_{38} - P_{40}

In transferring feed from one season to another, there are three factors to be considered:

(a) the direct financial cost of conserving pasture and storing it;

1/ As the return from one acre of barley is calculated on an enterprise net revenue basis, only fertilizer requirements in excess of those for one acre of pasture are included in the costs.

(b) the depreciation in feeding value of conserved pasture;

(c) the feed "losses" involved, represented by the portion of pasture conserved which is lost for mechanical reasons during the conservation, storing, or feeding operations.

The two main costs are thus direct financial losses represented by (a) and conservation losses represented by (b) and (c). Each unit of feed conserved therefore involves a financial cost and results in less than one unit being available for subsequent feeding. In estimating these factors, figures used are those suggested by Walker (61).

1 lb average pasture (DM) 1/ = 0.62 lb D.O.M.

1 lb pasture hay (DM) = 0.46 to 0.60 lb D.O.M.

1 lb pasture silage (DM) = 0.46 to 0.65 lb D.O.M.

Because there are only small differences between the feeding value of hay and silage, an average from Walker's figures of

1 lb conserved pasture D.M. = 0.53 lb D.O.M. will be used for both hay and silage.

The analysis is based on units of D.O.M., and

1 lb D.O.M. = 1.62 lb pasture (D.M.)

∴ 1 lb D.O.M. (as pasture D.M.) supplies (1.62 x 0.53)
= 0.86 lb D.O.M. as hay or silage.

The depreciation in feeding value can therefore be estimated to be 14 per cent (1.00-0.86).

Other losses have been estimated at 30 per cent (47), so

1/ DM is an abbreviation for dry matter.

that conservation losses in total are 44 per cent. Each pound of D.O.M. as pasture conserved therefore results in o.56 lb of D.O.M. being available for subsequent feeding as hay or silage.

The costs of feed conservation are similar for hay or silage. These are calculated on the basis of each 100 lb of D.O.M. conserved.

100 lb D.O.M. (as pasture) = 56 lb D.O.M. (as hay)

≈ 106 lb DM (as hay)

and 106 lb D.M. (hay) would be equivalent to the material contained in two bales of hay. Costs of harvesting and baling are estimated at 20c/bale, and storage at 5c/bale. This gives a total cost of 50 cents for each 100 lb D.O.M. made available for hay or silage.

Summary: 100 lb D.O.M. as pasture supplies 56 lb of D.O.M. as hay or silage at a cost of $0.50. Each unit of hay or silage making activity represents the conservation of approximately two bales of hay.

In the model, all hay or silage making activities supply feed in the winter. For example, activity P_{38} takes one unit of feed from the spring and supplies 0.56 units to the winter at a cost, as denoted by a negative value or income, of $0.50. In the same way activities P_{39} and P_{40} remove feed from the summer and autumn respectively for subsequent feeding in the winter.

5.12 THE AUTUMN-SAVED PASTURE ACTIVITY, P_{37}

Included in the programme is an activity which allows feed to be transferred from autumn to winter. Since no cost is involved in this transfer, winter feed can never have a greater imputed [1] value than autumn feed.

If excessive feed transfer from autumn to winter had been included in any computed farm plan, a restraint could have been imposed to ensure that the transfer was kept to levels practical on the farm. In no case, however, was more than one-third of the autumn feed-supply carried into the winter. Since a three-month season is involved, this implies that pasture need only have been saved for up to a month for subsequent feeding. As Brougham (11) recommends a 60-day grazing rotation on the farm during autumn, the feed transfer which occurred would be consistent with a grazing management system designed for optimum pasture production.

5.13 FEED-BUYING ACTIVITIES, $P_{41} - P_{44}$.

Activities which allow feed-grain to be purchased in any season are included in the model. As each unit of feed represents 100 lb D.O.M. costs will be calculated on this basis.

The farmer could have purchased barley-meal at $60 per 2000 lb in the 1969/70 season, and again using figures supplied by Walker (61) this becomes 4.5 cents per lb D.O.M. or $4.50 per feed unit as used in the model. The purchase of feed is entirely related to price, so that barley meal is used which is considered by Walker to be the cheapest source of D.O.M. No losses during feeding are considered, since farmer experience has shown that losses are negligible with careful feeding.

1/ Imputed value is the "shadow price" of a limiting resource. For any farm plan, the price which could be paid for an additional unit of a scarce resource is calculated. This is its imputed value for that plan with a given cost and price structure.

P_{41} supplies one unit of feed in the spring at a cost of \$4.50, and P_{42} to P_{44} are the activities which enable feed to be supplied in summer, autumn and winter respectively, at the same cost.

5.14 FEED-SELLING OR LAMB FATTENING ACTIVITIES

The purchase of store lambs in December or January to be sold fat two or three months later is a feasible enterprise on this farm. The farmer has in past years, elected to carry his own lambs to heavier weights and thus avoid the vagaries of the store market. This policy has additional flexibility in that his own lambs are more readily saleable if a dry summer should ensue.

Any surplus autumn or summer feed may be used to fatten lambs, or make hay for sale. The choice will depend on current markets.

5.14.1 Lamb Fattening

The feed required to fatten store lambs depends on the time for which the animals are on the farm, and the weight-gains achieved. Joyce (37) has estimated the feed requirements of a lamb growing between 50 and 70 lb to be 1.8 lb D.O.M./day.

The farmer estimates that over a three-month period he could expect a return of between \$1.40 and \$1.50 per lamb purchased after subtraction of direct costs.

Over a 90 day period a lamb growing between 50 and 70 lb live-weight would consume 162 lb D.O.M. If the net revenue is estimated at \$1.45/lamb the farmer is receiving 0.9 cents/lb D.O.M., which becomes \$0.90/feed unit.

5.14.2 Hay-Selling

It was previously estimated that the production of two bales of hay require 100 lb of D.O.M. or one feed-unit as pasture D.O.M. Hay-making costs are estimated by the farmer to be 20 cents per bale, and hay could usually be sold for 75 cents per bale.

Some fertility loss is associated with hay-selling and a cost of 10 cents per bale[1/] is included so that fertility levels may be maintained.

hay-making costs	20c/bale
fertility loss	10c/bale
hay sold for	75c/bale
net return per bale	45 cents

In this way the supply of 100 lb D.O.M., or one feed-unit, makes available for sale two bales of hay with a total net return of $0.90 per 100 lb D.O.M.

5.14.3 Summary

At the costs and prices assumed, returns from lamb fattening and hay-selling are the same, using a feed-unit basis. The farmer's choice would depend on relative prices for the two in any one season. There is no point in differentiating between the use of surplus feed for lamb fattening or hay-selling, and for the rest of this thesis activities P_{46} and P_{47} will simply be referred to

1/ It is normal farming practice to apply 2 - 3 cwt. of potassic super to an area after removal of a hay crop. This would cost about $6.00 per acre applied and assuming a crop of 60 bales/acre, fertility replacement becomes 10 cents per bale.

as feed-selling activities. One unit of activity P_{46} makes 100 lb D.O.M. available for hay-selling or lamb fattening in the summer, while a unit of activity P_{47} makes the same amount available for sale in the autumn, both with a net return of $0.90/feed unit.

5.15 SUMMARY

Case Farm 1 has been described, together with the alternatives to the farmer which include fat lamb farming, beef-production and barley growing.

The real restraint to any enterprise chosen is feed supply, and figures for this are derived in part from previous stock performance on the farm and in part from harvesting measurements made by the Department of Agriculture at Flock House.

The input/output coefficients and costs associated with possible farm enterprises are typical of those encountered during discussions with farmers, and figures are derived for these accordingly.

The parametric beef-selling activity allows the impact of changing beef schedule prices to be examined. To do this, cognisance must be taken of those costs which are related to beef schedule price. In particular, the purchase price of replacement beef animals is found to vary with beef schedule price and a method of incorporating this relationship into the model is described.

The parametric linear programming model as used for Case Farm 1 is presented and each activity is discussed. The model is not complex and illustrates the fact that optimum farm plans can be derived from a wide range of possible enterprises at various product prices of interest without undue computational burden.

CHAPTER SIX

CASE FARM RESULTS

6.1 INTRODUCTION

In this chapter the results of a linear programming analysis applied to the Case Farms are presented. The model presented in Chapter Five is applied to Case Farm 1, and Case Farm 11 is described together with alterations made to the Case Farm 1 model so that it can be applied to Case Farm 11.

For both Case Farms, breeding-ewes are compared to both "slow" and "fast" growth-rate beef animals, and results are presented in the form of Price Maps. For Case Farm 1, the effect of reduced summer or autumn feed supply is examined.

6.2 GENERAL COMMENTS ON PRESENTATION OF RESULTS

Since the models are almost identical for both Case Farms, activity numbers will represent the same farm enterprise for both unless otherwise stated.

The models presented in both cases include both "fast" and "slow" growth-rate beef animals as defined previously although for Case Farm 11 "fast" growth rates will not be the same as for Case Farm 1. To examine possible farm systems with only "slow" growth-rate beef animals, "fast" growth-rates, i.e. activities P_{19} - P_{34}, are simply excluded from the model. When "fast" growth-rates are examined, "slow" growth-rates are left in the model to enable comparison, but as will become evident, only "fast" growth-rate animals are selected.

In presenting results, it should be noted that activity levels have been rounded to the nearest digit, since the purchase or sale of fractions of any animal is obviously impractical. The rounding errors involved are small since in no case does the introduction of activity levels at low levels become critical such as would be the case for example with employment of labour units. Integer Restraints (26) could be imposed in any analysis where the introduction of activities at low levels became critical.

6.3 THE RESULTS FOR CASE FARM 1

The results with two possible levels of beef-cattle performances are presented separately.

6.3.1 "Slow" Growth Rates

The Price Map for "slow" growth-rate beef animals is presented in Fig. 6.1 and the activity levels for each farm plan represented are given in Table 6.1. A sheep and beef price, together with the total enterprise net revenue[1/] or value to the farm at these prices is also given for each farm plan. It should be apparent from Fig. 6.1 however, that these price combinations are only examples of the many price combinations which are defined by one farm plan[2/]. Similarly, the revenue stated is only relevant to the particular combination of prices associated with it.

1/ See 5.3.2 for a definition of net revenue. The "Value" in this context is synonomous with total enterprise net revenue.

2/ In all tables which are presented, the highest beef price quoted is taken from a farm plan which is optimum for beef prices up to $30.00. In Table 6.1 for example, a beef price of $27.2 is quoted for plan 12 and this plan is optimum for beef prices up to $30.00.

FIGURE 6.1

PRICE MAP FOR "SLOW" GROWING BEEF ANIMALS, CASE FARM L.

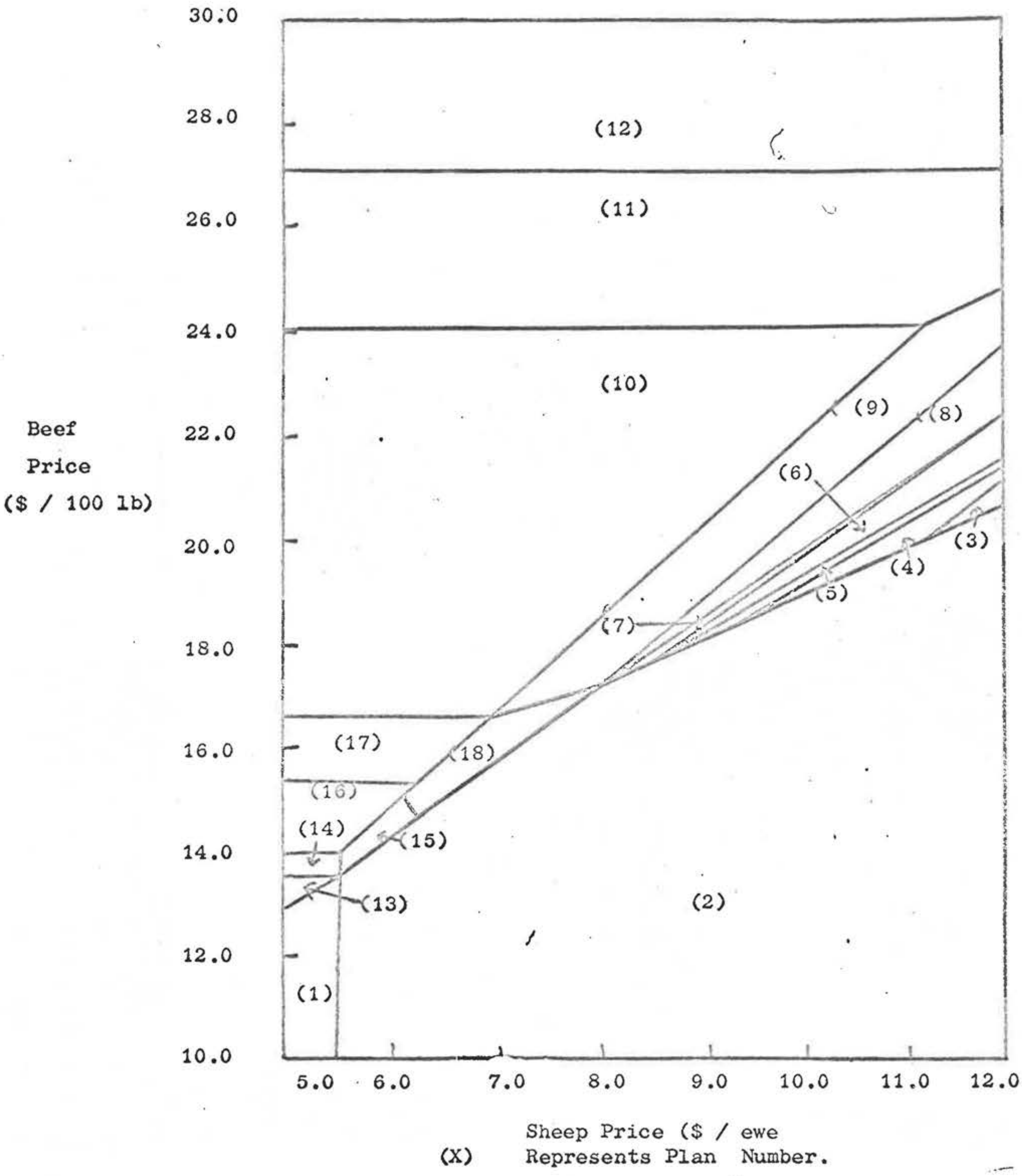


Table 6.1

Activity Levels for Farm Plans in Figure 6.1

PLAN NUMBER	BEEF PRICE ($)	SHEEP PRICE ($)	PLAN VALUE ($)	ACTIVITY LEVELS P1	P3	P4	P6	P7	P15	P16	P18	P35	P36	P37	P38	P45	P46	P47
1	10.0	5.0	9450	-	-	-	-	-	-	-	-	-	435	-	-	154	655	1615
2	10.5	9.0	14163	-	-	-	-	-	-	-	-	-	1252	1269	-	-	1902	1315
3	20.5	11.5	17329	-	-	-	145	-	-	-	-	466	878	1312	-	-	344	-
4	20.1	11.0	16704	-	-	43	134	-	-	-	-	555	796	1322	-	-	-	-
5	20.5	11.0	16926	-	71	-	127	-	-	-	-	603	741	1328	-	-	-	-
6	20.7	11.0	17051	-	141	-	-	78	-	-	-	650	687	1334	-	-	-	744
7	18.3	9.0	14174	-	253	-	-	-	-	-	-	689	602	1344	-	-	-	-
8	18.7	9.0	14456	-	202	-	-	-	58	-	-	816	434	1681	-	-	-	-
9	18.9	9.0	14620	-	203	-	-	-	-	81	-	944	214	1618	-	-	-	-
10	16.6	5.0	11936	-	196	-	-	-	-	110	-	1063	-	1506	188	-	-	-
11	24.1	5.0	19960	161	219	-	-	-	-	43	-	1143	-	1535	-	-	-	-
12	27.2	5.0	23507	220	225	-	-	-	21	-	-	1171	-	1527	-	-	-	-
13	12.8	5.0	9452	-	-	-	-	-	-	-	50	202	-	-	-	176	474	1212
14	13.7	5.0	9634	-	-	-	-	-	-	-	159	637	-	1456	-	46	1514	-
15	13.9	5.5	9824	-	-	-	-	-	-	-	149	596	-	1798	-	-	1886	-
16	14.0	5.0	9860	-	-	-	-	-	-	-	187	752	-	1682	227	-	1980	-
17	15.3	5.0	10842	-	-	-	-	-	-	181	-	869	-	1474	390	-	1239	-
18	15.3	6.5	11045	-	-	-	-	-	-	125	-	600	-	1713	-	-	1327	-

While any farm plan is stable, or optimum, over a range of beef and sheep prices, income will increase within the plan boundary as price increases for any activity included in that plan. Thus while net revenue increases with increasing prices, optimum plans change abruptly at the sheep and beef price combinations represented by plan boundaries shown in Fig. 6.1.

The farm plans for "slow" growth-rate beef animals are summarised in Table 6.2, where enterprises have been combined and "1 yr weaners" represent animals purchased as weaners at 12 weeks to be sold before their second winter, while "2 yr weaners" represent animals purchased at 12 weeks or 6 - 7 months of age and kept on the farm for a second winter, to be sold at approximately two years of age.

If the Price Map given in Fig. 6.1 is now divided into five major areas, Fig. 6.2 results, and the five areas may be described as follows:-

(A) An area including plans 1, 13 and 14 where barley is grown as a major farm enterprise.

(B) An all-sheep area represented by plan 2.

(C) An area of mixed sheep and beef enterprises represented by plans 3 to 9 inclusive.

(D) An all-beef area of predominantly 2-year cattle represented by plans 15, 16, 17 and 18.

(E) An area represented by plans 10, 11 and 12 which is all beef and predominantly 1 year cattle.

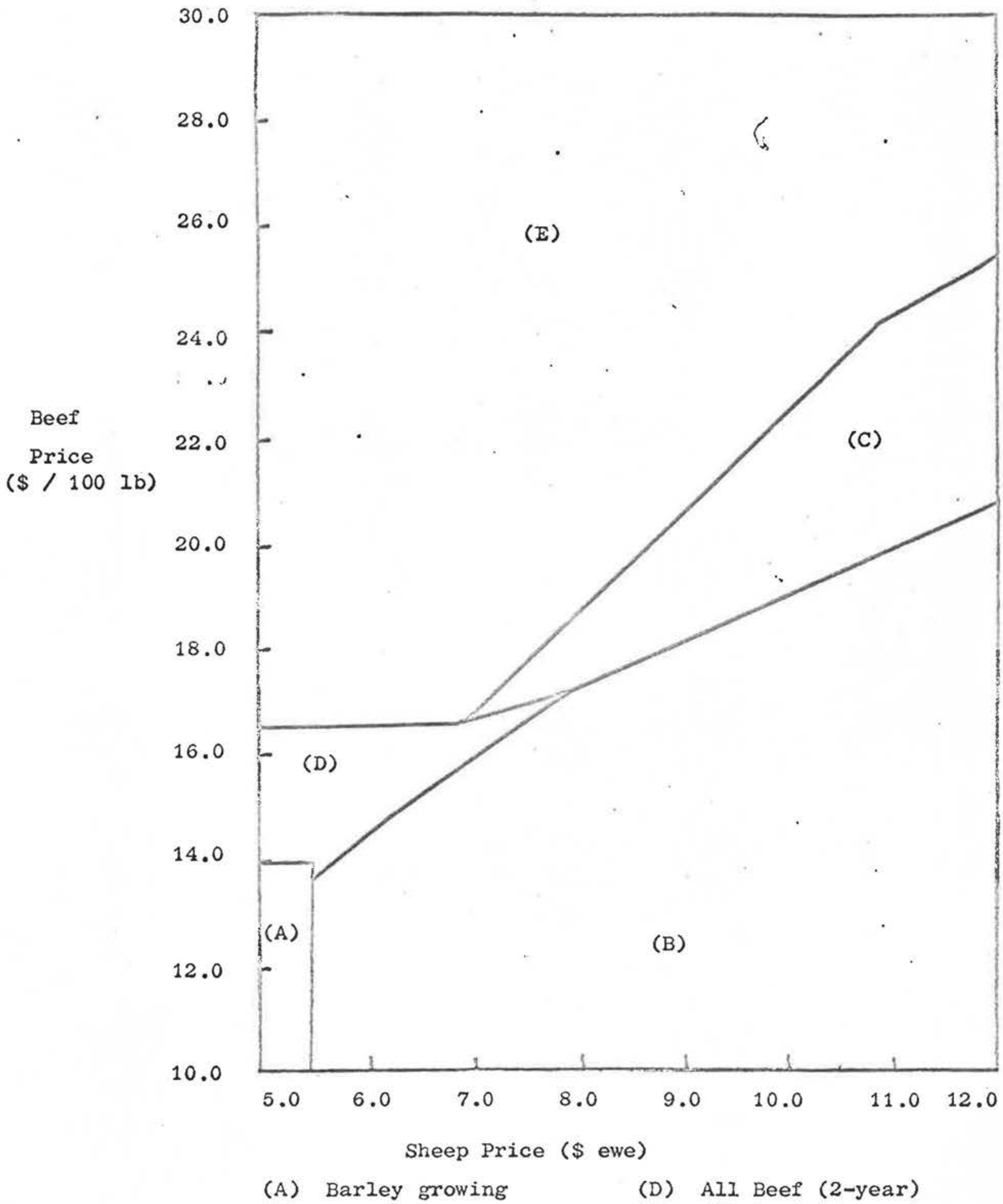
Table 6.2

Summarised Farm Plans With "Slow" Growing Beef Animals, Case Farm 1

Plan No.	Ewe Flock	1 Yr Weaners	2 Yr Weaners	Crop (acres)	Feed Sold (100 lb D.O.M.)
1	435	-	-	154	2270
2	1252	-	-	-	3217
3	878	145	-	-	344
4	796	177	-	-	-
5	741	198	-	-	-
6	687	141	-	-	-
7	602	253	-	-	744
8	434	202	58	-	-
9	214	203	81	-	-
10	-	196	110	-	-
11	-	380	43	-	-
12	-	445	21	-	-
13	-	-	50	176	1686
14	-	-	159	46	1514
15	-	-	149	-	1886
16	-	-	187	-	1980
17	-	-	181	-	1239
18	-	-	125	-	1327

FIGURE 6.2

SIMPLIFIED PRICE MAP FOR "SLOW" GROWING BEEF ANIMALS, CASE FARM I.



(A) Barley growing
(B) Breeding ewes
(C) Mixed sheep and Beef
(D) All Beef (2-year)
(E) All Beef (1-year)

Within the Price Map, several trends, rather than abrupt and major policy changes over small price changes may be noted.

(a) With beef prices below $12.80 per 100 lbs, no beef activities enter the final plan. As the sheep price increases, there is a trend from an essentially cropping system to an all-sheep system. No crop enters the farm plan above a sheep price of $5.30 per ewe.

With sheep prices below $5.30 per ewe, a similar trend exists from cropping to all-beef policies as beef price increases. With a sheep price of $5.00, cropping is finally excluded and an all-beef plan is reached with a beef price of $14.00.

Area (A) in Fig. 6.2 thus represents a cropping policy which would be the most profitable set of alternatives available on Case Farm 1 at both low sheep and beef prices. If the beef price is held constant and sheep price increases the trend is from cropping to an all-sheep system, while at low sheep prices increasing beef price gives a trend toward an all-beef system.

(b) The second trend of interest is the replacement of 2 yr cattle with 1 yr cattle as beef price increases. If all-beef plans are ranked in order of ascending beef price at which each becomes optimum, Table 6.3 results. The trend, within all-beef policies, is toward sale of animals at a younger age as the beef price increases.

Table 6.3

The Replacement of 2 Yr With 1 Yr Beef Animals as Beef Price Increases.

Plan No.	Beef Price ($)	2 Yr Weaners	1 Yr Weaners
15	13.6	149	-
16	14.0	187	-
18	14.8	125	-
17	15.3	181	-
10	16.6	110	196
11	24.1	43	380
12	27.2	21	445

(c) A third trend which may be noted at sheep prices of $8.00 and above, is the gradual replacement of sheep with beef as beef price increases. If a fixed sheep price of $10.00 is taken for example, the following plans become optimum as the beef price increases. The beef prices shown are those at which a plan just becomes optimum at a $10.00 sheep price.

Table 6.4

The Replacement of Sheep With Beef Animals as Beef Price Increases (Sheep Price $10.00)

Plan No.	Beef Price	No.Ewes	1 Yr Wnrs	2 Yr Wnrs
2	10.0	1252	-	-
4	19.0	796	177	-
5	19.2	741	198	-
6	19.4	687	141	-
7	19.7	602	253	-
8	20.0	434	202	58
9	20.7	214	203	81
10	22.3	-	196	110
11	24.1	-	380	43
12	27.2	-	445	21

To some extent, the trend discussed in (b) where 2 yr cattle tend to be replaced by 1 yr cattle as beef price increases, is also apparent as beef replace sheep activities.

(d) A fourth trend noted from Table 6.1 is that as the beef price increases, a reduction in feed-selling, or lamb fattening activities is noted. Finally, with all-beef plans 10, 11 and 12, no feed-selling activity is included in the optimum plan.

(e) As sheep are replaced by beef activities with increasing beef price, the trend is toward sale of 1 yr cattle at an earlier date. In no case are weaners purchased in April for sale before their second winter, all purchases for these animals being made in December.

For plans 3 - 12 the following sale dates are chosen for animals purchased in December and sold before their second winter.

Table 6.5
The Sale Dates of Beef Animals Purchased as Weaners in December.

Plan No.	Ewe No.	Dec.	Feb.	Mar.	May	June
3	878	-	-	-	145	-
4	796	-	-	43	134	-
5	741	-	75	-	127	-
6	687	-	141	-	-	78
7	602	-	253	-	-	-
8	434	-	202	-	-	-
9	214	-	203	-	-	-
10	-	-	196	-	-	-
11	-	161	219	-	-	-
12	-	220	225	-	-	-

6.3.2 "Fast" Growth Rates

The linear programming analysis was repeated for Case Farm 1, this time with the inclusion of "fast" growth-rate beef activities P_{19} - P_{34}. The model in all other respects is identical to that used for "slow" growth rates.

The results are again presented in the form of a Price Map as shown in Fig. 6.3, and activity levels for each plan within the map are shown in Table 6.6. The price map can be divided into four main areas as shown in Fig. 6.4, and each area described as follows:-

(A) An area including plans 1 and 8 where cropping is the major farm activity.

(B) An all-sheep area represented by plan 2.

(C) An area of mixed sheep and beef activities represented by plans 3, 4 and 5.

(D) An all-beef area represented by plans 9, 10, 11, 12, 6 and 7.

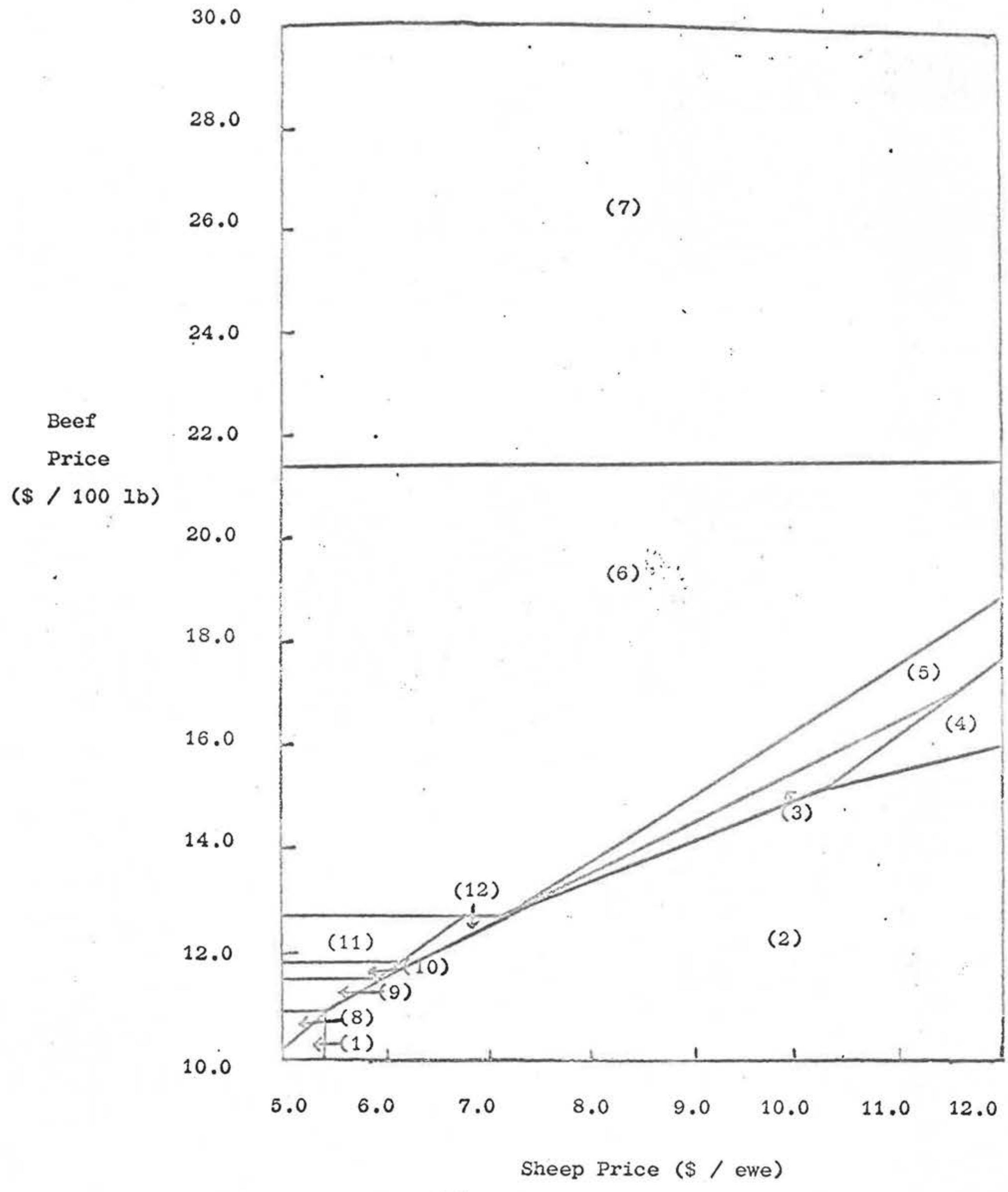
It may be noted that plans 1 ans 2 in Fig. 6.1 are identical with those in Fig. 6.3. This is because plans 1 and 2 do not include any beef activities and therefore have not been influenced by the changes made in the model. However, the area over which each of these plans is optimum is very much reduced with the inclusion of "fast" growth rates.

Again, there are several trends of interest which may be noted as follows:-

(a) At low sheep and beef prices the optimum farm plan is almost wholly barley growing. At an \$11.00 beef-

FIGURE 6.3

PRICE MAP FOR "FAST" GROWING BEEF ANIMALS, CASE FARM I.



(X) Represents Plan Number.

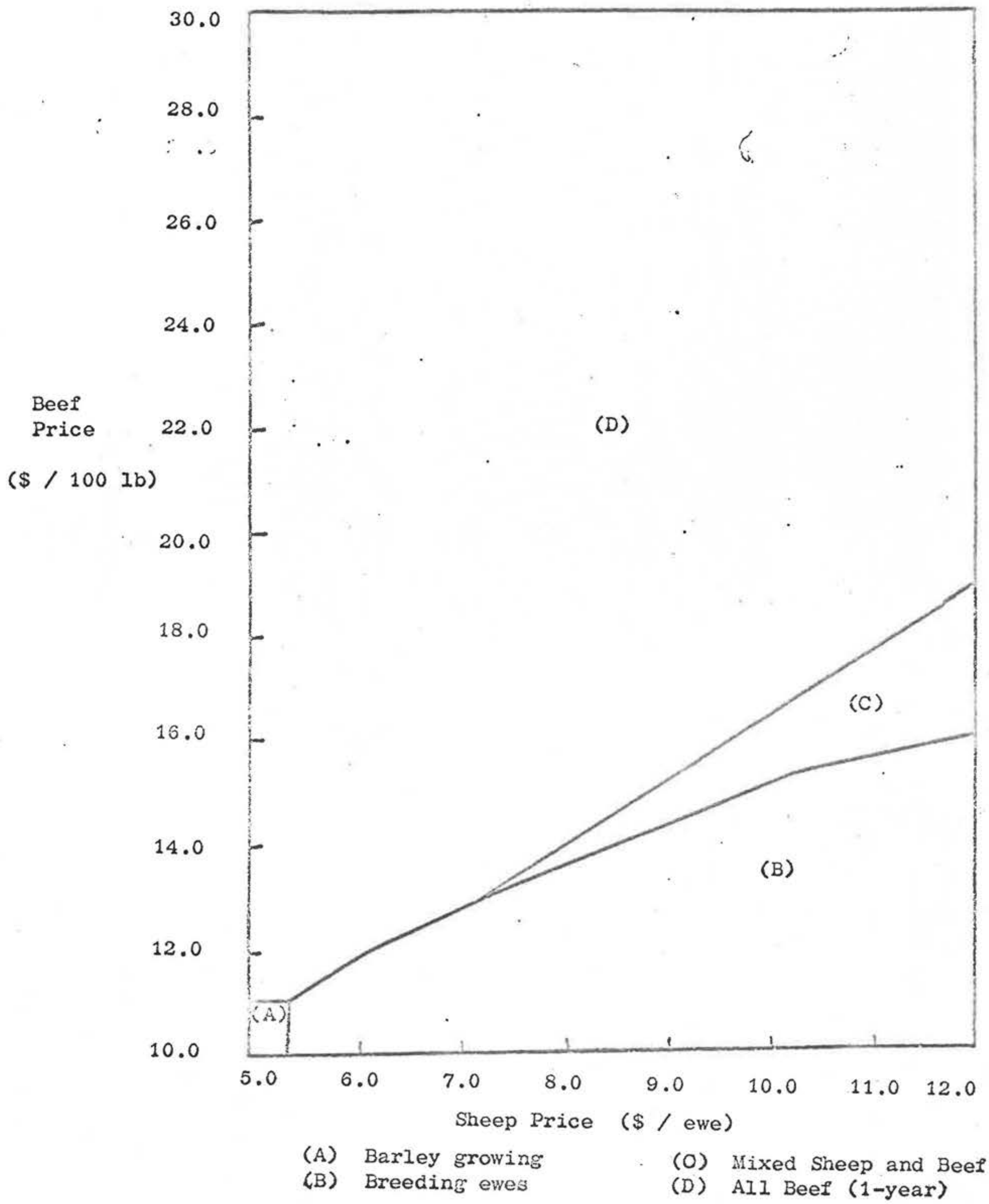
Table 6.6

Activity Levels for Farm Plans in Figure 6.3

Plan Number	Beef Price ($)	Sheep Price ($)	Plan Value ($)	ACTIVITY LEVELS											
				P21	P25	P26	P27	P29	P31	P35	P36	P37	P45	P46	P47
1	10.0	5.2	9,538	-	-	-	-	-	-	-	435	-	154	655	1615
2	10.0	5.9	10,282	-	-	-	-	-	-	-	1252	1269	-	1902	1315
3	15.0	9.5	14,978	-	-	-	-	-	102	437	913	1526	-	1084	-
4	16.0	11.0	16,814	-	64	-	-	-	-	347	1040	1430	-	1103	-
5	15.1	9.5	15,039	-	-	-	-	173	64	894	463	1867	-	-	-
6	12.8	5.0	11,839	-	-	-	123	228	26	1277	-	2218	-	-	-
7	21.5	5.0	22,952	125	-	-	120	132	-	1312	-	2218	-	-	-
8	10.2	5.0	9,472	-	-	88	-	-	-	223	-		181	911	1421
9	10.9	5.0	9,695	-	-	377	-	-	-	953	-	2218	-	-	261
10	11.6	5.0	10,371	-	-	-	377	-	-	1081	-	2218	-	-	261
11	11.9	5.0	10,706	-	-	-	123	254	-	1259	-	2218	-	-	261
12	12.2	6.5	11,084	-	-	-	-	237	-	847	-	1867	-	-	651

FIGURE 6.4

SIMPLIFIED PRICE MAP FOR "FAST" GROWING BEEF ANIMALS, CASE FARM I.



schedule barley is replaced with an all-beef system, while at schedules below this barley is replaced by an all-sheep system at a sheep price of $5.30. The trend is thus similar for "slow" growth rate cattle except that transition to an all-beef plan takes place at lower beef prices, and the all-beef plan reached at this point is not "2 yr" cattle but "1 yr" cattle.

(b) If plans 9, 10, 11, 6 and 7 are considered in order of ascending beef price at which each becomes optimum with a static sheep price of $5.00, a pattern emerges as shown in Table 6.7.

Table 6.7

Plan Changes With Increasing Beef Price (Sheep Price $5.00)

Plan No.	Beef Price	April Wnrs	Dec. Wnrs	Feed Sold (100's lb D.O.M.
9	10.9	377	-	4191
10	11.6	377	-	2572
11	11.9	377	-	261
6	12.8	377	-	-
7	21.5	252	135	-

In all cases, the same number of weaners are purchased. The trend, however, is toward holding animals on the farm for a longer period at the expense of feed-selling. This trend is highlighted if the buying and selling dates for each activity are listed as in Table 6.8.

Table 6.8

The Purchase and Sale Dates of Beef Animals as Beef Price Increases (Sheep Price $5.00)

Plan No.	Dec-Feb.	April-Dec.	April-Jan.	April-March
9	-	377	-	-
10	-	-	377	-
11	-	-	123	254
6	-	-	123	228
7	125	-	120	132

The first month mentioned denotes purchase date, and the second denotes sale date, e.g. Dec-Feb. means animals purchased on 1st Dec. for sale on 1st Feb.

With an increasing beef price, there are few major changes in the optimum beef policy. Animals are simply held longer to utilise feed previously sold at low beef prices.

(c) At high sheep prices, there is a trend towards replacement of sheep with beef animals as beef price increases. If a fixed sheep price of $11.00 is taken, and plans ranked in order of ascending beef price at which each becomes optimum, a pattern emerges as shown in Table 6.9.

Table 6.9

The Replacement of Sheep With Beef Animals as Beef Price Increases (Sheep Price $11.00)

Plan No.	Beef Price ($)	Ewe Nos.	Dec. Wnrs	April Wnrs	Feed Sold (100's lb D.O.M.)
2	10.00	1252	-	-	3217
4	15.60	1040	64	-	1103
3	16.20	913	-	102	1084
5	16.60	463	-	237	-
6	17.60	-	-	377	-
7	21.50	-	125	252	-

With increasing beef price, the trend is toward reduction in ewe numbers and feed-selling, with an all-beef plan becoming optimum at $17.60 at an $11.00 sheep price. It is also of interest to note the pattern of sale of beef animals as numbers increase, as shown in Table 6.10.

Table 6.10

The Pattern of Sale of Beef Animals as Beef Numbers Increase

Plan No.	Dec/Feb.	Dec/June	April/Jan.	April/March	April/May
2	-	-	-	-	-
4	-	64	-	-	-
3	-	-	-	-	102
5	-	-	-	173	64
6	-	-	123	228	-
7	125	-	120	132	-

With an increase in beef numbers and increasing beef price, the trend is toward sale of animals at a younger age. Thus in plan 4, all animals are sold on the 1st of June, while with plan 7 selling commences on the 1st of January and animals are all sold by the 1st of March.

6.3.3 Reduced Summer and Autumn Feed-Supply

To examine the impact of reduced summer or autumn feed-supply on the optimum plan, two traverses were taken with a fixed sheep price of $8.00, and with the following alterations made to the model:-

(a) A 30 per cent drop in autumn feed-supply to simulate an summer drought.

(b) A 30 per cent drop in autumn feed-supply to simulate an autumn drought.

From pasture-harvesting measurements taken at Flock House (3), it would seem that a reduction in feed-supply of this order occurs about one year in five, and may occur either in the summer or autumn.

6.3.3.1 Summer Drought

With a sheep price of $8.00 the optimum plans as presented in Table 6.11 were obtained.

Table 6.11

Farm Plans with "Fast" Growing Beef Animals and "Summer Drought" Conditions

Beef Price ($)	Sheep Price ($)	Value ($)	P_{21}	P_{26}	P_{27}	P_{29}	P_{31}	P_{32}	P_{35}	P_{36}	P_{37}	P_{46}	P_{47}
10.0	8.0	11876	-	-	-	-	-	-	-	1252	2369	725	1315
13.5	8.0	11894	-	-	-	-	94	-	402	940	1505	-	106
13.8	8.0	12035	-	-	-	-	75	19	409	940	1505	-	-
13.9	8.0	12079	-	9	-	-	100	-	452	889	1544	-	-
14.1	8.0	12146	-	249	102	-	26	-	1189	-	2218	-	-
21.5	8.0	21063	125	-	246	6	-	-	1223	-	2218	-	-

The optimum plans may be summarised as in Table 6.12.

Table 6.12

Summarised Farm Plans With "Summer Drought" Conditions

Beef Price ($)	Ewe Flock	Dec. Wnrs	April Wnrs	Feed Sold (100's lb D.O.M.
10.0	1252	-	-	2040
13.5	940	-	94	106
13.8	940	-	75	-
13.9	889	-	109	-
14.1	-	-	377	-
21.5	-	125	252	-

These results must be compared with a similar traverse taken through the price map (Fig.6.3) which includes "fast" growth-rates, again at a sheep price of $8.00. The results for a "normal" year's pasture production are as shown in Table 6.13.

Table 6.13

Farm Plans with "Fast" Growing Beef Animals and "Normal" Pasture Availability

Beef Price ($)	Plan No.	Ewe Flock	Dec.Wnrs	April Wnrs	Feed Sold (100's lb D.O.M.)
10.0	2	1252	-	-	3217
13.4	3	913	-	102	1084
13.6	5	463	-	237	-
13.8	6	-	-	377	-
21.5	7	-	125	252	-

The major changes with a 30 per cent reduction in summer feed-supply are:-

(a) a reduced sale of summer feed;

(b) a slightly higher ($0.20) beef price at which sheep are finally excluded from the optimum plan;

(c) the earlier sale of some cattle. If plan 7 from Fig. 6.3 is compared with the optimum plan for beef prices over $21.50 in Table 6.13, i.e. over the same range of beef prices, it can be seen that 126 animals previously sold in March are sold in January, under "summer drought" conditions;

(d) at a beef price of $21.50, there is a reduction of $1,889.00 in farm income, when comparison is made at the same beef price with a normal season's pasture production.

6.3.3.2 Autumn Drought

Results obtained with a 30 per cent reduction in autumn feed-supply are presented in Table 6.14.

Table 6.14

Optimum Farm Plans With "Autumn Drought"

Beef Price ($)	Sheep Price ($)	Value ($)	P_{27}	P_{29}	P_{35}	P_{36}	P_{37}	P_{38}	P_{46}
10.0	8.0	11721	-	-	-	1251	1266	3	1903
14.1	8.0	11768	-	264	942	243	1382	492	-
14.4	8.0	12098	50	277	1134	-	1410	609	-

These can be compared with optimum plans shown in Fig. 6.3 and described in Table 6.6 for a normal pattern of pasture production, and the following differences are noted:-

(a) Sheep are excluded at a higher beef price ($2.05).

(b) The sale of feed is much reduced.

(c) No weaners are purchased in December at beef prices above $21.50 as is the case with plan 7 in Fig. 6.3. Instead, all animals are purchased as weaners in April, and 327 in total are purchased, compared with 377 for a normal season's pasture availability.

(d) A reduction in autumn feed-supply has a greater impact on farm revenue than a similar reduction in summer feed-supply. For example, if revenue is compared at a beef price of $14.10 in Table 6.11

with that shown at the same beef price in Table 6.14, an additional $378.00 in farm income has been lost because of the feed reduction.

6.4 COMMENTS ON RESULTS FOR CASE FARM 1

As was mentioned in Chapter 5, this farmer has experienced sheep prices of the order of $8.00 - $9.00 in the past, and these prices could reasonably be used as a basis for making profitability comparisons.

If "slow" growth-rates describe future beef-animal performance, a beef price of $20.00 is required for all-beef farming to become more profitable than having some sheep. However, some sheep could profitably be replaced with beef animals at beef prices above $18.00. The farmer has demonstrated however, that "fast" growth rates on this farm are possible, and the beef price at which sheep are replaced by beef animals is thus reduced.

For sheep prices of $8.00 - $9.00, and "fast" growth rates, some beef animals could profitably replace sheep at a beef price of $13.00, and the most profitable plan is all beef at beef prices above $15.00.

Cropping is unlikely to be of interest to the farmer since it is included only in those plans where both sheep and beef prices are below those which have been experienced, and those which could reasonably be expected.

The farmer was asked to comment on the results and considered that all plans were feasible. The farm plan which he hopes to achieve is plan 7 in Fig. 6.3 since he believes that at reasonable beef prices this is, in fact, the most profitable combination of alternatives.

The trends through both price maps, i.e. Figs. 6.1 and 6.3, can be accounted for almost wholly by the increasing value of beef relative to other costs and prices. This has the following effects:-

(a) Sheep, cropping, and feed-selling activities become relatively less profitable.

(b) The cost of replacement beef animals, which is only partly dependent on beef price, becomes relatively less important as beef price increases. There is thus a tendency with increasing beef price to have animals on the farm only over that period when they are growing fastest. At high beef prices no animals are kept on the farm for a second winter, and progressively fewer are kept through a second autumn.

Animal performance can also have a significant effect on profitability. Total enterprise net revenue to the farm is $22,952.00 with plan 7 in Fig. 6.3 with fast growth-rates for beef animals at a $21.50 beef price. However, if this same beef price is imposed on a similar all-beef plan with slow growth-rates, e.g. plan 12 in Fig. 6.1, a net revenue of only $16,832.00 is obtained. In this case, increased growth-rates have given rise to an additional $6,120.00 in net income. This sum amounts to approximately $25.00 per acre, which indicates that animal performance, in terms of growth-rate, can have a marked effect on profitability to the farmer[1/].

In practice, the farmer increases growth-rates by giving his

1/ See Chapter 7 for more detailed revenue comparisons.

available feed-supply to fewer animals. For example, plan 7 with fast growth-rates requires the purchase of 377 beef weaners, while plan 12 with slow growth-rates requires 466 beef weaners to be purchased. To achieve fast growth rates, the farmer must therefore lower his stocking rate from approximately two beasts per acre to one and one-half beasts per acre. From results obtained in the analysis, this reduction in stocking rate could lead to an increase in return to the farm of $25.00 per acre.

It is also interesting to note the impact animal performance can have on the relative profitability of beef production. The effect is similar to that for increasing beef price, and effectively reduces the beef price required for beef animals to replace all sheep, by approximately $5.00. Since "fast" growth animals produce more beef than "slow", they are also able to recover their purchase price and return a profit at a lower age than for "slow" growing animals. No 2 yr animals are included in an optimum plan where "fast" growth-rates are included in the model.

6.5 CASE FARM 11

The farm has a grazeable area of 480 acres of Marton Clay Loam. The soil is naturally fertile and well suited to cash cropping, while the contour is flat to rolling. Wintering of cattle can become a problem due to the heavy nature of the soil. The farm is well subdivided with a good water supply.

The farmer is a very competent stockman and keeps detailed records of all farm activities. His interest in beef production stems from a wish to reduce the labour requirement on this farm. To this end, he is increasing beef numbers at the expense of his ewe flock.

At present, his stocking rate on this farm is 7.5 Ewe Equivalents per acre, made up of 3,600 breeding-ewes, and a small number of cattle. Lambing percentages are usually around 120 per cent with lambs fattened on the farm, half of these being slaughtered by mid-December. A swede crop is usually grown to assist wintering management.

6.6 THE LINEAR PROGRAMMING MODEL FOR CASE FARM 11

The linear programming model used for Case Farm 11 is presented in Table 6.15. The model is the same as that used for Case Farm 1, except that the following alterations have been made:-

6.6.1 Feed Available

The farm is adjacent to the Marton Research Area, where the Field Research Division of the Department of Agriculture has for many years been measuring pasture production using a cutting and harvesting technique. As with Case Farm 1, this information was combined with previous stock performance on the farm to give a picture of the seasonal availability of feed to stock on the farm.

The feed available on a whole farm basis is taken as follows:-

Spring	14,000	feed	units	(100's lb D.O.M.)
Summer	8,700	"	"	"
Autumn	7,200	"	"	"
Winter	4,200	"	"	"
Total	34,100	"	"	"

6.6.2 Cropping

The farmer considers that an area of swedes is required on this soil-type to enable beef cattle to be wintered without

TABLE 6.15 - THE LINEAR PROGRAMMING MODEL FOR CASE FARM 11

Feed Available	Activity No.	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}
	Value	-17.79	-17.86	-17.94	-18.01	-18.08	-18.15	-18.22	-11.85	-11.90	-11.95	-12.00
14.000 :	Spring	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
8.700 :	Summer	4.5	8.0	11.7	14.9	14.9	14.9	14.9	-	3.5	7.3	10.4
7.200 :	Autumn	5.7	5.7	5.7	5.7	9.1	12.5	16.2	4.0	4.0	4.0	4.0
4.200 :	Winter	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
	Beef Sell	-2.10	-2.40	-2.73	-2.89	-3.05	-3.21	-3.38	-1.32	-1.63	-1.95	-2.11
	Crop	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05

Activity No	P_{12}	P_{13}	P_{14}	P_{15}	P_{16}	P_{17}	P_{18}	P_{19}	P_{20}	P_{21}	P_{22}	P_{23}
Value	-12.05	-12.10	-12.15	-18.59	-18.66	-12.40	-12.45	-17.79	-17.86	-17.94	-18.01	-18.08
Spring	9.6	9.6	9.6	19.2	23.7	19.2	23.7	12.5	12.5	12.5	12.5	12.5
Summer	10.4	10.4	10.4	14.9	14.9	10.4	10.4	4.92	9.37	13.95	18.88	18.88
Autumn	7.4	10.9	16.2	16.2	16.2	14.5	14.5	6.5	6.5	6.5	6.5	11.56
Winter	5.7	5.7	5.7	16.9	16.9	16.9	16.9	8.04	8.04	8.04	8.04	8.04
Beef Sell	-2.27	-2.42	-2.58	-4.56	-4.81	-3.77	-4.01	-3.12	-3.45	-3.75	-4.09	-4.45
Crop	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05

Continued . . . .

TABLE 6.15 (CONTINUED)

Activity No.	P_{24}	P_{25}	P_{26}	P_{27}	P_{28}	P_{29}	P_{30}	P_{31}	P_{32}	P_{33}	P_{34}
Value	-18.15	-18.22	-11.85	-11.90	-11.95	-12.00	-12.05	-12.10	-12.15	--2.05	-2.06
Spring	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	3.99	8.49
Summer	18.88	18.88	-	4.43	9.02	13.39	13.39	13.39	13.39	-	-
Autumn	16.66	22.10	4.52	4.52	4.52	4.52	9.57	14.67	20.23	3.53	3.53
Winter	8.04	8.04	8.04	8.04	8.04	8.04	8.04	8.04	8.04	9.67	9.67
Beef Sell	-4.81	-5.18	-2.36	-2.69	-2.98	-3.32	-3.67	-4.04	-4.40	-1.11	-1.43
Crop	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05

Activity No.	P_{35}	P_{36}	P_{37}	P_{38}	P_{39}	P_{40}	P_{41}	P_{42}	P_{43}	P_{44}	P_{45}
Value	10.0	5.0	-	-0.5	-0.5	-0.5	-4.5	-4.5	-4.5	-4.5	55.0
Spring	-	3.73	-	1.0	-	-	-1.0	-	-	-	59.6
Summer	-	1.62	-	-	1.0	-	-	-1.0	-	-	37.0
Autumn	-	1.45	1.0	-	-	1.0	-	-	-1.0	-	30.6
Winter	-	2.10	-1.0	-0.56	-0.56	-0.56	-	-	-	-1.0	-58.4
Beef Sell	1.0	-	-	-	-	-	-	-	-	-	-
Crop	-	-	-	-	-	-	-	-	-	-	-1.0

excessive pasture damage, and from his experience a minimum of 0.05 acres per beef animal wintered is required.

As swedes are normally grown as part of a fodder and cash-crop rotation in this area, a cropping rotation was included in the model. This may be described as follows:-

(a) Land is ploughed from pasture on the 1st of November and swedes are planted to make feed available to stock the following winter.

(b) Wheat is planted in the spring following the swedes being fed, and is harvested in time for pasture to be resown the following autumn.

(c) The young pasture, planted about the 1st of April, produces half that of normal established pasture for the winter following sowing.

The crop rotation thus occupies an acre of ground for two years and to some extent "consumes", or makes unavailable for stock consumption, the pasture normally produced by one acre over this period. The rotation does, however, supply feed during the period when the swedes are being fed off and during periods when grass is being produced. Each unit of crop rotation activity occupies one acre of land for two years, but since the analysis is carried out on a one-year basis, the rotation occupies two acres for one year. One unit of crop rotation activity thus represents one acre of swedes plus one acre of wheat. The costs for one unit of this activity are estimated as follows:-

	$/acre
Cultivate for swedes	10.00
Swede seed	2.00
Cultivate and drill for wheat	9.00
Wheat seed	3.50
Fertilizer (additional)[1]	3.00
Weed spray	2.00
Heading costs	10.00
Sacks, twine, drying	2.50
Freight	6.00
Insurance levy (wheat)	1.50
Cultivate and return to grass	4.00
Grass seed	4.00
Total Costs	57.50

The income from a 75-bushel crop which is usual on this farm, for a wheat price of $1.50/bushel, is $112.50, leaving a net return per unit of cropping activity of $55.00 and this figure is used in the model.

The feed supplied by an acre of swedes during the winter is estimated on the basis of a 35 ton/acre crop, of 11.5 per cent dry-matter, and D.O.M. of 0.86. (61)

$$\text{yield} = \left(\frac{35}{1} \times \frac{2240}{1} \times \frac{11.5}{100} \times \frac{.86}{1} \times \frac{1}{100}\right)$$

$$= 75.4 \text{ feed-units (100's lb D.O.M.)}$$

This is the amount of feed supplied in the winter when swedes are fed off.

1/ Only fertilizer costs above those which would normally be incurred with the same area of pasture, are included.

To ensure that at least 0.05 acres of crop are included for every animal wintered, a cropping restriction is incorporated into the model for Case Farm 11. In Table 6.15, this restriction shows as a positive figure, 0.05, in the crop row for every animal wintered. The cropping activity, P_{45}, has a negative figure, -1.0, in this row and thus the inclusion of any beef animal which has to be wintered, forces at least 0.05 units of the cropt rotation to enter the final plan.

6.6.3 Feed-Selling

The feed-selling activities, P_{46} and P_{47}, included in the model for Case Farm 1 have not been included for Case Farm 11. The farmer does not consider hay selling or purchase of store lambs to be fattened a feasible enterprise on this farm since summer or autumn feed surpluses are uncommon.

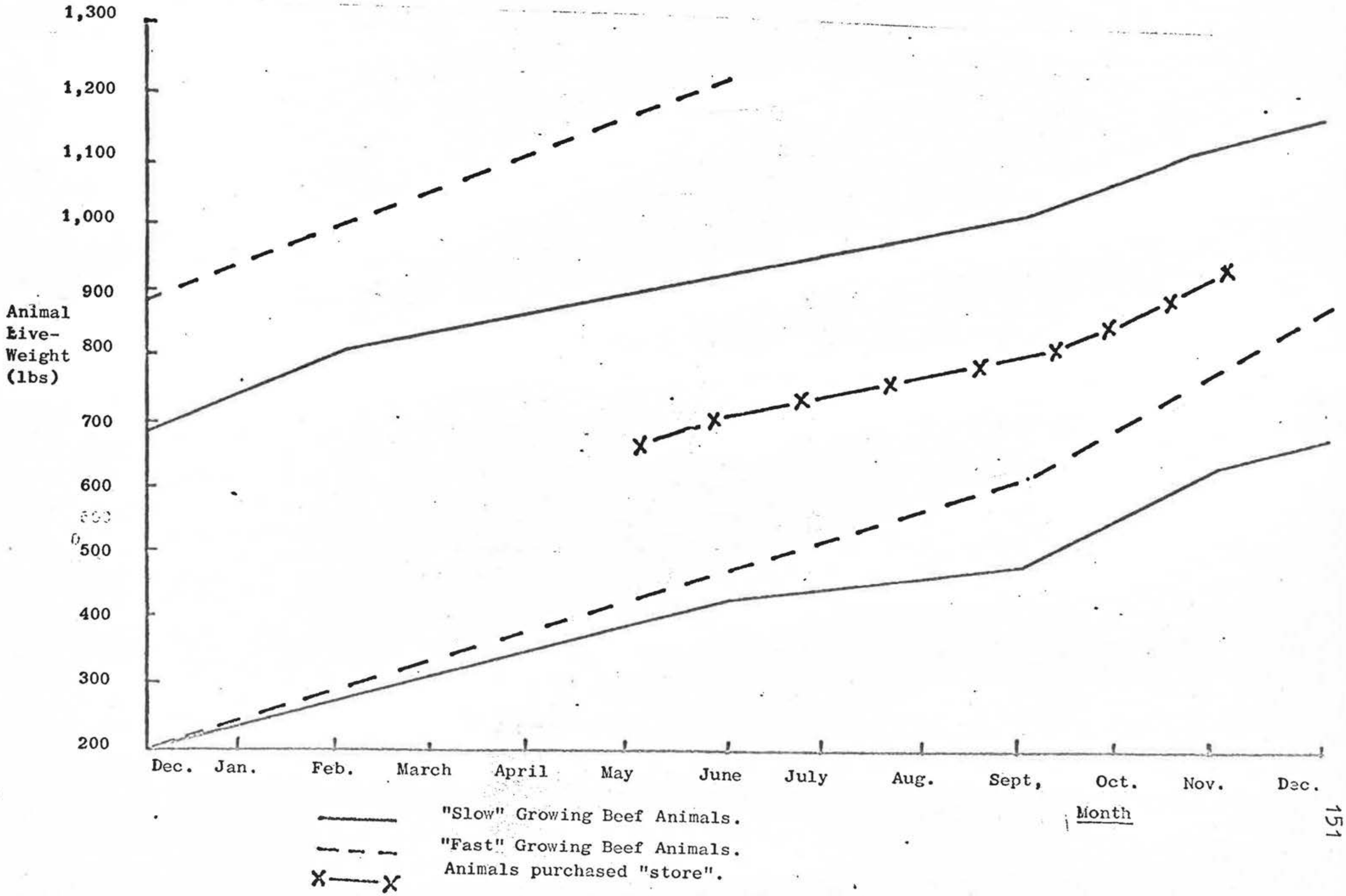
6.6.4 Beef-Producing Activities

The "slow" growth-rate activities, P_1 - P_{18}, are exactly the same as for Case Farm 1. The "fast" growth-rate activities, P_{19} - P_{32}, however, are as described in Fig. 6.5. The "fast" growth-rates are again based on performances which have proven possible on the farm being considered, and on this farm the use of a winter root-crop and different pattern of pasture production is reflected in growth-rates through the year which are not the same as those observed on Case Farm 1.

The purchase of 18-month cattle, activities P_{33} and P_{34}, are also different on this farm. Animals are purchased on

FIGURE 6.5

THE GROWTH PATTERN OF BEEF ANIMALS, CASE FARM II.



the 1st of May to be sold on the 1st of October or the 1st of November following. The growth-rates of these animals are as described in Fig. 6.5 and were derived from previous stock performances on this farm. These policies are included since the farmer believes they are potentially profitable.

The costs associated with beef producing activities on this farm are the same as for Case Farm 1 since apart from the crop requirement, no major differences in cost structure were apparent.

6.7 THE RESULTS FOR CASE FARM 11.

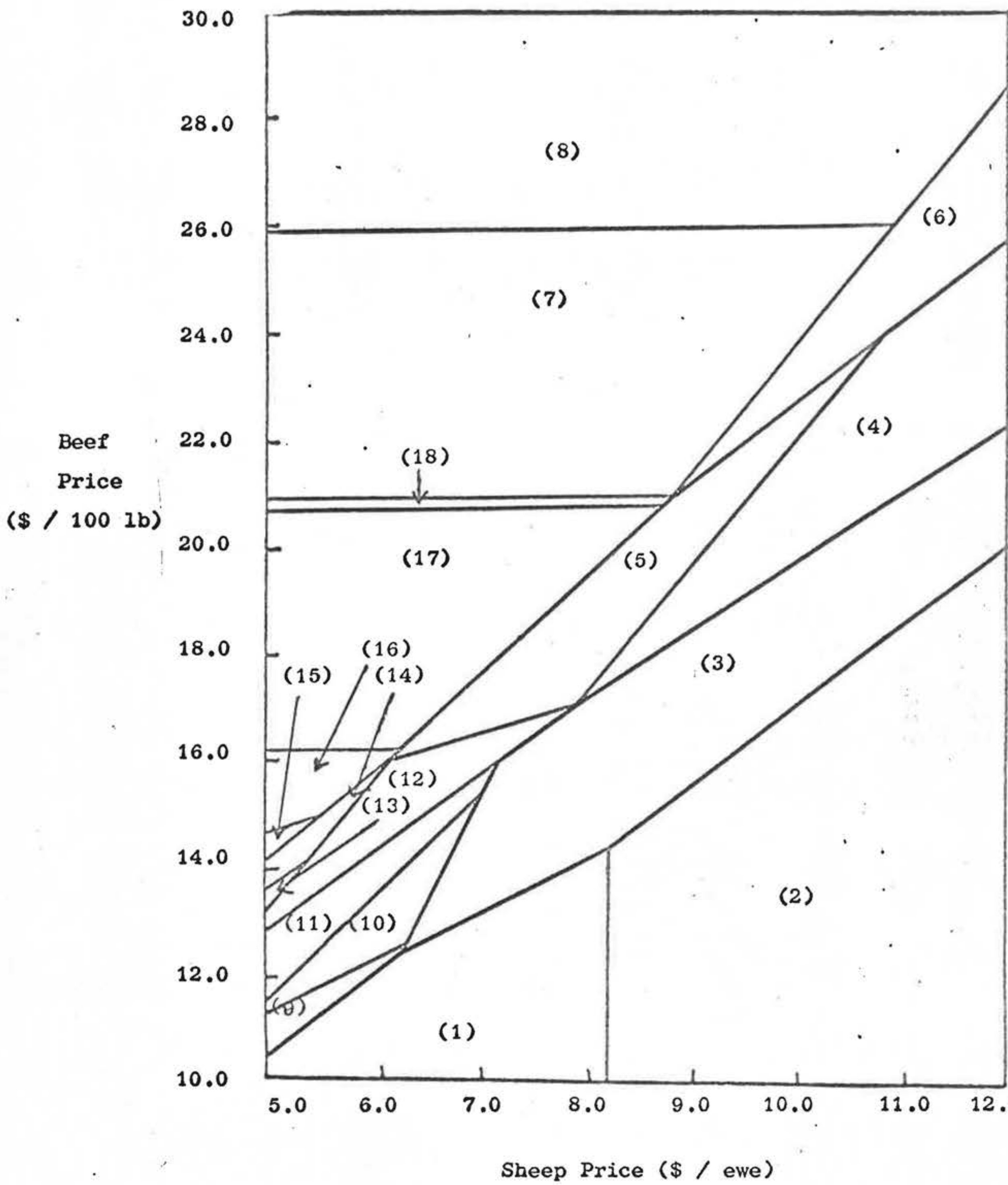
The results for Case Farm 11 are presented in a similar way to those for Case Farm 1.

6.7.1 "Slow Growth Rates

The Price Map for "slow" growth-rate beef animals is presented in Fig. 6.6 and activity levels for each plan represented on the map are presented in Table 6.16. These plans were derived by the model presented in Table 6.15 with beef-producing activity P_{19} - P_{34} excluded.

The plans are summarised in Table 6.17, where Dec. - 2 yr cattle represent weaners purchased in December for sale after a second winter, and April - 2 yr cattle are similar animals purchased in April.

FIGURE 6.6
PRICE MAP FOR "SLOW" GROWING BEEF ANIMALS, CASE FARM II



(X) Represents Plan Number.

Table 6.16

Activity Levels for Farm Plans in Figure 6.6

PLAN NUMBER	BEEF PRICE ($)	SHEEP PRICE ($)	PLAN VALUE ($)	ACTIVITY LEVELS P3	P4	P6	P7	P9	P10	P11	P15	P16	P18	P35	P36	P37	P38	P39	P45
1	10.0	5.0	18200	-	-	-	-	-	-	-	-	-	-	-	3390	1588	-	-	23
2	10.0	11.0	39304	-	-	-	-	-	-	-	-	-	-	-	3660	1714	-	2555	6
3	14.1	8.0	28411	-	215	-	-	-	-	-	-	-	-	620	2745	1123	-	-	29
4	17.3	8.0	30409	302	-	-	-	-	-	-	-	-	-	825	2482	933	-	-	31
5	17.5	8.0	30576	188	-	-	-	-	-	-	-	149	-	1231	1580	-	-	-	46
6	24.2	11.0	43678	266	-	-	-	-	-	-	-	261	-	1981	449	-	2019	-	26
7	20.8	5.0	35969	28	-	-	-	-	436	-	-	259	-	2171	-	-	1263	-	36
8	25.9	5.0	47041	132	-	-	-	448	243	-	-	137	-	2222	-	-	-	-	48
9	10.4	5.0	18236	-	-	-	117	-	-	-	-	-	-	395	2807	-	-	-	40
10	11.1	5.0	18527	-	46	156	-	-	-	-	-	-	-	633	2583	-	-	-	41
11	11.2	5.0	18611	-	111	-	-	-	-	-	134	-	-	933	1989	-	-	-	49
12	12.4	5.0	19751	-	124	-	-	-	-	-	-	167	-	1160	1625	-	-	-	47
13	13.3	5.0	20796	-	-	-	-	-	-	192	-	193	-	1333	1264	-	-	-	48
14	13.4	5.0	20948	-	-	-	-	-	-	326	-	-	245	1670	551	-	-	-	51
15	14.1	5.0	22122	-	-	-	-	-	-	372	-	-	291	1953	-	-	-	-	49
16	14.8	5.0	23499	-	-	-	-	-	490	79	-	-	232	2054	-	-	-	-	51
17	16.2	5.0	26377	-	-	-	-	-	661	-	-	34	186	2083	-	-	-	-	50
18	20.7	5.0	35753	-	-	-	-	-	481	-	-	254	-	2159	-	-	1101	-	38

Table 6.17

Summarised Farm Plans With "Slow" Growing Beef Animals
Case Farm 11

Plan No.	Ewe Flock	2 Yr Beef (Dec.)	2 Yr Beef (April)	Spring Hay	Summer Hay	Crop Acres
1	3390	-	-	-	-	23
2	3660	-	-	-	2555	6
3	2745	-	-	-	-	29
4	2482	-	-	-	-	31
5	1580	149	-	-	-	46
6	449	261	-	2019	-	26
7	-	259	-	1263	-	36
8	-	137	-	-	-	48
9	2807	-	-	-	-	40
10	2583	-	-	-	-	41
11	1989	134	-	-	-	49
12	1625	167	-	-	-	47
13	1264	193	-	-	-	48
14	551	-	245	-	-	51
15	-	-	291	-	-	49
16	-	-	232	-	-	51
17	-	34	186	-	-	50
18	-	254	-	-	-	38

The price map can be divided into three major areas, as shown in Fig. 6.7, and the three areas may be described as follows:-

(A) An area including plans 1 ans 2 from Fig. 6.6, where breeding ewes are the main farm enterprise, and a small area of crop grown.

(B) An area of mixed sheep and beef activities represented by plans 3 - 6 and 9 - 14 inclusive.

(C) An all-beef area represented by plans 7, 8 and 15 - 18 inclusive.

Two trends through the price map are of interest. These are firstly the replacement of sheep by beef animals as beef price increases at low sheep price, and secondly a similar replacement at high sheep price.

(a) If a static sheep price of $5.00 is taken, and plans ranked in order of beef price at which each becomes optimum, the pattern shown in Table 6.18 becomes apparent.

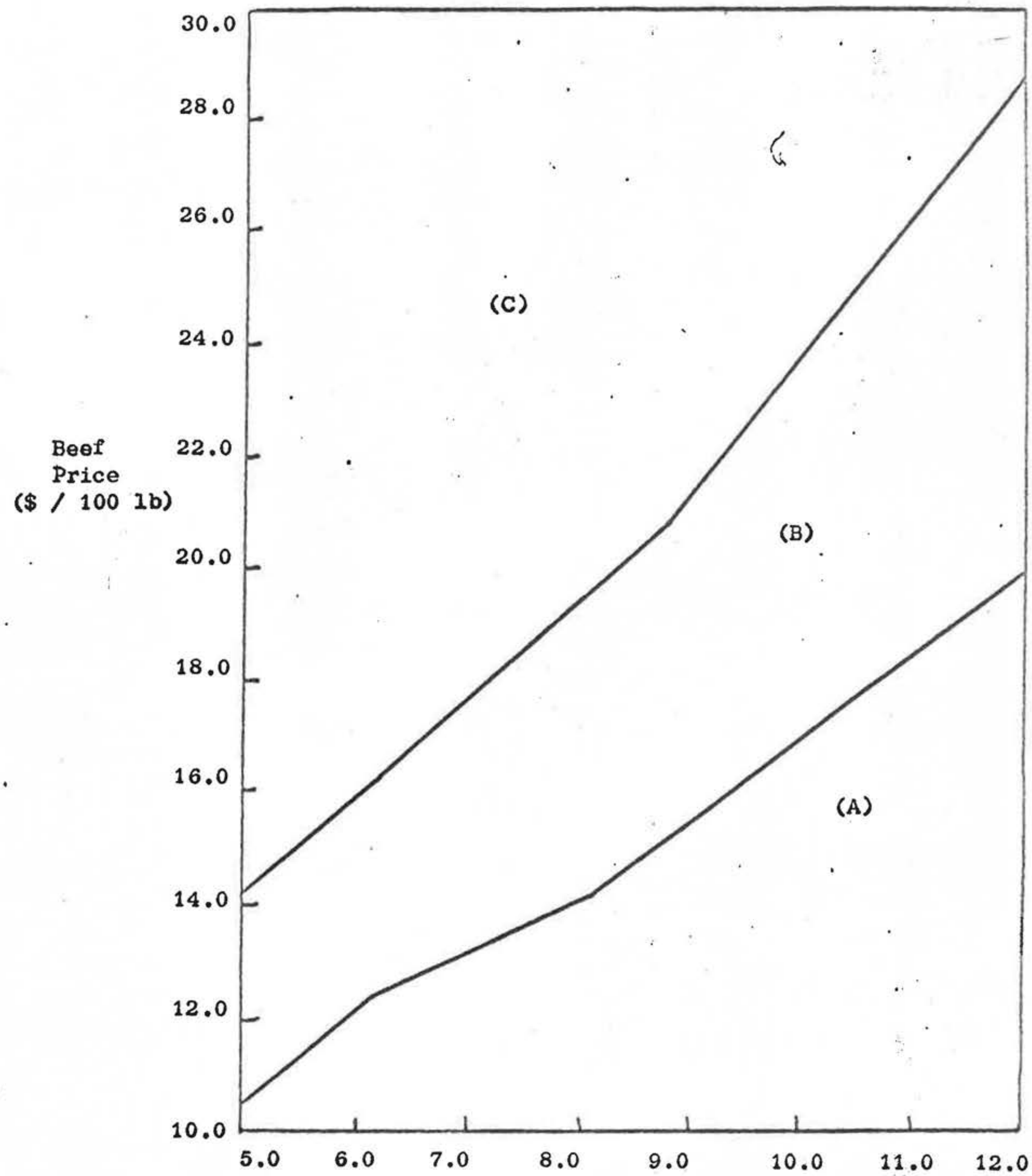
Table 6.18

The Replacement of Sheep With Beef Animals as Beef Price Increases (Sheep Price $5.00)

Plan No.	Beef Price ($)	Ewe Flock	Dec/ March	Dec/ May	Dec/ June	April/ Feb.	April/ March	Dec. (2 Yr)	April (2 Yr)
1	10.0	3390	-	-	-	-	-	-	-
9	10.4	2807	-	-	117	-	-	-	-
10	11.2	2583	46	256	-	-	-	-	-
11	11.4	1989	111	-	-	-	-	134	-
12	12.8	1625	124	-	-	-	-	167	-
13	13.4	1264	-	-	-	-	192	193	-
14	13.6	551	-	-	-	-	326	-	245
15	14.2	-	-	-	-	-	372	-	291
16	14.6	-	-	-	-	490	79	-	232
17	16.2	-	-	-	-	661	-	34	186
18	20.7	-	-	-	-	481	-	254	-

FIGURE 6.7

SIMPLIFIED PRICE MAP FOR "SLOW" GROWING BEEF ANIMALS, CASE FARM II.



(A) Breeding ewes.
(B) Mixed Sheep and Beef
(C) All Beef.

Through plans 1, 9 and 10, the sale date of weaners purchased in December is reduced as beef numbers increase until with plan 11, there is a change toward holding animals purchased as weaners for a second winter. Through plans 11, 12 and 13, beef numbers increase, mainly in the form of 2 yr cattle. However, in plan 13, there is a further change toward purchase of weaners in April, and as sheep are finally excluded in plan 15 there is little difference between plans. Plan 18 is similar to plan 8, to which it is adjacent on the price map.

(b) If a static sheep price of $10.00 is taken and plans are ranked in ascending order of beef price, the results shown in Table 6.19 are obtained.

Table 6.19

The Replacement of Sheep With Beef Animals as Beef Price Increases (Sheep Price $10.00)

Plan No.	Beef Price ($)	Ewe Flock	Dec/ Feb	Dec/ March	April/ Jan	April/ Feb.	2 Yr Dec
2	10.0	3660	-	-	-	-	-
3	13.8	2745	-	215	-	-	-
4	15.0	2482	302	-	-	-	-
5	16.6	1580	188	-	-	-	149
6	16.8	449	266	-	-	-	261
7	21.7	-	28	-	-	436	259
8	22.7	-	132	-	448	243	137

The trend is similar to that for (a) in that as sheep numbers decrease, there is change from weaners purchased in December to weaners purchased in April, these being held in increasing numbers for two years. However as beef price exceeds $22.00 and all sheep are replaced, the trend is reversed and fewer animals are held for a second winter.

6.7.2 "Fast" Growth Rates

The Price Map for "fast" growth rates is presented in Fig. 6.8 and activity levels for each of the plans represented are given in Table 6.20, and summarised in Table 6.21.

Table 6.21

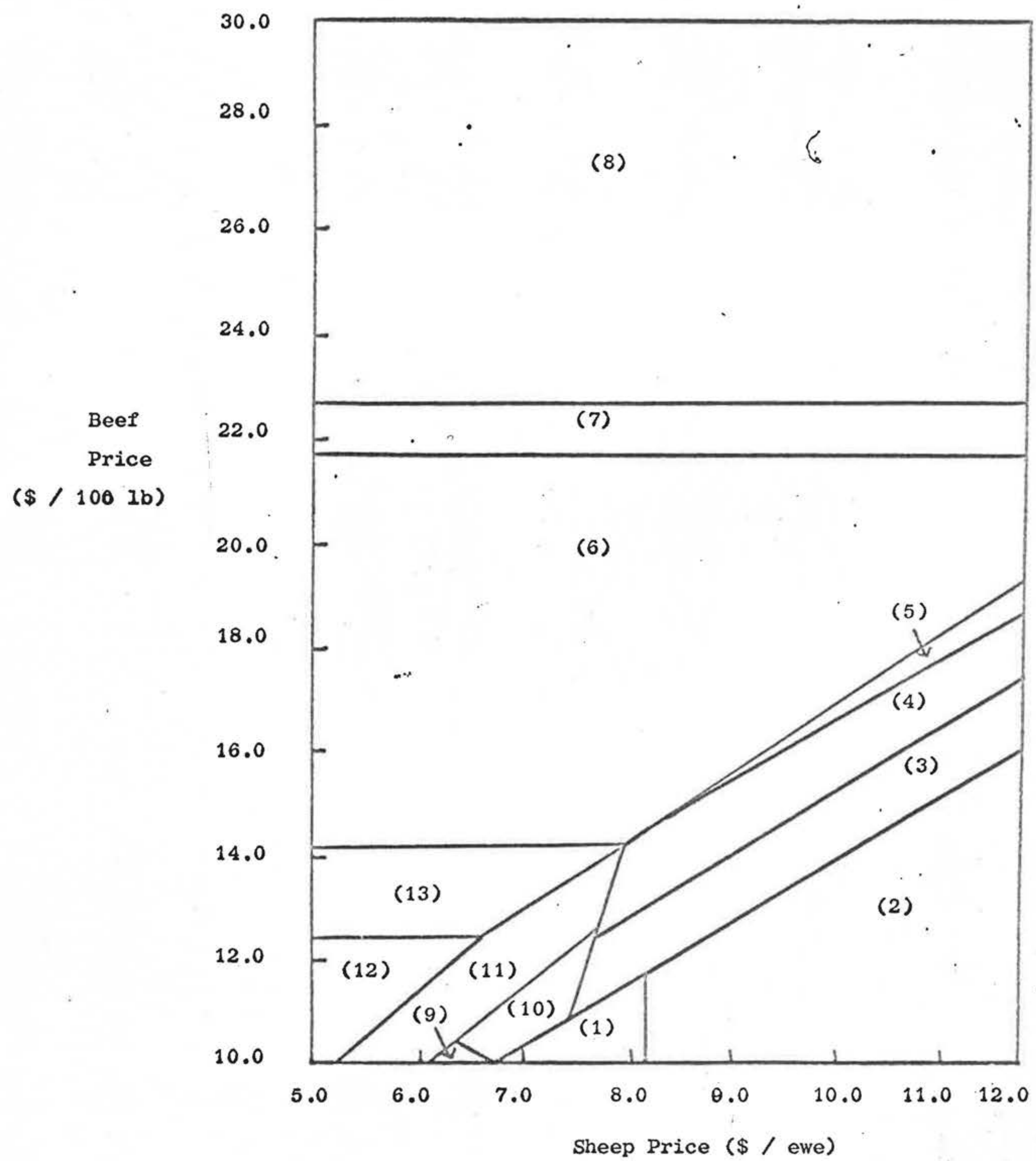
Summarised Farm Plans With "Fast" Growing Beef Animals
Case Farm 11

Plan No.	Ewe Flock	Dec (1 Yr)	April (1 Yr)	"Stores" (18 mths)	Summer Hay	Crop (acres)
1	3390	-	-	-	-	23
2	3660	-	-	-	2555	6
3	2729	172	-	-	-	28
4	2367	-	294	-	-	25
5	1512	-	540	-	-	27
6	-	-	904	-	-	45
7	-	587	317	-	-	45
8	-	656	249	-	-	45
9	2818	84	-	-	-	41
10	2549	160	-	-	-	42
11	2165	-	269	-	-	43
12	-	-	458	473	-	69
13	-	-	883	-	-	50

The Price Map can be divided into four main areas as shown in Fig. 6.9.

FIGURE 6.8.

PRICE MAP FOR "FAST" GROWING BEEF ANIMALS, CASE FARM II.



(X) Represents Plan Number.

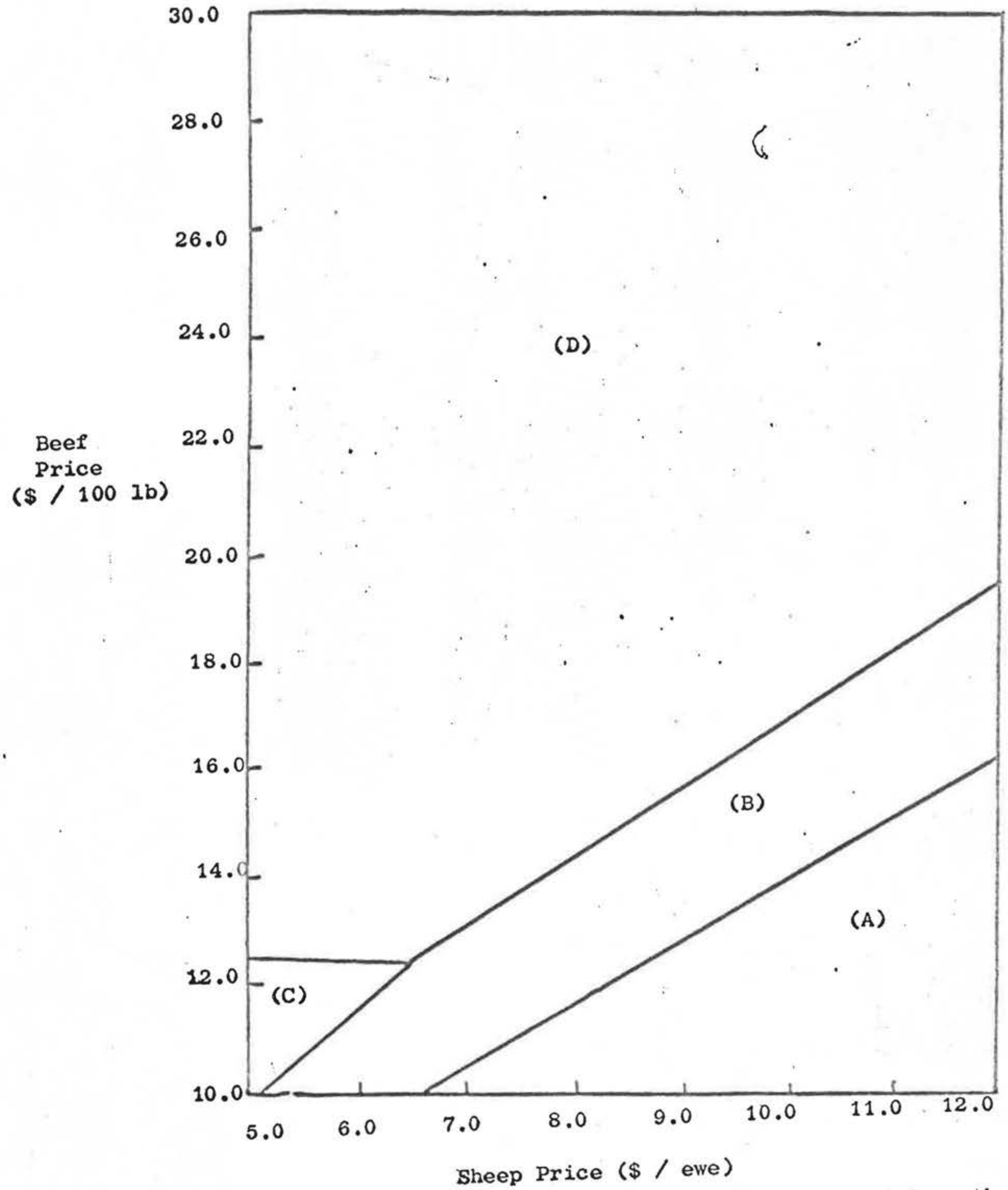
Table 6.20

Activity Levels for Farm Plans in Figure 6.8

Plan Number	Beef Price ($)	Sheep Price ($)	Plan Value ($)	ACTIVITY LEVELS														
				P19	P20	P22	P23	P24	P25	P27	P29	P31	P34	P35	P36	P37	P39	P45
1	10.0	7.0	24,979	-	-	-	-	-	-	-	-	-	-	-	3390	1588	-	23
2	10.0	8.5	30,154	-	-	-	-	-	-	-	-	-	-	-	3660	1714	2555	6
3	12.1	8.5	30,157	-	-	172	-	-	-	-	-	-	-	701	2729	1627	-	28
4	13.4	8.5	31,064	-	-	-	-	-	-	-	294	-	-	976	2367	1671	-	25
5	14.9	8.5	32,520	-	-	-	-	-	-	221	319	-	-	1654	1512	1740	-	27
6	15.0	8.5	32,628	-	-	-	-	-	-	567	209	128	-	2737	-	430	-	45
7	21.6	8.5	50,887	-	587	-	-	-	-	304	-	13	-	2897	-	430	-	45
8	22.6	8.5	53,697	49	607	-	-	-	-	249	-	-	-	2915	-	430	-	45
9	9.1	6.0	21,594	-	-	-	-	-	84	-	-	-	-	435	2818	-	-	41
10	9.7	6.0	21,868	-	-	-	87	73	-	-	-	-	-	739	2549	-	-	42
11	9.8	6.0	21,977	-	-	-	-	-	-	-	118	151	-	1002	2165	-	-	43
12	11.6	6.0	23,842	-	-	-	-	-	-	-	335	123	473	2285	-	-	-	69
13	12.4	6.0	25,688	-	-	-	-	-	-	554	163	166	-	2703	-	-	-	50

FIGURE 6.9

SIMPLIFIED PRICE MAP FOR "FAST" GROWING BEEF ANIMALS, CASE FARM II.



(A) Breeding ewes
(B) Mixed Sheep and Beef
(C) All Beef (18 months)
(D) All Beef (1-year)

(A) An all-sheep area, which is identical with the all-sheep area in Fig. 6.7 for "slow" growth-rates, since no change has been made other than to beef-producing activities.

(B) An area of mixed sheep and beef activities.

(C) An area of all beef, where some animals are purchased as 18-month cattle to be sold the following spring.

(D) An all-beef area where animals are purchased as weaners and are all sold before their second winter.

The trends through the Price Map are similar to those noted for "slow" growth-rates. As beef animals replace sheep, both at high and low beef prices, weaners are purchased in increasing numbers, but when all sheep are replaced and beef price further increases a greater number are purchased in December.

Plan 12 includes 473 "store" animals purchased at 18 months of age and is a beef and cropping policy, with the large numbers of beef animals wintered utilising the 69 acres of swedes which are grown. This plan, however, is only optimum at both low sheep and beef prices.

6.8 COMMENTS ON RESULTS FOR CASE FARM 11

This farmer has experienced sheep prices in the $7.00 - $8.00 range over the last five years, and could profitably change to an all-beef enterprise on the basis of these results, particularly if cattle performances approaching those described under "fast" growth rates are attained, as they have been in the past. As for Case Farm 1, attaining "fast" growth rates increases net income by approximately $25.00 per acre, and stocking rate is reduced by about half a beast per acre[1].

Cropping in no case appears profitable on a large scale, at the prices used. Only at low sheep and beef prices are crop areas beyond that required to winter beef animals included in the final plan.

The cost to the farmer of a minimum crop requirement to winter beef animals increases with beef price. If the enterprise net revenue for the cropt rotation is compared with its shadow price[2] over a range of beef prices, the results in Table 6.22 are obtained. The beef-producing enterprises are those where "fast" growth rates are achieved.

Table 6.22

The Shadow Price of the Cropping Rotation as Beef Price Increases

Beef Price ($)	Crop Net Revenue ($)	Shadow Price ($)
10.00	55.00	24.90
14.90	55.00	54.15
14.96	55.00	54.53
21.63	55.00	111.01
22.60	55.00	125.98

From the figures in Table 6.22, it can be seen that with beef prices above $15.00, the crop rotation with an enterprise net revenue of $55.00 utilises farm land less profitably than beef

1/ See Chapter Seven for more detailed revenue comparisons.

2/ For a given set of costs and prices, the linear programming technique gives the enterprise net revenue required for any "shadow price" of that enterprise.

production. At beef prices above $22.00, the income from one unit of crop rotation would need to increase by approximately $75.00 before the crop rotation became as profitable as beef production. Since wheat yields of 75 bushels per acre are usual on this farm, the wheat price would need to increase by $1.00 per bushel before the crop rotation became as profitable as beef production at a beef price of $22.00.

The cost to the farmer of a minimum crop requirement to winter beef animals is therefore substantial, and expenditure on some other means of carrying these animals over the winter, such as a sawdust pad, would be justified at high beef prices.

The inclusion of "fast" growth-rate activities again reduced by about $5.00, the beef price required before sheep were finally excluded from the optimum plan. Their inclusion also means the exclusion of all activities requiring animals to be kept for a second winter.

With slow growth-rates, and particularly at lower beef prices, some animals kept for a second winter are included in the optimum plan. This is a result of the reasonably good winter pasture growth, coupled with the requirement for 0.05 acres of crop for each animal wintered on this farm. Winter feed-supplies are thus adequate to enable animals to be kept for a second winter.

The farmer considered that all plans were feasible, and hopes to achieve either plan 6, 7 or 8 in Fig. 6.8. These all-beef plans are quite similar, the only difference being that at high beef prices weaners are purchased in December rather than April.

6.9 SUMMARY

The results of a linear programming analysis applied to two

Case Farms show that while present and previous returns from these farms have been high, present beef prices indicate that a complete change to beef-production would increase profitability.

A comparison of two levels of beef-cattle performance showed that the beef price required for beef animals to replace sheep can be lowered by $5.00 if fast growth-rates are attained.

Similar results were obtained for both farms and showed that the most profitable beef policy in general was the purchase of weaners to be grown as fast as possible and sold before their second winter. Only at slow growth-rates and low beef prices should animals be kept for a second winter. Similarly, the purchase of "store" 18-month cattle to be sold the following spring does not compete with fast-growing young cattle at reasonable beef prices.

CHAPTER SEVEN

SUMMARY AND CONCLUSIONS

7.1 INTRODUCTION

In this chapter the main features which arose from the Case Farm analysis are discussed, and the results generalised with particular reference to the beef policies most likely to maximise profit to the farmer.

The opportunity cost to farmers through not selecting the most profitable farm enterprises available will be illustrated with examples taken from the Case Farms considered.

The applicability of linear programming to the type of problems encountered in this thesis will be discussed and some recommendations made on the future place this technique might have in agricultural research and extension in New Zealand.

Finally, the ways in which sheep farmers may best be encouraged into increased beef production based on the findings of this study, will be discussed.

7.2 GENERAL COMMENTS ON CASE FARM RESULTS

The two Case Farms discussed differed in one essential feature; the distribution of pasture growth within a year. Other differences such as the inclusion of feed-selling activities for Case Farm 1 and the requirement of a minimum cropping area for Case Farm 11, had little impact on the type of beef enterprise selected or on the way in which beef animals were substituted for sheep as beef price increased.

The amount of pasture produced and its pattern of production, is a major influence in selecting the most profitable farm system. It may be noted however, that even widely different feed-availability figures such as those for Case Farms 1 and 11 gave similar general guide-lines as to the most profitable farm plan. The Price Map for "slow" growth-rates on Case Farm 1 in Fig. 6.1 was derived using the same beef activities as for the "slow" growth-rates on Case Farm 11 given in Fig. 6.6. Even though the pattern of feed availability on these farms is very different, the Price Maps are similar in many respects, and complete replacement of sheep with beef animals occurs at similar prices.

If the Price Maps for "fast" growth-rates are compared, a similarity again becomes apparent and the optimum combination of beef policies for the two Case Farms is very similar particularly at higher beef prices. Again the substitution of beef animals for sheep occurs at similar beef and sheep prices.

From the trends noted in all four Price Maps, several general points become apparent and it would appear that these points could be considered of relevance to any sheep farmer contemplating increased beef production, who could attain the animal performances described for Case Farms 1 or 11.

(a) At beef and sheep prices which have been experienced over the last few years, and could reasonably be expected in the future, sheep farmers could make substantially more profit from beef animals than breeding ewes.

The "Plan Values" quoted in Tables 6.1, 6.6, 6.16 and 6.20 for Case Farms 1 and 11, represent a total enterprise net revenue at the relevant beef and sheep prices. Fixed farm costs as defined in 5.3.4, and taxation, have not been included in the calculation. A figure for tax-paid profit would be of interest to the Case farmers, but would of necessity require information which would not be of general interest. For the purpose of this thesis, calculation of tax-paid profit to the farmer is unnecessary and would tend to obscure more important issues.

Total enterprise net revenue for the remainder of this discussion may be simply referred to as income, and represents the sum of money from which the farmer must meet his fixed farm costs, farm development and personal expenditure, and taxation.

From Tables 6.1, 6.6, 6.16, and 6.20, the impact of sheep and beef price on farm incomes becomes apparent. Both Case farmers have experienced sheep prices of around $8.00 and beef prices of the order of $20.00 over the last few years, and these prices will be used as the basis of an income comparison.

(a) Case Farm 1: With a beef price of $20.00 and a sheep price of $8.00, income per acre is $51.60 with an all-sheep system, $61.80 with all "slow" growing beef animals and $84.10 with all "fast" growing beef animals.

(b) Case Farm 11: Again with a beef price of $20.00 and a sheep price of $8.00, income per acre is $56.90 with an all-sheep system, $64.70 with all "slow" growing beef animals and $94.60 with all "fast" growing beef animals.

Both of these farmers, and indeed any sheep farmers who could attain the beef animal performances described for Case Farms 1 and 11 at similar costs and prices, can increase their farm incomes by over 50 per cent through changing from breeding ewes to beef animals.

However, beef animal performance has a major influence on profitability, and if growth rates are slow, only small increases in farm incomes would result.

(b) Fast growth-rates by ample feeding for as much of the year as possible must be the aim. If plan 7 in Fig. 6.3 is compared with plan 12 in Fig. 6.1 for the same beef prices on Case Farm 1, it is noted that with "slow" growth-rates 466 beef animals are included in the optimum plan, while for "fast" growth-rates only 377 animals are included. In other words, stocking rate has been reduced from two to one and a half animals per acre, and the beef price required for beef animals to replace sheep has been lowered by $5.00. This indicates that low stocking rates and well-fed animals are more profitable than higher stocking rates with resultant slow growth rates.

(c) Holding animals on the farm for a second winter is less profitable than selling animals at 15 - 20 months of age, unless low beef prices and slow growth-rates prevail. As beef price increases, the importance of having only fast growing animals producing beef, increases.

(d) Hay, silage or grain feeding should be kept to a minimum and pastures should be grazed "in situ" where possible. In only few plans were hay or silage making activities included on a large scale, which may be attributed largely to the feed losses involved, calculated at 44 per cent of feed conserved. Particularly at high beef prices, it is most profitable to utilise spring and summer pastures by high levels of feeding with animals sold before their second winter, and the available winter pasture given to the following year's weaners.

Grain feeding at the prices used, did not become profitable at beef prices below $30.00. It would seem that only under special circumstances such as prevention of animal mortality or a cheap source of grain, would meal-feeding become profitable.

(e) The transfer of standing pasture from autumn to winter as autumn-saved pasture was an essential feature of most beef policies. This highlights the need for careful grazing management, or "feed-budgeting" to use pasture resources the most profitable way.

(f) The pattern of feed availability can affect the price ranges over which sheep and beef animals can profitably be farmed together. For Case Farm 11, which has a greater production of pasture in spring in relation to other seasons than Case Farm 1, there was a much wider range of beef prices over which both sheep and beef animals were included in farm plans. This may be attributed to the high spring demand for pasture by sheep, and their inclusion in plans for Case Farm 11 to utilise feed at this time.

(g) Where summer or autumn feed shortages occur in some years, it becomes even more desirable to adopt a policy of fast growth-rates so that animals may sooner reach killable weights.

7.3 THE COST TO THE FARMER OF NOT SELECTING THE OPTIMUM PLAN

It should be recognised that while each plan on a Price Map represents the optimum plan in terms of profitability for the price ranges defined, profitability may not be substantially reduced by selecting a non-optimum plan.

In Table 6.20, the total enterprise net revenue for each plan is given for Case Farm 11, along with the sheep and beef prices relevant to each plan. The loss in profit opportunity through selecting a sub-optimum plan may simply be derived by assigning the relevant prices to the sub-optimum plan and comparing total enterprise net revenue with that derived from the optimum plan at the same prices.

Example: The farmer on Case Farm 11 elects to adopt plan 2 in Fig 6.8 when sheep price is \$8.50 and beef price is \$21.60. From the Price Map, this price combination suggests plan 7 as optimum, and at these prices the plan would give a total enterprise net revenue to the farm of \$50,887.00. However, if plan 2 is selected, these prices give a net return of only \$30,154.00. The opportunity cost to the farmer in this case through selecting a sub-optimum plan is, therefore, $20,733.00.

However, with a sheep price of $8.50 and a beef price of $14.90, the farmer can select plan 2 with little loss in revenue. At this price combination the optimum plan is No.5 in Fig. 6.8 and revenue earned by this plan at these prices is $32,520.00. The revenue loss or opportunity costs in this case through selecting a sub-optimum plan is only $2,366.00.

In making major policy decisions, a farmer must not only consider what the optimum plan is for his farm at a given combination of prices, but also must consider what the opportunity cost of selecting a non-optimum plan might be.

For Case Farms 1 and 11 where sheep prices of $8.00 - $9.00 have been realised and $20.00 beef prices could confidently be expected, there is opportunity for an approximate 50 per cent rise in total enterprise net revenue to the farm by changing from sheep to all beef animals. However, if the sheep price should increase to $11.00, or beef price should fall to $15.00, increase in net revenue would be small and a change may not be justified. Prices are unlikely to change to this extent however, so that increased beef production at the expense of breeding ewes is likely to lead to a substantial increase in farm profits.

7.4 SOME COMMENTS ON LINEAR PROGRAMMING AS USED IN THIS STUDY

Linear programming proved ideally suited to a profitability comparison of several livestock systems competing for a restricted feed-supply. Construction of the model was time consuming, since price relationships, feed requirements and other input/output data had to be defined. However, on reflection it is clear that unless this input/output data had adequately been examined, the investigation would have been very superficial. In this thesis activity levels only have been presented in most cases and where possible these have been summarised. In practice, the technique provides much more information than this, some of which was used in the construction of the Price Maps, and in checking the feasibility of results.

The construction of Price Maps proved a valuable extension of the linear programming technique and could play a major role in presenting results so as to be acceptable and clearly understood by farmers. The data requirements to enable detailed examination of most farms would not be great once feed requirements and general input/output coefficients are available. The main requirements would be -

(a) a pattern of feed availability on the farm which may be gained from previous stock performance on the farm, cutting measurements, or a combination of the two. This information need not be precise as the analysis showed results were sensitive to the amount of feed available rather than its distribution;

(b) a list of alternatives available on the farm, with some estimate of stock performances, e.g. lambing percentage or growth-rate for beef animals;

(c) any items peculiar to the farm, e.g. a cheap source of grain, or a minimum crop requirement for wintering beef animals.

The farmer can then be left to subtract from linear programming results, such items as fixed farm costs and tax, and make adjustments where applicable for any other factors such as a possible saving in labour costs. He may also need to estimate the opportunity cost of not adopting the optimum plan since if this is small personal preference may influence his choice of enterprises.

7.5 SUGGESTED WAYS OF INCREASING BEEF PRODUCTION ON SHEEP FARMS

If it is in the National interest to increase beef production at the expense of the National ewe flock, there are some comments which could be made as a result of this study:-

(a) A large-scale swing toward beef production would require an appropriate extension effort.

During discussion with farmers, it was apparent that few sheep farmers realised beef production could increase their net farm returns by 50 per cent. Most farmers who had changed were motivated by non-profit objectives such as a reduced personal labour requirement.

(b) Farmers lose confidence in long-term markets for their products because of ill-informed predictions by some industry leaders. A thorough investigation into the long-term market prospects for beef and sheep products would help improve farmer confidence.

(c) Many sheep farmers are currently in a low equity situation. The "working capital" problem with beef production is very real and readily available finance to provide working capital for the first year or two following a change from breeding ewes to beef animals would allow more farmers to make the change.

(d) There is insufficient information available to farmers on some relatively simple aspects of beef production. For example, veterinary costs can be quite high, yet most farmers are ill-informed as to the requirements for parasite control and are dependent on sometimes unreliable information supplied by commercial firms.

(e) There is too much attention given by research and extension workers to some aspects of beef production which could have little impact on profitability to the farmer. Farmers are confused as to the merits of various breeds and sexes, and these differences are often relatively unimportant. Some research workers, for example, recommend grain-feeding while others are emphatic that it is unprofitable. If more attention was given to the major economic issues, a significant increase in profitability to the farmer would be possible.

(f) Meat buyers for both local and export markets tend to discriminate against beef animals of dairy breeds. This confuses many farmers who have heard statements made publicly by research workers (41) that differences between breeds in meat quality do not exist. If animals of dairy breeds are to play an increasingly important part in the Beef Industry, this conflict must be resolved.

(g) The present slaughtering facilities for beef animals are inadequate in some part of New Zealand and the problem is further aggravated by frequent work stoppages. For a properly planned beef production system, the time at which animals are slaughtered can be critical, and some farmers are reluctant to expand their beef enterprise because of unreliable slaughtering facilities.

7.6 FUTURE RESEARCH REQUIREMENTS

It has been suggested in this thesis that beef-production requires a "feed-budgeting" approach to farm management. Adjusting feed requirements to feed production, and allotting feed resources in the most profitable manner is the method suggested as being most likely to maximise profits. The linear programming technique can do precisely this, and more of this type of research is required.

This study could well be extended to include beef breeding cows, and to examine the impact of changing beef prices within a year. This would require information which is at the moment, not readily available.

Integrated physical research work to compare livestock systems would seem to have little merit unless the physical inputs and outputs for each system are reliably identified. Techniques such as linear programming can integrate systems and compare them, provided the physical information is available and reliable.

A farmer's most critical resource in most cases is his feed-supply. More information is required about present and potential feed resources in New Zealand. More information about feed requirements at various production levels, for our livestock systems, is also required.

7.7 SUMMARY

From the Case Farm results the most profitable beef system is the purchase of weaners at 12 weeks or six to seven months of age to be given high levels of feeding for slaughter before their second winter. Stocking rates should be low rather than high, and grazed pasture should form the basis of their diet.

Linear programming is a technique ideally suited to the type of problem where several possible enterprises compete for a limiting resource such as feed-supply. Price Maps are a useful extension of the technique and appear to have a place as an extension device. The opportunity cost to the farmer of not selecting the optimum plan should be considered, since if this is not great major changes may not be justified.

Future research work should involve collection of physical input/output data to enable techniques such as linear programming to be applied. Some major issues have been ignored by research workers and in particular more attention should be given to estimating feed availability on the farm and the feed requirements of various livestock systems.

If sheep farmers are to be encouraged into beef production, a considerable extention effort in this field would be required, directed mainly at the economic issues involved. Increased availability of short term credit would enable more sheep farmers to increase beef production.

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APPENDIX 1

DRESSING-OUT PERCENTAGES FOR BEEF ANIMALS

Dressing-out percentages for beef animals may be defined as the percentage of an animal's live-weight which is represented by the carcass weight at slaughter. The definition should, however, include some estimate of the animal's gut contents at the time when live-weight was recorded. If animals have not been denied access to food and water for at least twelve hours before live-weight is recorded, differences in gut content can lead to substantial differences between calculated and actual carcass weight.

MacDonald[1/] estimated dressing-out percentages to vary from 50 per cent to 62 per cent over live-weights from 700 to 1600 pounds. He also emphasised that the figure is largely a measure of the animal's stage of maturity and that as body weight increases, dressing-out percentage would also increase proportionately.

The decision to exclude kidney and channel fats from carcasses however, has raised the need for new estimates of the weight of saleable carcass the farmer can expect from an animal of given live-weight.

These figures will apply only to animals slaughtered for export, since meat for local consumption is not trimmed for kidney and channel fats.

1/ MacDonald, M.A. (1963) "The Principles of Efficient Beef Production". Proceedings of the Ruakura Farmers Conference Week.

Three variables are likely to affect dressing-out percentages:

(a) the weight of an animal's gut contents at the time when live-weight is recorded;

(b) the animal's live-weight;

(c) the breed of animal.

Gut Contents: Brougham (11) measured dressing-out percentages of 72 animals with an average carcass weight of 390 pounds. Animals were weighed "full" off pasture and "empty" after being denied access to food and water for twelve hours. Over this period, average animal live-weight decreased from 870 pounds to 790 pounds. In this case, the weight of gut contents had decreased by 40 pounds and the dressing-out percentage of these animals increased by 2.4 per cent from 47.9 per cent to 49.4 per cent.

The error in this example through not taking account of gut content in calculating carcass weights would have been 2.4 per cent or conversely 40 pounds of the apparent live-weight of the "full" animals was gut content.

Live-Weight: Trial work by Barton (6, 7) where carcasses were trimmed to estimate kidney and channel fat content are summarised in Table A.1.

If a comparison is made between the 20 and 30 month old animals, the figures shown in Table A.2 result.

Table A.1

The Effect of Age and Breed on Carcass Characteristics of Beef Animals

Breed	Age (months) (ave)	Live-weight at Slaughter (lbs ave)	Total Carcass Weight (lbs ave)	Kidney and Channel Fat (A) (lbs ave)	Dressing-out % with (A) in (B) (ave)	Dressing-out % with (A) out (C) (ave)	(B)-(C) (ave)
A.A.	20	985	513	14.2	52.0	50.7	1.3
H.	20	1077	568	18.6	52.7	51.1	1.6
F.	20	963	478	13.6	49.7	48.2	1.5
A.A.	30	1209	647	19.8	53.5	51.9	1.6
H.	30	1266	702	15.4	55.5	54.3	1.2
F.	30	1256	658	22.6	52.4	50.6	1.8
A.A.	20	814	412	9.0	50.6	49.5	1.1
H.	20	915	468	10.4	51.2	50.0	1.2
F.	20	933	453	10.8	48.4	47.4	1.0
J/F.	20	868	425	16.1	49.0	47.1	1.9
C/J.	20	889	448	14.8	50.4	48.7	1.7

Abbreviations:
A.A. : Aberdeen Angus
H. : Hereford
F. : Friesian
J/F. : Jersey/Friesian cross
C/J. : Charolais/Jersey cross

Source: Barton, R.A. (1968) "A Comparison between beef-bred and dairy-bred steers for Growth and Carcass Characteristics - Trial 1V". Massey Sheepfarming Annual P. 103 - 108.

Table A.2

The Effect of Live-Weight on Dressing-out Percentages

Age (months)	Average Live Wt. (lb)	Dressing-out % 1/ (B) ave.	Dressing-out % 2/ (C) ave.	Difference (B-C) ave.
20	1008	51.5	50.0	1.5
30	1244	53.8	52.3	1.5

From these observations, dressing-out percentages have increased by 2.3 per cent for an average increase in live-weight of 236 pounds. If a linear relationship is assumed, it can be hypothesised that a 100 pound increase in live-weight results in a 1.0 per cent increase in dressing-out percentage. It is also important to note however, that increases in dressing-out percentage of the same order occur whether kidney and channel fats are included or not.

For carcasses trimmed of kidney and channel fats, the following relationship may be postulated:

"The dressing-out percentage of a 1,000 pound live-weight beast is 50 per cent. For each 100 pound increase in live-weight dressing-out percentage increases by 1.0 per cent, while the reverse is true for a 100 pound decrease in animal live-weight".

Where kidney and channel fats are not excluded, dressing-out percentages are likely to be 1.5 per cent higher, as shown in Table A.2.

As the animals in the trials quoted above had been denied

1/ With kidney and channel fats included.

2/ With kidney and channel fats excluded.

access to food and water for twelve hours before their live-weight was recorded, animals weighed off pasture would have a dressing-out percentage of approximately 2.4 per cent lower as suggested by Brougham.

If the hypothesis is checked against results reported by Brougham and Barton for animals with kidney and channel fats excluded, it is found that apart from small random errors, calculated carcass weights agree closely with actual carcass weights recorded, except that a difference between breeds becomes apparent.

Breed Differences: Again based on information supplied by Barton, it is possible to compare actual dressing-out percentages of various breeds, with a figure derived using the hypothesis discussed previously.

Table A.3

Breed Differences in Dressing-out Percentages

	A.A.	H.	F.	F/J	C/J.
Trial 1					
Calculated %	49.8	50.8	49.6	-	-
Actual %	50.7	51.0	48.2	-	-
Difference	-0.9	-0.2	1.4	-	-
Trial 2					
Calculated %	52.1	52.7	52.6	-	-
Actual %	51.9	54.3	50.6	-	-
Difference	0.2	-1.6	2.0	-	-
Trial 3					
Calculated %	48.1	49.2	49.3	48.7	48.9
Actual %	49.5	50.0	47.4	47.1	48.7
Difference	-1.4	-0.8	1.9	1.6	0.2

Abbreviations: A.A. : Aberdeen Angus
H. : Hereford
F. : Friesian
F/J. : Friesian/Jersey cross
C/J. : Charolais/Jersey Cross

Source: Barton, R.A. A Series of Trials Investigating Carcass Characteristics of Beef Animals at Massey University (6, 7, 8).

From the results in Table A.3, it can be seen that while the suggested method of estimating carcass weight from animal live-weight holds generally true, there are consistent differences between breeds.

In particular, Friesians and Friesian/Jersey crosses tend to have dressing-out percentages, on average, 2.5 per cent below those of traditional beef breeds.

Summary: The hypothesis that "the dressing-out percentage of a 1,000 pound beef animal is 50 per cent and that for each 100 pound increase in live-weight dressing-out percentages increase by 1.0 per cent while the reverse holds true for a 100 pound decrease in live-weight" gives a reliable estimate for carcass weights of beef animals when kidney and channel fats have been excluded.

However, the estimate should also recognise the following:-

(a) animal live-weights should be recorded after animals have been denied access to food and water for twelve hours. Dressing-out percentages can vary by 2.4 per cent as a direct result of differences in gut contents.

(b) Friesian and Friesian/Jersey cross animals have a dressing-out percentage of 2.5 per cent lower than animals of traditional beef breeds.

(c) both Brougham (11) and Barton (8) report that animals within breeds can vary widely in dressing-out percentages. For any one animal, there would seem to be no reliable method, of accurately forecasting carcass weight from animal live-weight.

(d) if kidney and channel fats are not excluded, dressing-out percentages 1.5 per cent higher can be expected.