ECONOMICS OF DRY LOT CATTLE FINISHING OPERATIONS WITH PARTICULAR REFERENCE TO CATTLE FEEDING IN OREGON

by

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CHAPTER 1

INTRODUCTION

This study is concerned with the economics of feeding cattle in dry lot with specific reference to cattle feeding in Oregon. The specific objectives of this study are: (1) to appraise the possibility of expanded feed lot operations in Oregon and (2) to develop some guides for increasing economic efficiency in cattle feeding. These objectives are interrelated. An economic analysis of the dry lot cattle feeding enterprise is required for the attainment of both objectives. Most of the analysis and discussion emphasizes economic efficiency in cattle feeding.

The cattle industry in the west and in Oregon traditionally has been based upon the supplying of feeder cattle to corn belt and eastern feed lots. The growing of feeder cattle on ranches still is the most important phase of cattle production in the west. However, there has been a steady growth in cattle finishing operations in the western portion of the United States in the past two decades. This growth in cattle feeding operations has been due primarily to the increased demand for meat in the west and the increase in the supply of feeds available for finishing cattle for market. The increased demand for meat was due primarily to the increase in the population in the western states. The increased supply of feeds came about through the increased production of forages.

In the period from 1940 to 1952, the three Pacific coast states increased the number of cattle on feed in the dry lot from an estimated 206,000 to 447,000 head (44, p.7). The estimated number of cattle on feed in Oregon during this period has remained about the same. The number on feed in Oregon during the past decade has ranged from a low of 22,000 to a high of 32,000 with an average of 27,000 head. The expansion of cattle feeding in the Pacific coast states has been due mainly to the increased number of cattle finished for market in California.

The population of the Pacific states increased about 49 per cent during the period from 1940 to 1950 (42, pp.2, 10, 13). An additional 25 per cent increase in population for the west coast has been estimated for the period 1950 to 1960, as compared with an estimated increase of about 12 per cent for the United States in the same period (43, p.7).

It is logical to expect the expansion in population to be accompanied by an increase in the demand for beef in the west. This means an expanded market for animals finished in western feed lots.

Dry lot cattle finishing operations in Oregon are located mainly in areas with roughages available at a comparatively low cost. Roughages fed by cattle feeders are farm grown and/or are purchased locally. Cattle feeders in Wallowa, Union, and Baker Counties produce most of the roughage fed on their own farms and ranches. On the other hand, many cattle feeders in eastern and southern Oregon purchase locally all or nearly all the roughage fed cattle in the dry lot.

In northeast and southern Oregon the principal roughages fed are alfalfa and mixed hay. Beet pulp is an additional roughage supply in Malheur County. In central Oregon mixed hay and clover chaff are the main roughages utilized as cattle feed. Pea vines fed fresh or dry as ensilage, mixed hay, and alfalfa hay are the principle roughages fed in Umatilla County. Straw and silage are fed by some producers in all the major cattle feeding areas. Surplus potatoes in the potato growing areas (Malheur County, central and southern Oregon) are purchased and fed to cattle.

Feed grains are produced in all of the major cattle producing areas. The cattle feeders utilize locally produced feed grains. However, the supply of low cost roughages, instead of the feed grain production, is the principle factor in the development of feed lot operations in the state. This is because of the relatively high value of grain in the cash market.

It is logical to expect any expansion in cattle feeding in Oregon to begin in the areas already finishing cattle for market. The supply of roughages, the price of feed grains, the price of finished cattle, the price of feeder cattle, and the operating efficiency are the most important factors which will influence the future scale of cattle feeding in Oregon. Currently the price of the feed grains in relation to cattle prices is the most significant factor limiting the expansion of the dry lot cattle feeding. Either a lower price for feed grains and/or a higher price for cattle will bring about a more favorable cattle-grain ratio. The price of feeder cattle in relation to the price of finished cattle will have short-run effects on the scale of cattle feeding. Usually a margin between purchase price and selling price is necessary for success with the cattle feeding enterprise. Without this margin cattle feeding will be discouraged. Opportunities exist for Oregon cattle feeders to increase operating efficiency. Any increase in efficiency will encourage an expansion in cattle feeding operations.

Although all of the above mentioned factors influencing cattle feeding in Oregon are taken into account in this study, most of the analysis deals with operating efficiency. The major consideration in operating efficiency is feeding practices. The basic factors to take into account in feeding efficiency are the physical input-output relationships for different kinds of cattle and feed, price of feed, and prices of different grades of slaughter cattle. The price of feeder cattle in relation to the price received for finished cattle is not emphasized in the discussion, although this factor alone may be responsible for profits or losses on individual lots of cattle. Changes in value of the initial weight of the animals due to grade changes are given due consideration in the analysis.

Past experiments on cattle feeding were concerned mainly with efficiency from a physiological standpoint. The economy of gains was of a secondary consideration. Most of the past experiments were reported in such a manner that producers could be misled on the kind of feeds and feeding practices that were most economical. It is possible that combinations and kinds of feeds or feeding practices other than those reported in experimental results would have resulted in greater profits. Only a limited amount of economic analysis can be performed on the past experiments in cattle feeding because of the experimental designs used and method of recording data.

Some of the more recent experiments in cattle feeding have been designed and conducted in a manner adaptable to economic analysis. In particular, feeding trials conducted at Oregon State College for the past four years, provide input-output data in a form needed for economic analysis. The results of these feeding trials are used as the basis for most of the analysis in this thesis. Other data used in this analysis were results of feeding trials at the Idaho Experiment Station, records of feed consumption and gains of animals from Gilliam County Beef Feeders Association, and survey records of 18 feed lot operations in Umatilla and Klamath Counties.

In the chapter to follow the basic principles of cattle feeding are discussed. A brief review of past research in cattle feeding is presented in Chapter 3. The remaining chapters deal with analysis and interpretation of experimental and survey data.

CHAPTER 2

PRINCIPLES OF PROFIT MAXIMIZATION APPLIED TO THE CATTLE FEEDING ENTERPRISE

Principles for maximizing profits (or minimizing losses) in an enterprise are contained in a method called marginal analysis. As a method, marginal analysis is explained in the literature on economic theory. Some application of its use in solving agricultural problems are presented in agricultural economics literature (e.g., 5, pp.91-137, 229-271).

This chapter contains a discussion of the relevant variables for maximizing income in the cattle feeding enterprise. The structural relationships of the variables presented are based upon logical reasoning and past research findings. Marginal analysis is applied in interpreting these relationships in terms of income maximization. The analysis in this chapter is presented as a guide for analyzing and interpreting experimental and survey data. It is assumed that only one group of cattle are fed each year.

Income from the dry lot cattle feeding enterprise accrues from either one of two sources, or both: (1) increase in value of the initial weight of the animals, and (2) the margin over feed cost on the gains made by the animals. These two components of the income in cattle feeding can best be analyzed separately in order to demonstrate the effect of each variable on income.

The income component due to gains made by animals on feed first will be analyzed. This income component can be positive or negative, but most of the discussion in this chapter will deal with positive returns above feed costs on gains made by the animals. The next step will be to take grade changes into account. Change in slaughter grade during the feeding period brings about changes in value of the initial weight of the animals. These two components of income then will be integrated together to determine optimum marketing weights. A brief discussion of grain-roughage ratios to feed and uncertainties in the cattle feeding enterprise are included in the latter part of this chapter.

Physical growth of animals on feed is the basic factor in analyzing the economics of gains made in the dry lot. Physical input-output relationships (growth of animals on feed) are discussed in economics as production functions. Thus, the first step in this chapter will be to analyze the physical relationships (production functions) of cattle feeding.

Production Functions

Feed is the major input in the cattle feeding enterprise. The cost of feed for fattening cattle is about 80 per cent of the dry lot operating expenses (29, p.840). Thus, it is logical that feed be treated as the major variable input in this analysis. If the ratio of roughage and grain were held constant in the feeding period, feed could be considered one variable input. In some of the analysis to follow, feed is handled as one input and in other parts as two inputs (roughage and grain).

Other variables that enter into the production of beef in dry lot are (1) kind of feeder cattle, (2) building and lot facilities, (3) labor, etc. Different ages, sex, breed or grades of feeder cattle, as true of different kinds of feeds, result in different sub-production functions. In mathematical notation, a general production function of the form $Y = F\ (X_1, X_2 \ldots\ldots X_n)$ describes the case where all inputs vary; Y represents the output of beef and $X_1 \ldots\ldots X_n$ refer to the inputs. All inputs fixed or held constant except one is the sub-production function $Y = F\ (X_1 | X_2 \ldots\ldots X_n)$, where X_1 is the variable input and $X_2 \ldots\ldots X_n$ are fixed inputs. The variable input X_1 could be feed with kind of feeder cattle, labor, buildings, climate, etc. held constant. This is one type of function employed in this thesis. The other type is where feed is treated as two variable inputs instead of one.

The growth function or production function for beef cattle in the dry lot can be described by use of the terms diminishing, constant, or increasing physical returns. Diminishing physical returns occur when each additional unit of feed input adds less to the total weight than the preceding unit of input. Constant returns occur when each unit of feed input results in the same amount of output or gain in liveweight. Increasing returns occur when each additional unit of input results in greater total output than the preceding unit of feed input.

The prevalence of a combination of increasing, constant and diminishing returns in the growth function of cattle from birth to maturity is suggested by the following:

> "The curve representing the course of growth in weight or volume has a characteristic sigmoid form. There is no exception to this statement. It hold for growth of individual multicellular animals and plants and also for the growth of populations of unicellular or multicellular animals" (7, p.27).

The phase of diminishing returns of the growth function begins prior to the stage in which animals are put in dry lot. That most of the growth function of cattle encompasses diminishing returns is implied by the following statement by Hendricks, Jull and Titus (22, p.428):

> "It is common knowledge among workers in animal nutrition that the feed intake is used in two different ways. One portion is used to supply fuel required to carry on the metabolic activities of the animal and may be designated as the maintenance requirement. The other portion is used for growth and incorporated into the body tissues producing a gain in liveweight. It is self evident that if no feed were required for maintenance and if the fraction of the feed incorporated into the body tissues was always of the same chemical composition, the liveweight (W) of a growing animal would be a linear function of feed consumption (F). Since some feed is used for maintenance and the amount required for this purpose is known to increase as the animal becomes larger, $\frac{dW}{dF} = C$ cannot be constant but must be some diminishing function of liveweight".

The animal utilizes more nutrients for body maintenance as its body weight increases. Thus, the requirements for body maintenance increase throughout the feeding period. With the same chemical composition of the ration, the animal can increase the nutrient intake by eating more, but the increase in nutrient intake over the feeding period is less than the increase in body maintenance requirements. Therefore, the proportion of the nutrient intake available for gains in weight diminish. This is why the rate of growth cannot be constant but must diminish.

One would expect a change in chemical composition of the ration over the feeding period such as increasing the proportions of grain to decrease or eliminate diminishing returns for a considerable period of time. The change in the composition of the ration is equivalent to a change to another (higher) growth or production function. This change in composition of the feed by increasing the proportion of grain could be expected to be an economical practice so long as the cost of the gains in weight did not exceed their value.

The phase of diminishing returns for cattle fed a ration of the same chemical composition is attained at about five months of age (7, p.33). Hence, when cattle are placed in the feed lot they are generally of an age where they are in the diminishing returns phase of their growth. A change to a fattening ration may result in constant or increasing returns for a short period of time. Diminishing returns again will take place unless the composition of the ration can be changed to make the increased nutrient intake proportionate to the increased maintenance requirement.

Returns Above Feed Costs

Three factors effecting returns above feed costs on gains made by cattle in the dry lot are (1) efficiency of converting feed into pound gains, (2) price of feeds, and (3) price of slaughter cattle.

Efficiency of Converting Feeds into Gains

Different production functions of cattle in the dry lot may be due to differences in grade, age, and sex of animals provided the same ration is fed. Also animals will vary in rate of gain because of differences in their inherited ability to gain.

The grade of feeder cattle will affect the rate of gain of the animals and, therefore, the returns above feed cost. Experiments have shown that well-selected common grade or medium grade feeders have made the same gain as choice feeders with less feed than required for choice feeders (28, p.795). This was because of the thinner condition of lower grade feeders. However, one cannot expect to attain as high a slaughter grade for the common and medium feeders as with good to choice feeder cattle.

Differences in the growth of calves, yearlings, and two year olds as reported by Nelson (30, p.9) are shown in the top portion of Figure 1. It can be noted that the growth functions have less slope as the age of the animals increase. This indicates that calves make a higher rate of gain per unit of feed input than yearlings. In turn, yearlings make a higher rate of gain per unit of feed input than two year olds. These differences in rates of growth are shown in the lower portion of Figure 1.

Animals with higher additional gains per unit of feed input will return a greater margin above feed costs than animals less efficient in converting feed into pounds of growth. Therefore, returns above feed cost will be higher for calves than for yearlings or two year olds (assuming the animals have the same inherited ability to gain). The point of maximum returns above feed cost on the gains made by animals in the dry lot also will occur at a higher level of feed inputs for calves than yearlings or two year old cattle.

In research at the University of Missouri Experiment Station it was found that the growth curves (beginning at two months of age) flattened out at two years of age for cows, whereas steers flattened out at about four years of age (8, p.4). It is believed that the removal of the gonads may delay the ossification which is the major point of inflection in the growth curve just as removing flowers from tomato plants may delay their point of inflection (8, p.6).

According to Morrison (29, p.803):

> "Though heifers do not make as rapid gains as steers, they become fat sooner and therefore do not require so long a feeding period".

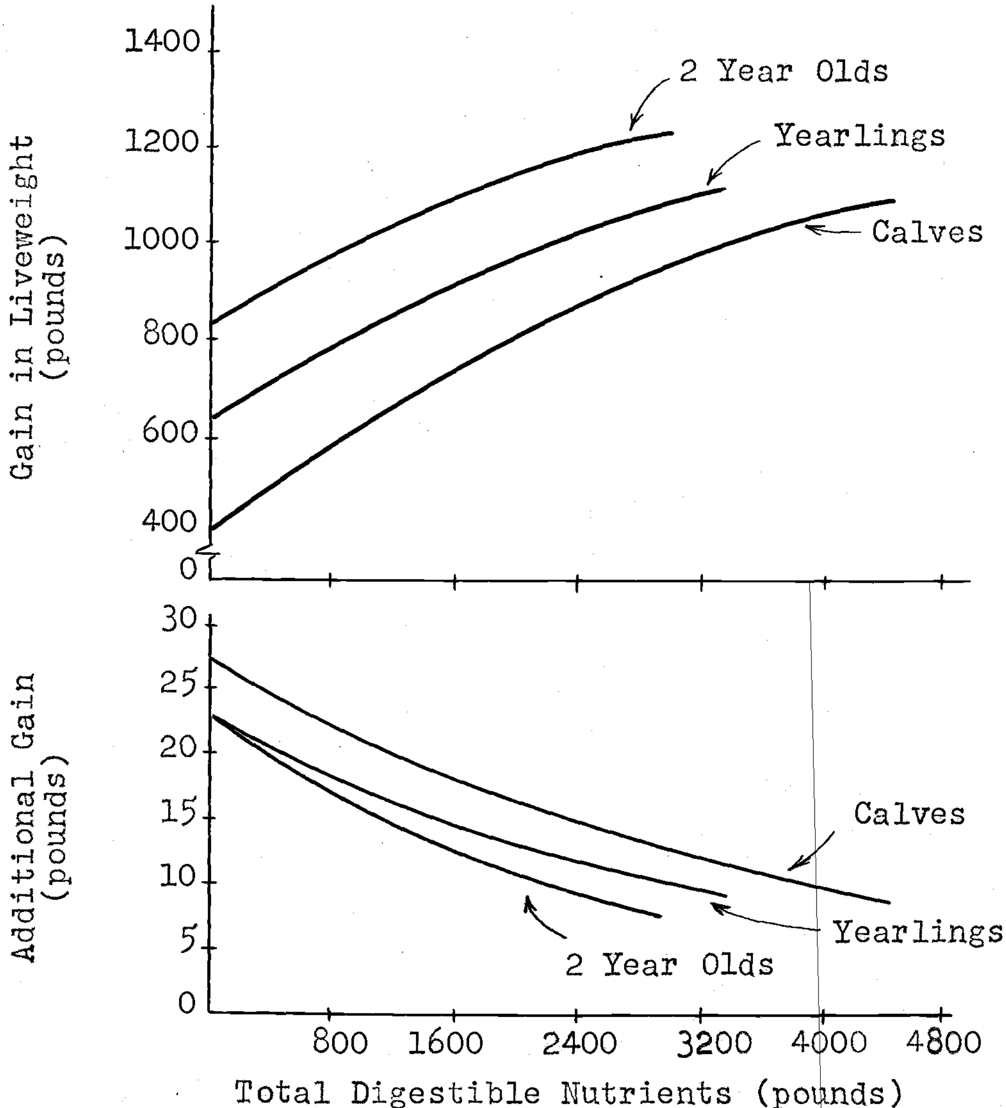

Figure ~~1.~~ 2 Differences in Growth of Calves, Yearlings, and Two Year Old Cattle in Dry Lot. (Based on data obtained in U.S.D.A. Tech. Bul. 900, pp. 9-10)

The top portion of Figure 2 represents hypothetical growth functions for heifers and steers in dry lot which correspond to the difference in growth expressed by Morrison. Differences in additional gains per unit of feed fed are illustrated in the bottom portion of Figure 2. With the growth higher for steers, one can expect returns above feed cost also to be higher than for the heifers.

Price of Feed and Slaughter Cattle

The economic implications of growth differences discussed earlier can be more clearly presented by changing the physical units of feed and gains into value units. This is done by use of feed and cattle prices. Returns above feed cost accumulate to a maximum so long as the value of additional gains are worth more than additional feed cost. Only the marginal gains and feed inputs need to be considered in determining relative returns above feed cost and points of maximum returns above feed cost for two or more different rates of growth.

Figure 3 can be used to demonstrate the effect of different rates of growth on returns above feed cost. Curves AB and CD can represent the value of additional gains for two animals. At a feed price OP_2, returns above feed cost increase to a maximum at the OX_2 feed input level on the less efficient animal. An additional quantity of

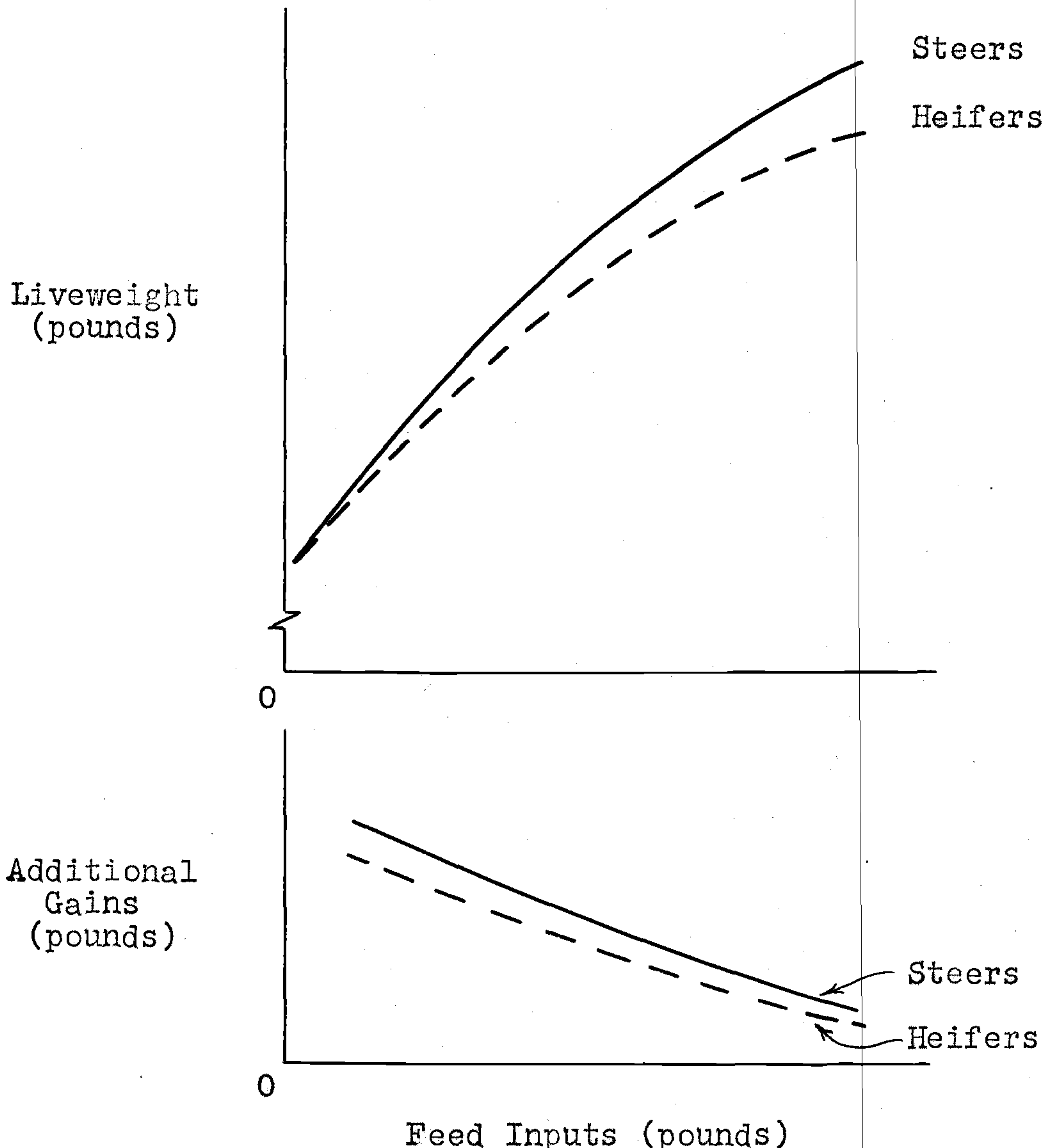

Figure 2. Hypothetical Growth of Steers and Heifers in Dry Lot.

feed (X_2X_4) is required to reach the point of maximum returns above feed cost for the more efficient animal. Also, the level of returns above feed cost for the more efficient animal is higher.

The effect of different feed prices can be demonstrated by the use of Figure 3. The two different feed prices can be represented by OP_1 and OP_2. At the feed price OP_1, returns above feed costs attain a maximum when OX_1 feed units have been consumed (on value of additional gains curve AB). A drop in the price of feed from OP_1 to OP_2 results in an increase in the level of feed inputs from OX_1 to OX_2 to reach a maximum returns above feed cost. It can be observed that the higher level of returns above feed costs occurs with the lower feed price.

A change in slaughter price has the same effect on returns above feed costs as the different rates of growth of animals discussed previously. Instead of curves AB and CD representing animals growing at two different rates, these curves can represent the same schedule of additional gains valued at two different prices.

It can be noted from the value of additional gain curves in Figure 3 that the rate of growth diminishes throughout the feeding period. In the case of constant instead of diminishing returns, these two curves would be

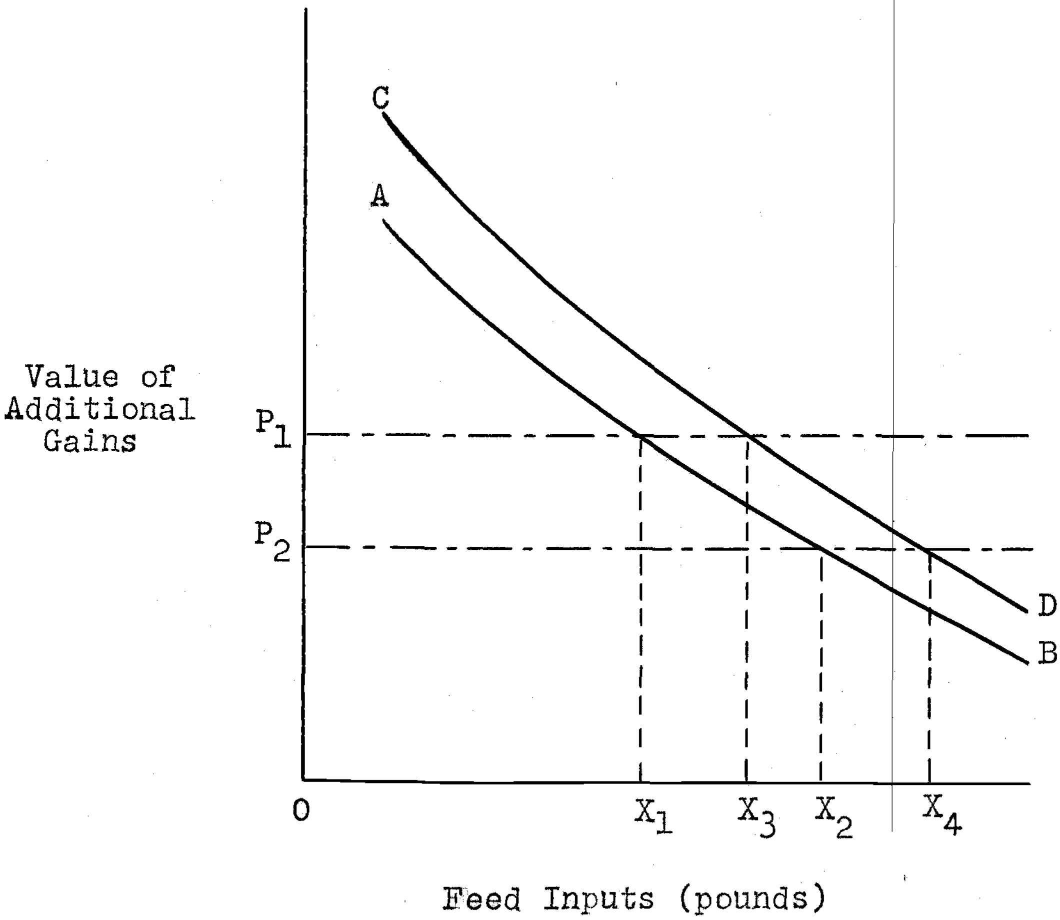

Figure 3. Graphic Illustration of Effect of Different Feed Prices and Value of Additional Gains on Returns Above Feed Costs.

horizontal lines. In this situation maximum returns above feed costs may not occur within the feeding period. However, the effect of different feed prices and the prices of slaughter cattle on the level of returns above feed cost would be the same as demonstrated for diminishing returns.

Total Value Change of Animals in Feeding Period

In the previous section, the effect of different rates of growth of animals, price of feed, and price of cattle upon returns above feed cost was discussed. Points of maximum returns above feed costs may not be consistent with the optimum market weight of cattle. This is because of the change in value of the initial weight of the animal with changes in slaughter grade during the feeding period. The conditions in which maximum returns above feed costs will be consistent with the optimum market weights of cattle are: (1) when the market price is the same for all slaughter grades, (2) when maximum returns above feed cost occur in the highest slaughter grade, and (3) when the value of gains from one grade change to the next is less than the decrease in returns above feed costs beyond the maximum.

Maximum returns above feed costs will be inconsistent with the optimum market weight when the change in value of initial weight with changes in slaughter grades more than offsets the decreases in returns above feed cost beyond the maximum.

The optimum market weight occurs when the total net change of value of the animal reaches a maximum (taking into consideration the returns above feed costs and change in value of the initial weight). Figure 4 can be used to illustrate graphically the conditions whereby the maximum returns above feed costs would be inconsistent as well as consistent with the optimum market weight.

In Figure 4, curves OA, OB, and OC represent returns above feed cost, change in value on initial weight of animals due to grade changes, and total net change in value, respectively, during the feeding period. Returns above feed cost (OA) and change in value of initial weight (OB) are added together to obtain the total net value change (OC). Maximum returns above feed cost occurs when OX_1 units of feed have been consumed. Beyond this point returns above feed cost decline. However, the value of the initial weight of the animal continues to increase beyond this point of maximum returns above feed cost. This increase in value of initial weight is sufficient to offset the decline in returns above feed cost as noted by the

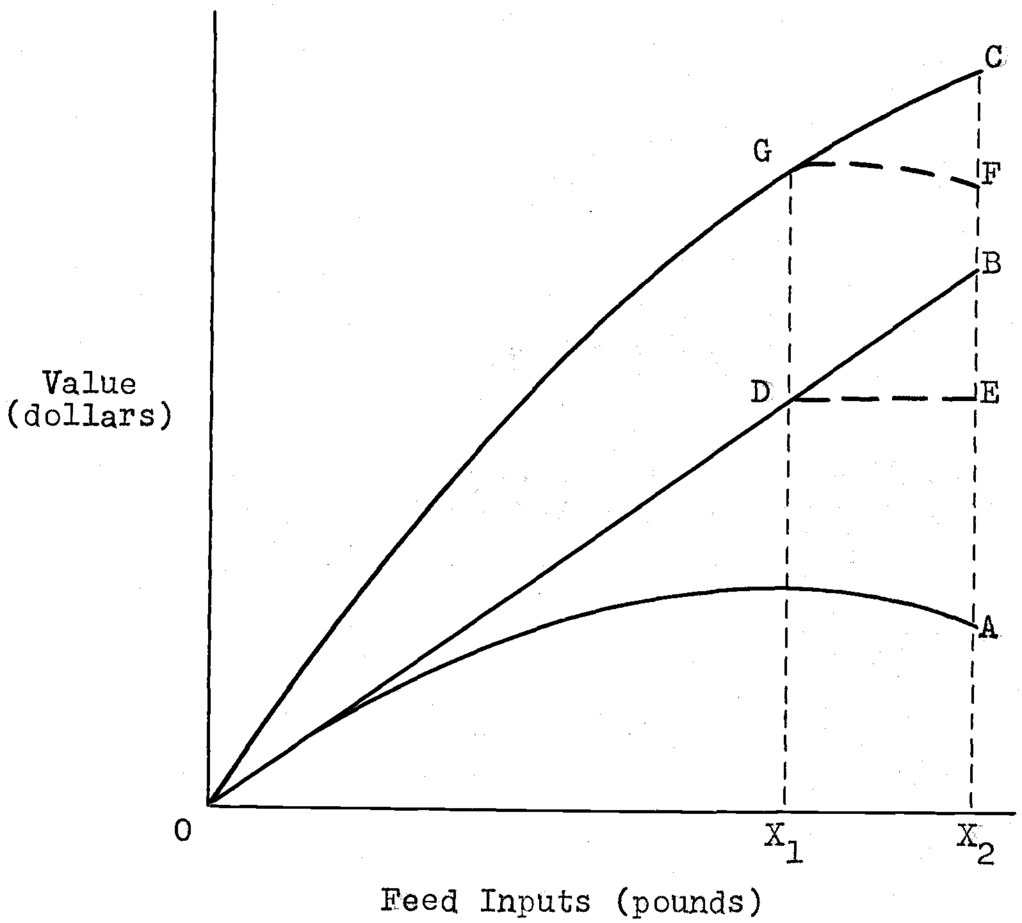

Figure 4. Illustration of Returns Above Feed Cost, Change in Value of Initial Weight, and Total Value Change of Animals in Dry Lot.

total net value change (OC). In this illustration, the optimum time to market would be at the feed input level OX_2 or higher.

The maximum returns above feed costs would be consistent with the optimum market weight when the change in value of initial weight is represented by ODE, (Fig. 4), and the total net returns by OGF. Here the returns above feed costs (OA) and change in the value of initial weight (ODE) are added together to obtain the total net value change (OGF). The optimum market weight occurs when OX_1 units of feed have been consumed, the same as the point of maximum returns above feed cost. The result would be the same had the value of initial weight ceased to increase at any point prior to the OX_1 level of feed inputs, or the point of maximum returns above feed cost on gains made by the animals in dry lot.

Grain-Roughage Ratio in Feeding Cattle

Few experiments have been conducted for the purpose of determining the possibilities of varying the ratio of grain to roughage in fattening beef cattle. As a general practice, most farmers feed more roughage when it becomes cheap in relation to the price of grain. On the other hand, when the price of grain becomes cheap relative to the price of roughage, more grain is fed. By determining the different combinations of grain and roughage which will result in the same output of beef, the optimum ratio to feed under any given grain-hay price relationships can be ascertained. A geometric illustration of this is given in Figure 5. Here the product contour representing 100 pounds of beef is ZZ'. The line PP'represents one price ratio of grain to roughage. At the point of tangency of this feed price ratio line with the product curve (ZZ'), a grain-roughage ratio is defined that when fed will represent a minimum feed cost in obtaining 100 pounds of gain. When the price of roughage becomes higher in relation to the price of grain, as indicated by the price ratio line PP', the minimum cost ratio shifts to OY_2 grain and OX_2 roughage. When the price of grain becomes higher in relation to the price of roughage, as indicated by the price ratio line QQ', the minimum cost ration is at OX_3 units of roughage and OY_3 units of grain.

These illustrations on the ratio of grain to roughage to feed for a minimum feed cost per 100 pounds of gain apply in case a constant ratio of grain to roughage is fed throughout the feeding period. When the ratio changes during the feeding period, as in case of an increasing

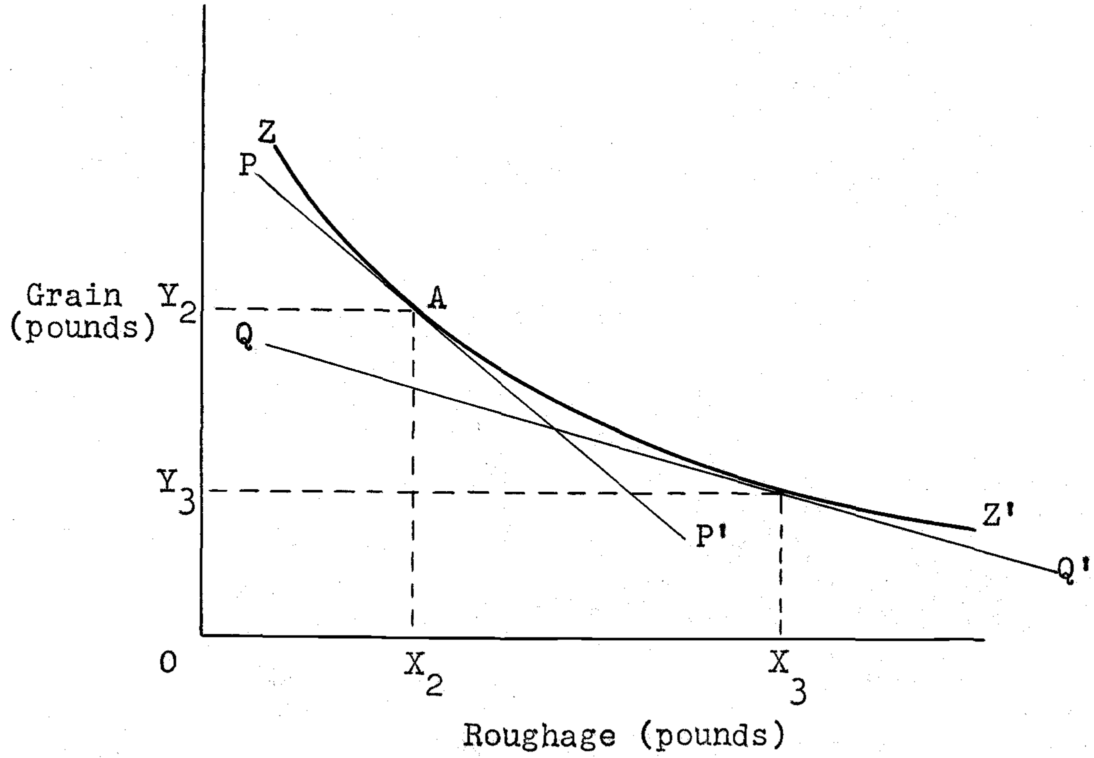

Figure 5. Illustration of Possibilities of Changing Grain-Roughage Ratios in the Ration with Varying Feed Price Relationships.

proportion of grain in the ration, the constant product contour still may approximate the possibilities in changing the average ratio for the feeding period.

Uncertainty

Up to this point in the discussion, fluctuating cattle prices, feed prices or irregular rate of gain have not been taken into account. Producers are aware of the possibilities of financial losses when the feeding period is lengthened through lower cattle prices, death losses, etc. Also, there is a possibility of a financial gain when marketing is delayed. The relevant future events (prices, mortality, etc.) for ascertaining how long to feed cattle cannot be predicted with certainty. They are uncertainties. The risk a cattle feeder incurs usually increases with the length of the feeding period because of the increase in investment per animal. This increase in risk may tend to cause the producer to sell cattle out of dry lot short of the most profitable time determined on the basis of no change or a predicted change in the relevant variables.

It is not the purpose of this study to fully analyze the uncertainties in cattle feeding with the intent of giving producers guides on how to reduce the impact of the different risks. Such would require another study.

However, the analysis in this study by handling the variables as if their magnitudes were known with certainty will contribute toward reducing the uncertainty in cattle feeding. This will be so if any contribution is made by this study to increase knowledge about cattle feeding economics.

CHAPTER 3

REVIEW OF LITERATURE

Most of the past experiments in cattle feeding have been conducted for the purpose of comparing gains made by different kinds of cattle, or gains made by comparable cattle on different rations. Different breeds, ages, sexes and grades of feeder cattle have been included in tests to compare gains made in dry lot. Different feeds and combinations of feeds in rations have been tested to determine their comparative value. The findings from these types of experiments have economic significance to cattle feeders. However, in most of the past experimental work in cattle feeding, economic objectives were not integrated with the biological objectives. Thus, the data obtained have a limited amount of adaptability for an economic analysis.

This chapter presents a brief summary of some research findings on growth of different kinds of cattle in dry lot and growth of cattle on different rations. Kinds of cattle include cattle of different age, sex, and grade. Experiments on rations reviewed include tests on the comparative value of different feeds in the ration and on the possibilities of varying the ratio of grain and roughage.

Experiments With Cattle of Different Age, Sex, and Grade

Culbertson, Evvard, and Hammond (13, p.240) reported that two year old steers made greater gains during their finishing period than yearlings and calves but they required more feed per hundredweight of gain. Calves required the least feed per hundredweight of gain.

Experiments at New Mexico Agricultural Experiment Station (36, pp.6-7) indicated that age was the most important factor in controlling gain per unit of liveweight, and that younger cattle steers tended to use their feed for body growth while older steers had more of a tendency to fatten. Younger steers required less feed per 100 pounds of gain.

Gramlich and Thalman (16, p.4) reported that two year old cattle required about 50 per cent more feed to produce a 100 pound gain than calves, and that yearlings required about 25 per cent more feed to produce a 100 pound gain than calves.

Experiments have shown that well selected common grade or medium grade feeder cattle will make fully as rapid and cheap gains as will good to choice feeders which are of better beef type and confirmation. This is chiefly because the lower grade feeders are generally thinner in flesh than the better cattle (29, p.795).

Hankins and Burk (19, p.36) concluded that fancy feeder steers indicated a distinct ability to produce prime carcasses but relatively large gains were required to produce that result. Choice and good feeders showed a tendency to produce carcasses no higher than choice, regardless of gains made.

Stangeland (37, p.16) stated that the range in findings on the amount of gain needed to bring choice feeder calves in dry lot to a slaughter grade of choice varied from 240 to 500 pounds. The amount of gain required to bring choice feeder calves to a prime carcass varied from 380 to 600 pounds.

Trowbridge and Moffett (41, p.23) found that steer calves gained more rapidly than heifer calves and required less feed than heifers to produce an equal amount of weight. The calves were of similar age, size and fleshing and were fed the same feed mixture during the fattening period. Morrison (29, p.803) reported that steers make more rapid gains than heifers.

Experiments With Different Rations

Past experiments with different rations for cattle have provided the basis for the development of feeding standards and for recommendations to farmers on how best to utilize available (local) feeds. Most of the research on rations has been in determining the comparative gains of animals fed different feeds (different grains, roughages, etc.). A limited number of experiments have been conducted for the purpose of determining how gains vary with the feeding of different ratios of grain to roughage.

Kinds of Feeds

The literature reviewed on kinds of feed was mainly the result of experiments on different grains and roughages. Comparisons of the feeding value of corn, wheat, oats, and barley were emphasized in this review.

Comparison of Grains

Morrison (29, p.476) states that corn excels as a grain for cattle feed because of its richness in total digestible nutrients and its palatability to cattle. Therefore, in many experiments corn is taken as a standard with which other grains are compared.

Haney and Elling (18, p.305) reported that calves fed ground wheat and alfalfa hay for 182 days in the dry lot made less gains than similar calves fed corn and cob meal and alfalfa hay.

Baker (21, p.7) found that calves gained less rapidly when fed ground wheat and alfalfa hay than when the grain was shelled corn or equal parts of shelled corn and ground wheat. Calves fed the mixture dressed higher and graded slightly higher in the carcass than those fed only wheat as the grain.

Weber and Connell (48, pp.5-6) stated that experiments and experiences up to 1931 have indicated rather consistently that corn should be rated somewhat higher than wheat when fed as the only grain to fattening steers.

Trowbridge and Moffett (40, p.2) stated that cattle consumed slightly larger quantities of whole wheat than they did shelled corn, but that gains were not as rapid with whole wheat. They reported that grinding wheat coarsely as a feed for fattening cattle increased the value of the grain about 10 per cent. When ground wheat was substituted for as much as half the full ration of shelled corn, gains produced were slightly more rapid than when shelled corn was fed. When ground wheat was substituted for all the corn, cattle consumed less grain; they gained less rapidly; and produced carcasses with less finish. Bloating, scouring and other digestive disturbances occurred more frequently when wheat constituted the sole grain in the ration.

According to Linfield (28, p.79) a mixture of ground wheat, ground oats, and barley was more satisfactory than ground wheat, ground oats, or barley when fed alone to fattening cattle.

Hickman (49, pp.42-43) compared a ration of wheat and alfalfa hay with a ration of barley and alfalfa hay. He reported that yearling cattle receiving ground wheat and alfalfa hay made slightly more gain than similar cattle fed barley as the grain. Substitution of oats for 25 per cent of the wheat resulted in essentially the same rate of gain.

Morton and Osland (30, pp. 1-2) concluded that calves fed equal parts of ground corn and ground wheat with a basal ration of cottonseed cake, wet beet pulp, alfalfa hay, mineral, and salt gained approximately 10 per cent more rapidly than similar calves fed either ground wheat, ground barley, or ground corn and barley. Calves fed ground wheat took to their feed slowly. They also sold for less per hundredweight, but dressed out as well as did the other lots.

According to Morrison (29, pp.504-505), fattening cattle fed wheat as the only grain gained less rapidly than those fed corn, but they required less feed per

100 pounds of gain when wheat was fed. Frosted or shrunken wheat was fully equal in feeding value to wheat of good milling grade.

Experimental results reported by Morrison (29, p.515) have shown that fattening cattle made about the same gains on ground barley as on shelled corn. However, the cattle fed barley usually sold for a lower price. The cattle fed barley required less feed per 100 pounds of gain. When pork was produced behind the cattle, the barley was worth about 88 per cent as much as the shelled corn.

Hoffman, Bogart, and Burris (25, pp.5-6) stated that ground corn and ground barley produced nearly identical rates of daily gain on yearling Hereford steers during a four year trial. The roughage used was a mixture of first and second cutting alfalfa hay. Rolled barley and ground barley produced nearly identical gains. Bloat hazard was far greater with barley than with corn.

From the results of a series of experiments conducted by the Oregon Agricultural Experiment Station (9, p.3) on feeding wheat to beef cattle, it was concluded that wheat was equal to or better than barley or other feed grains in the fattening ration. These were eastern Oregon tests.

Blizzard (4, p.20) found that a pound of No. 2 oats was 85 per cent as valuable as a pound of corn when oats replaced half the corn in a calf fattening ration. Also he concluded that feeding one-half oats and one-half corn was superior to feeding all oats the first half of the feeding period and all corn the second half of a 170 day feeding period.

The following comparison was made of the value of grains to corn by Beresford (2, p.356):

Feed	Weight per bu.	% of corn value per cwt.
Shelled corn	56	100
Barley	48	80-90
Wheat	60	100
Oats	32	70-75
Rye	56	70-80

Comparison of roughage. Ensminger (15, p.23) stated that there was practically no difference in daily gain between yearling steers fed alfalfa hay and those fed pea vine hay. Steers fed oat hay and rye hay made significantly smaller gains than steers fed alfalfa hay.

In a Wisconsin study (29, p.378) it was found that a ton of pea vine silage was worth 75 per cent as much as a ton of corn silage in fattening cattle when each was used along with ground ear corn, alfalfa hay, and protein supplement.

Morrison (29, p.418) indicated that cattle made about the same gain when fed grass hay with protein and calcium supplements as when fed legume hay. The grass hay ration generally required more feed per 100 pounds of gain.

According to Hackedorn (17, pp.8-11), two year old steers fed alfalfa hay and a grain ration of 50 per cent wheat, 25 per cent oats, and 25 per cent barley gained 15 per cent more than steers with wheat hay substituted for the alfalfa hay. When steer calves were fed these two rations, the gains were 35 per cent more for those fed the alfalfa hay than those fed the wheat hay. A mixture of wheat hay and alfalfa hay, half and half by weight, proved as efficient for calves as the alfalfa hay.

Beresford (2, p.371) stated that almost any roughage palatable enough for cattle to eat could be used in feeding cattle provided it was properly supplemented. An estimate of the feeding value per ton of different roughages using alfalfa hay as a basis for comparison are shown below:

Feed	Per cent value of alfalfa hay
Alfalfa hay	100%
Red clover	90%
Oat hay	75%
Timothy hay	70%
Prairie hay	65%
Corn silage	35%
Oat straw	25%
Wheat straw	20%

Thalman (39, p.36) reported slightly higher gains of yearling steers when wheat straw was mixed with alfalfa hay along with a basal ration of shelled corn, cottonseed cake, and minerals than cattle fed only wheat straw and the basal ration. The feed required per 100 pounds of gain was approximately the same for both groups, although the group receiving wheat straw consumed a little less roughage and slightly more grain. Gains and feed efficiency of these two groups were similar to yearling steers fed shelled corn and alfalfa hay.

Ensminger (15, p.25) found no significant difference between the rate of gain of steers fed sweet corn refuse and those fed corn silage or between steers fed either of the silages and those fed alfalfa hay.

Grain-Roughage Ratios

Numerous experiments have been conducted to determine the most profitable amounts of grain to feed to fattening cattle of various ages and under different conditions. These experiments have indicated that when full use is made of high quality roughage cattle can be fattened sufficiently to yield desirable carcasses with much less grain than was formerly believed necessary (29, p.789).

Most of these experiments have not been conducted or reported in a manner that will permit determination of the most profitable combination of grain and forage to feed. The past experimental results are useful for rough guides but need to be refined for more accurate determination of forage-grain substitution possibilities.

Heady and Olson (31, p.8-9) have done some initial work on substitution rates of grain and forage for feeding beef cattle. The grain-forage substitution rates that they computed for the production of 100 pounds of gain on choice yearling feeder steers are shown in Table 1.

Keith, Johnson, and Lehrer (26, pp.1-15) conducted an experiment on the optimum ratios of concentrate to alfalfa hay for fattening steers. The data from this experiment are analyzed in another section of this thesis.

Table 1

Forage and Grain Feed Combinations and Substitution Rates in Production of 100 Pounds of Gain on Choice Yearling Feeder Steers. (Data obtained from U.S.D.A. circular no. 905, p. 9)

Feed combinations for producing 100 lbs. of gain in weight: Forage	Feed combinations for producing 100 lbs. of gain in weight: Grain (lbs.)	Avg. quantity of grain replaced per lb. of forage added (lbs.)	Avg. quantity of forage required to replace a pound of grain (lbs.)	Forage as % of total feed (%)
Pounds:				
400	953.4			29.6
		0.353	2.83	
600	882.7			40.5
		.326	3.07	
800	817.5			49.5
		.298	3.36	
1000	757.9			56.9
		.271	3.69	
1200	703.9			63.0
		.249	4.02	
1400	654.0			68.2
		.211	4.74	
1600	611.8			72.3
		.189	5.29	
1800	574.0			75.8
		.166	6.02	
2000	541.8			78.7
		.133	7.52	
2200	515.1			81.0
		.111	9.01	
2400	493.8			82.9
		.079	12.50	
2600	478.0			84.5
		.056	17.86	
2800	467.8			85.7
		.024	41.07	
3000	463.0			86.6

CHAPTER 4

SOURCE OF DATA AND METHOD OF ANALYSIS

The following data were used for analysis in this study:

(1) Feed and growth records obtained in feeding trials by the Oregon Agricultural Experiment Station.

(2) Feed and growth records obtained in tests conducted by the Gilliam County Beef Improvement Association.

(3) Grain-roughage ratio experimental data obtained in feeding trials by the Idaho Agricultural Experiment Station.

(4) Survey records on feeding practices of 18 cattle feeders in Umatilla and Klamath Counties.

Feeding Trials

The data obtained in feeding experiments by the Animal Husbandry Department at Oregon State College consisted of growth and feed consumption records on bull, heifer, and steer calves. These data were obtained in experiments covering the four year period, 1949-1953. An analysis of the growth of heifers and bulls in the feeding trials of 1949-1953 has been made and reported by Dahmen and Bogart (14, pp.1-23). The same data on heifers and bulls were analyzed again in this study. There is very little duplication of the two analyses because of the differences in objectives.

Experimental Methods

Animals included in the three trials from 1949-1952 were purebred Hereford bulls, Angus bulls, Angus heifers, grade Hereford heifers, and grade Hereford steers. Three different proportions of grain and roughages were fed to the animals during these trials. Each calf received one part grain and three parts hay until a weight of 600 pounds was obtained. From a weight of 600 pounds to 700 pounds the ratio was one part grain and two parts hay; from 700 pounds to 800 pounds the calves were fed one part grain and one part hay.

The feeding period for each calf was terminated when slightly over 800 pounds liveweight ere attained. Initial weights averaged about 450 pounds per calf. The roughage fed was a high quality chopped alfalfa hay. The grain mixture is shown in Table 2.

Liveweights were taken at two week intervals and the weights and feed consumed for each period were recorded on individual forms for each calf throughout the feeding period.

Table 2

The Grain Mixture Used in the Experimental Feeding During the 1949-1952 Trials.

Feed Stuff	% of Mixture
Rolled barley	60.0
Ground oats	20.0
Dried beet pulp	10.0
Wheat bran	5.0
Soybean meal	2.5
Linseed meal	1.0
Dried skim milk	0.5
Bone meal	0.5
Salt	0.45
Irradiated yeast (9,000 units Vitamin D per gram)	0.05
TOTAL	100.00

In the feeding experiment in 1952-53 purebred Hereford bulls, Angus bulls, Hereford heifers, and Angus heifers were individually fed a constant proportion of grain and hay. The ration consisted of one part of grain and two parts of No. 2 alfalfa hay. The feed was fed in the form of pellets. The feed mixture is shown in Table 3.

Liveweights were taken at fourteen day intervals and weights and feed consumption for each interval were recorded for each calf. The feeding period terminated when each individual calf attained a weight of about 800 pounds.

Selection of Animals for Inclusion in Analysis

The following method was used in the selection and grouping of the data from the 1949-52 experiments for inclusion in this study:

(1) Calves in each experiment were divided into separate classes on the basis of sex and breed.

(2) Individual growth data were plotted for each calf.

(3) From these classifications animals were selected that had similar initial weights and growth patterns. Also calves which failed to gain over a significant period of time as a result of being off feed or sick were eliminated from the analysis.

Table 3

Feed Mixture Used in 1952-1953 Experimental Feeding Trial with Constant Proportion of Grain to Roughage.

Feeds	% of Mixture
Alfalfa hay (No. 2)	66.5
Molasses	5.0
Rolled barley	15.0
Ground oats	5.38
Beet pulp	3.25
Wheat bran	2.25
Soybean meal (44%)	1.75
Linseed meal (32%)	0.35
Steamed bone meal	0.175
Dried skim milk	0.20
Yeast	0.009
Salt	0.15
TOTAL	100.014

(4) By use of regression techniques growth curves were estimated for each of the groups classified on the basis of sex and breed. Since the calves were fed three different proportions of grain to hay during the feeding period, three different growth functions were estimated for each class of animals. One growth function included the feed inputs and gains up to a liveweight of 600 pounds; the second, from a liveweight of 600 to 700 pounds; and the third, from a liveweight of 700 to 800 pounds. These growth curves corresponded to the grain to hay ratios of 1:3, 1:2, and 1:1 during the three periods.

(5) The animals then were grouped into categories consisting of grade and purebred heifers, grade steers, and purebred Angus and Hereford bulls. These groupings were made by combining the classes of animals with similar growth patterns. Growth functions for each of the three groups of animals were estimated by statistical techniques.

Animals in the 1949-1952 feeding trials by groups and the number in each group used in this study were: (a) fourteen grade Hereford steers, (b) thirty-six grade and purebred Hereford heifers, and (c) twenty-nine purebred Angus and Hereford bulls.

Records on all calves in the 1952-53 feeding trials were not complete at the time this analysis was made.

All the calves with complete feed consumption and growth records were included in this study. The calves included were divided into the following groups for estimation of growth functions: (a) purebred Angus and Hereford bulls (16 head), and (b) purebred Angus and Hereford heifers (16 head).

Statistical Procedure

Curvilinear regression techniques were used in estimating growth curves for the calves selected for inclusion in this study. The data were fitted to the quadratic equation $Y = a+bX+cX^2$, where Y was gain in weight and X was quantity of feed consumed. Grain and hay were combined and treated as one input. Estimation equations were determined for each period of growth where the same ratio of hay to grain was fed. The b and c coefficients were tested for significance. In some cases the X^2 term was dropped when found not to be significant and the equation reduced to the form $Y = a+bX$.

Other types of regression models, such as logarithmic functions, could have been used. The quadratic form was chosen because results obtained were adequate for the purpose intended. Perhaps a logarithmic function would correspond more closely to the theoretical growth pattern of animals.

Gilliam County Tests

Gilliam County Beef Cattle Improvement feeding tests for 1952-53 were available for inclusion in this study. The calves selected from these feeding tests included 10 Hereford heifers and 24 purebred bulls of various breeds.

The calves were individually fed for a period of 154 days. They received a ration containing one part grain to two parts hay be weight during the first 84 days of the feeding period. During the last 70 days this was changed to one part grain and one part hay. The roughage consisted of two-thirds alfalfa and one-third beardless wild rye grass. The concentrates consisted of 30.7 per cent wheat, 30.7 per cent oats, 30.7 per cent barley, and 8.0 per cent cottonseed meal. Trace mineralized salt and bone meal were kept before the calves at all times. The calves were fed twice daily at regular hours.

At twenty-eight day intervals the calves were individually weighed. Weights and the feed consumption for each period were recorded for each animal. The average initial weight of the bulls was about 500 pounds, and the average final weight was about 890 pounds. The heifers averaged about 450 pounds at the beginning of the feeding period and had an average weight of about 750 pounds at the termination of the test.

The statistical techniques used in the analysis of this data were the same as those used for the Oregon data. Since these cattle were fed two different proportions of grain and hay, two functions for the dry lot feeding period were determined.

Grain-Roughage Ratio Experiments

Data from two experiments (26, pp.1-15) at the Branch Agricultural Experiment Station at Caldwell, Idaho, were used for estimating constant product functions. The feeding period was for a period of 154 days for calves and 126 days for yearling steers.

In one experiment sixty grade Hereford steer calves were fed grain and alfalfa hay for a period of 154 days. These calves were divided into six lots of ten animals each. A different ratio of grain to hay was fed each lot. The ratios of grain to hay for the six lots were 4:1, 3:1, 2:1, 1:1, 1:2, and 1:3. The animals were fed twice daily at approximately 12 hour intervals in individual stalls without shelter. They were allowed to exercise in lots between feedings. Water and salt were available to the animals at all times.

The grain mixture was composed of 46 parts ground barley, 22 parts ground oats, 22 parts dried molasses beet pulp, 8 parts cottonseed oil meal and 2 parts salt. The alfalfa hay was chopped. The grain and the hay were weighed for each individual feeding and then mixed and fed together.

In the second experiment forty yearling Hereford steers were fed grain and alfalfa hay for a period of 126 days. These forty steers were divided into five lots of eight steers each. The five ratios of grain to alfalfa hay fed were 3:1, 2:1, 1:1, 1:2, and 1:3. All steers were fed individually in stalls. They were fed the same grain mixture as the calves in the previous experiment. The ratios of grain to hay were kept constant throughout the 126 day feeding period.

These data were used for estimating constant product curves of 300 pounds for calves and 200 pounds for yearlings. The data were fitted to the general quadratic equation $Y = a+b_1X_1+b_2X_2+b_3X_1^2+b_4X_2^2+b_5X_1X_2$ where Y was the gains of the animals, X_1 was pounds of gain, and X_2 was pounds of hay.

The experimental procedure employed to obtain these data has definite limitations from the standpoint of attaining economic objectives. The appropriate procedure in obtaining data for determing the optimum ratio of grain to roughage to feed would be to feed each lot to the same average gain (e.g., 200 pounds or 300 pounds). This would mean feeding cattle on the low ratio of grain to roughage longer than the lots fed a high proportion of grain because of the lower rate of gain made by animals fed the smaller quantities of grain.

Forty animals in the calf experiment were selected for inclusion in the analysis. An attempt was made to select animals with about the same average initial weight and gain per lot. The selection process was necessary in order to satisfy the condition of having the same amount of gain for each ratio of concentrate to hay fed. The number of animals selected for each concentrate to hay ratio ranged from five to nine with an average of 6 2/3 animals per lot.

In the two lots where a grain to hay ratio of 1:2 and 1:3 were fed there was an insufficient number of animals averaging 300 pound gains, therefore, the gains and feed consumption were adjusted before selecting the animals. In the lot fed 1:3 ratio, no animal attained a 300 pound gain during the 154 day feeding period. Adjustments were made by extending the gains of the calves on the basis of the average daily gain during the 154 day feeding period. The calves with the 1:2 ratio of concentrates to hay were adjusted by adding 10 per cent additional gain and 10 per cent more feed. The lot receiving 1:3 concentrate to hay was adjusted by adding 30 per cent gain in weight and 30 per cent to the feed consumption.

In the yearling steer experiment animals were selected from each of the five grain to hay ratios to give an equal product of 200 pound gain instead of 300 pounds as in the case of the calves. An attempt was made to get steers with about the same average initial weight in each lot. The number of animals selected for each ratio varied from 5 to 6 with an average of 5.6 animals per lot.

Gains and feed consumption of the steers in the 1:2 ratio of concentrate to hay were adjusted upward 10 per cent. The gainsand feed consumption of the individuals selected in the lot of 1:3 ratio were increased by 20 per cent. These adjustments were made on the basis of the average daily gain and feed consumption for the respective lots during the 126 day feeding period.

The method of selection and adjustment places definite limitations upon the results obtained by this procedure. However, in order to determine combinations of grain and roughage which will result in the same output of beef the selection and adjustment procedure used was judged to be the appropriate alternative.

Survey of Dry-Lot Beef Operations in Oregon

A survey was made of 18 cattle feeders in Klamath and Umatilla Counties in the spring of 1953. The names of cattle feeders were obtained from County Agents and other agricultural leaders. These 18 cattle feeders do not represent a random sample of cattle feeders in the two counties. An attempt was made to include feeding operations of different sizes in the two areas. The sample was too small and the feeding practices and results obtained were too variable for a statistical analysis of the data. These data were obtained mainly for case studies. Two purposes of this survey were: (1) to compare the results obtained by some of the Oregon feeders with those obtained under experimental conditions, and (2) to obtain an understanding of the problems experienced by cattle feeders in the state.

Information was obtained on size of operations, age of cattle, grades of feeder cattle, grades at which cattle were marketed, length of feeding periods, amounts of different feeds fed, amount of gains, and other management practices.

CHAPTER 5

ANALYSIS AND INTERPRETATION OF OREGON EXPERIMENTAL DATA

This chapter deals with the statistical analysis and interpretation of Oregon experimental data on calf feeding. Both biological and economic interpretations will be given. The discussion will begin with the basic physical input-output relationships derived from the data. The economic analysis of the growth data follows the derivation and biological interpretation of the input-output relationships.

Growth Comparisons of Cattle in Experiments

Growth differences due to sex, feeding practices, and rations will be discussed in this section. Bulls, steers, and heifers were used in these feeding trials. Comparison of feeding practices is limited to the feeding of an increasing proportion of grain in the ration and the feeding of a constant proportion of grain and roughage. The discussion of ration differences is integrated with the growth comparisons by sex and feeding practices.

Comparison of Growth of Heifers and Bulls Fed Constant Ratio of Grain to Roughage

Growth curves for purebred bull and heifer calves were derived by a regression analysis of 1952-53 experimental data. These are shown in the top portion of Figure 6. The lower portion of Figure 6 shows the additional gains per pound of additional feed consumed. These estimates of total and additional growth apply only in the period of dry lot feeding. Initial weights of the heifers and bulls in the feeding trials averaged about 495 pounds each.

The estimation equations for the two growth curves (top portion Figure 6) are:

$$\text{Bulls:} \quad Y = 6.4220 + .22438X - .00003551X^2 \qquad (1)$$

$$\text{Heifers:} \quad Y = 7.4732 + .14826X - .00001416X^2 \qquad (2)$$

where Y represents the pounds of gain in weight and X the quantity of feed consumed in pounds. Both grain and roughage are included in the X terms. Two parts of roughage and one part of grain in pellet form were fed the calves in these two feeding trials. Total liveweight of the animals in the above two equations can be estimated by adding the initial weight (495 pounds).

The coefficients of both the X and X^2 terms in the above two equations were significant at the 99 per cent level of probability. Ninety per cent confidence limits on these coefficients were:

	X coefficient		X^2 coefficient	
	Lower limit	Upper limit	Lower limit	Upper limit
Bulls (1)	.2069	.2419	-.00004366	-.0002736
Heifers (2)	.1353	.1612	-.00001873	-.00009596

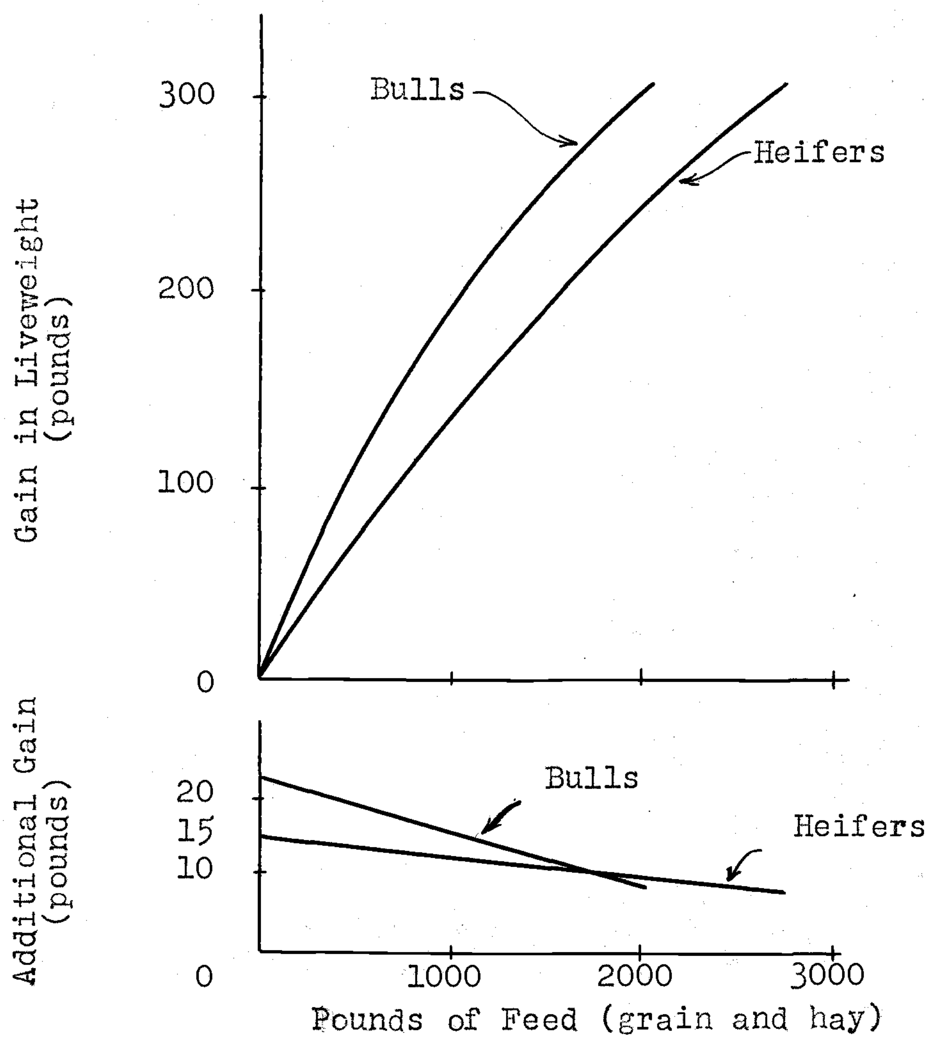

Figure 6. Growth Curves for Bull and Heifer Calves in Dry Lot (top portion) and Additional Gains Per Pound of Additional Feed (lower portion).

From these statistical analyses, the following conclusions can be drawn on the growth of the bulls and heifers in the 1952-53 feeding trials:

(1) Diminishing returns were significant for both bulls and heifers. These are evident from the significant negative X^2 coefficients.

(2) Growth patterns for bulls and heifers differed significantly. The confidence limits on the coefficients of the two regression equations provide evidence of this. Gain per unit of feed input was higher for bulls.

(3) The rate of gain declined more rapidly for bulls than heifers. This is shown graphically in the lower portion of Figure 6. Bulls gained at a much higher rate in the early part of the feeding period, and the significantly more rapid decline in weight did not offset the more rapid earlier growth.

The lower additional growth for bulls compared with that of heifers near the end of the feeding period is not considered significant. This may have been caused by the type of equation used in estimating the growth pattern of the animals. The equation for the two additional growth lines in the lower portion of Figure 6 are:

Bulls: $Y = .22438 - .00007102X$ (3)

Heifers: $Y = .14826 - .00002832X$ (4)

where Y is the additional gain and X refers to feed in pounds. Equations (3) and (4) are the first derivatives of equations (1) and (2) respectively.

The finishing of bulls in dry lot for market is not a common practice. However, the bull-heifer growth comparisons do have considerable practical significance. It will be shown in the following section that bull and steer calves used in previous tests made about the same total and additional gains. Thus, the two growth equations may be considered estimates of growth differences between heifers and steers. The economic analysis of these two growth functions is based upon the possibility of this representing steer-heifer growth differences as well as bull-heifer growth differences.

Comparison of Growth of Bulls and Steers with a Changing Ratio of Grain to Roughage

Growth functions for bulls and steers fed three ratios of grain to hay in the 1949-1952 Oregon feeding trials are shown in Figure 7.

No effort was made to join the different segments into a smooth growth function for the complete feeding period. Initial weights were 412 pounds for the steers and 481 pounds for the bulls.

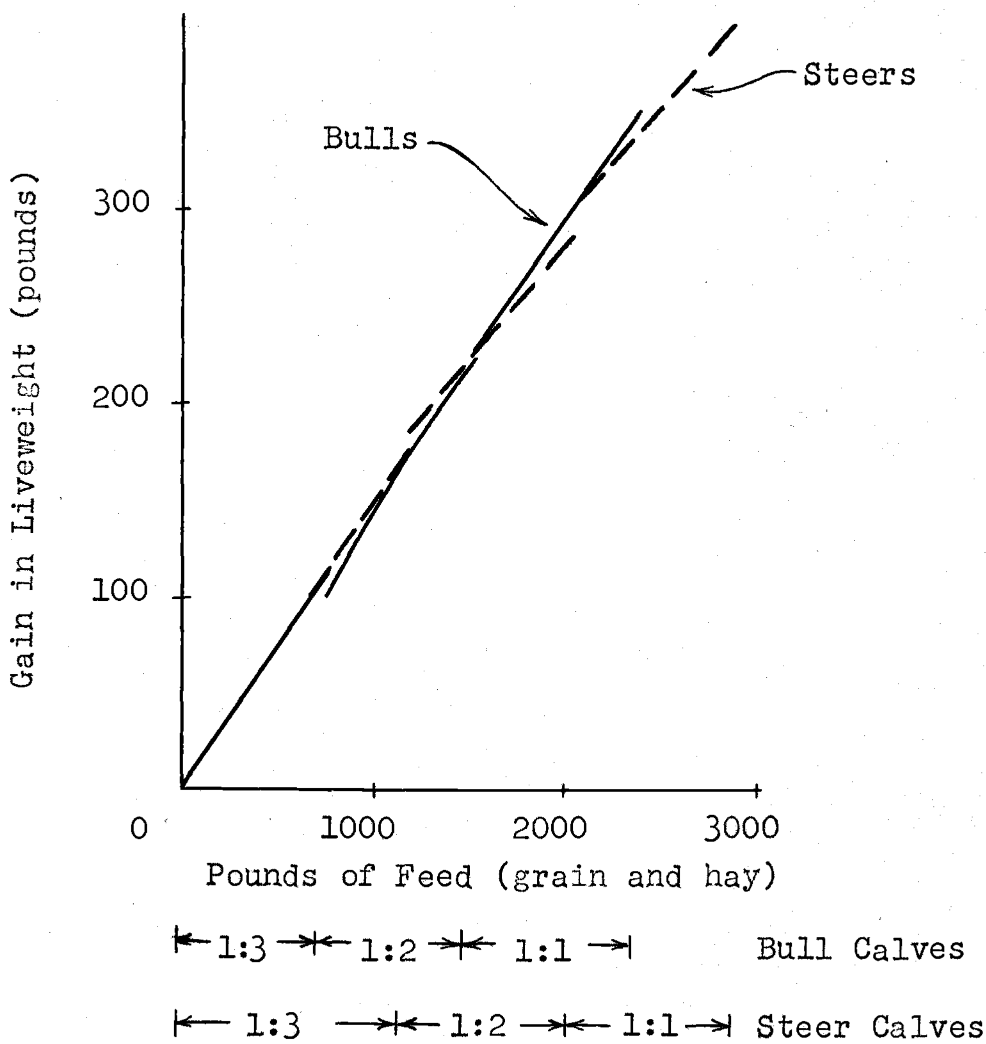

Figure 7. Growth Curves for Bull Calves and Steer Calves Fed Three Different Ratios of Grain to Hay.

The estimation equations for the steers fed different grain-hay ratios were:

$$
\begin{aligned}
&1{:}3 \text{ ratio: } Y = 4.1774 + .1517X && (5a)\\
&1{:}2 \text{ ratio: } Y = 8.9765 + .1170X && (5b)\\
&1{:}1 \text{ ratio: } Y = 14.9272 + .1129X && (5c)
\end{aligned}
$$

where Y is gain in weight and X is the total feed consumption with the respective feed ratios. The X^2 terms were dropped from each of the above equations when found not to be significant.

The estimation equations for the bull growth were:

$$
\begin{aligned}
&1{:}3 \text{ ratio: } Y = 6.7431 + .1430X && (6a)\\
&1{:}2 \text{ ratio: } Y = -9.9780 + .1909X - .0000483X^2 && (6b)\\
&1{:}1 \text{ ratio: } Y = 5.6729 + .1393X && (6c)
\end{aligned}
$$

where Y and X refer to gains and feed consumption as before. The X^2 terms were dropped from equations (6a) and (6c) when found not to be significant.

For the feeding period as a whole, diminishing returns are not evident for steers or bulls. Diminishing returns are evident when the 1:2 ratio was fed bulls, but this cannot be considered significant for the feeding period when interpreted jointly with growth on the 1:3 and 1:1 ratios. The X coefficients decrease in size from equations (5a) to (5c), but this could be interpreted as an indicator of diminishing returns only when the size of the constant terms in these equations is the same. These do not remain the same, but increase which tends to offset the decrease in the size of the X coefficients. It is possible that the rate of growth did diminish near the end of the feeding period for each ratio of grain to roughage, or for the feeding period as a whole, but this was not detected by the statistical analysis because of the variablity of the growth data. One would expect diminishing returns to occur when animals are continued on any one of the ratios of grain to hay for a considerable period of time.

The sizes of the constant and X coefficient terms in equations (5a), (5b), (5c), (6a), and (6c) provide little if any evidence of a difference in growth of bulls and steers. The same may be concluded from Figure 7. It is possible that real differences in growth between steers and bulls do exist, and the above test is inadequate for showing this. However, it also is possible that any real difference in growth between steers and bulls does not become prominant until the animals are larger and older than the animals in these feeding trials. For purposes of economic analysis in a later section, the growth of bulls and steers will be considered the same.

Comparison of Growth of Heifers and Steers with a Changing Ratio of Grain and Roughage

The 1949-52 feeding trials on calves included heifers fed the three proportions of grain and roughage. Estimates of growth of heifers on these ratios were made for comparison with the growth of steers. Initial weights averaged 444 pounds.

The estimation equations for the heifers were:

$$1{:}3 \text{ ratio: } Y = 1.5314 + .1362X \quad (7a)$$
$$1{:}2 \text{ ratio: } Y = -6.8075 + .1439X - .0000228X^2 \quad (7b)$$
$$1{:}1 \text{ ratio: } Y = -6.2298 + .1440X - .0000328X^2 \quad (7c)$$

These equations are plotted in Figure 8 along with the growth of steers in the same series of tests.

No significant diminishing returns occurred for the heifers while fed the 1:3 ratio of grain to roughage. However, significant diminishing returns did occur in the periods when the 1:2 and 1:1 ratios were fed.

Growth of steers was higher than the growth of the heifers. This could be expected because of the previous results on growth comparisons of bulls and heifers and bulls and steers. The lower growth of heifers is due, in part, to the significant decrease in rate of growth, whereas this could not be detected in the case of the steers.

<u>Comparison of Feeding Practices:</u>
<u>Constant and Changing Grain-Roughage Ratios</u>

In the Oregon experiments direct tests were not made to compare the feeding of an increasing proportion of grain

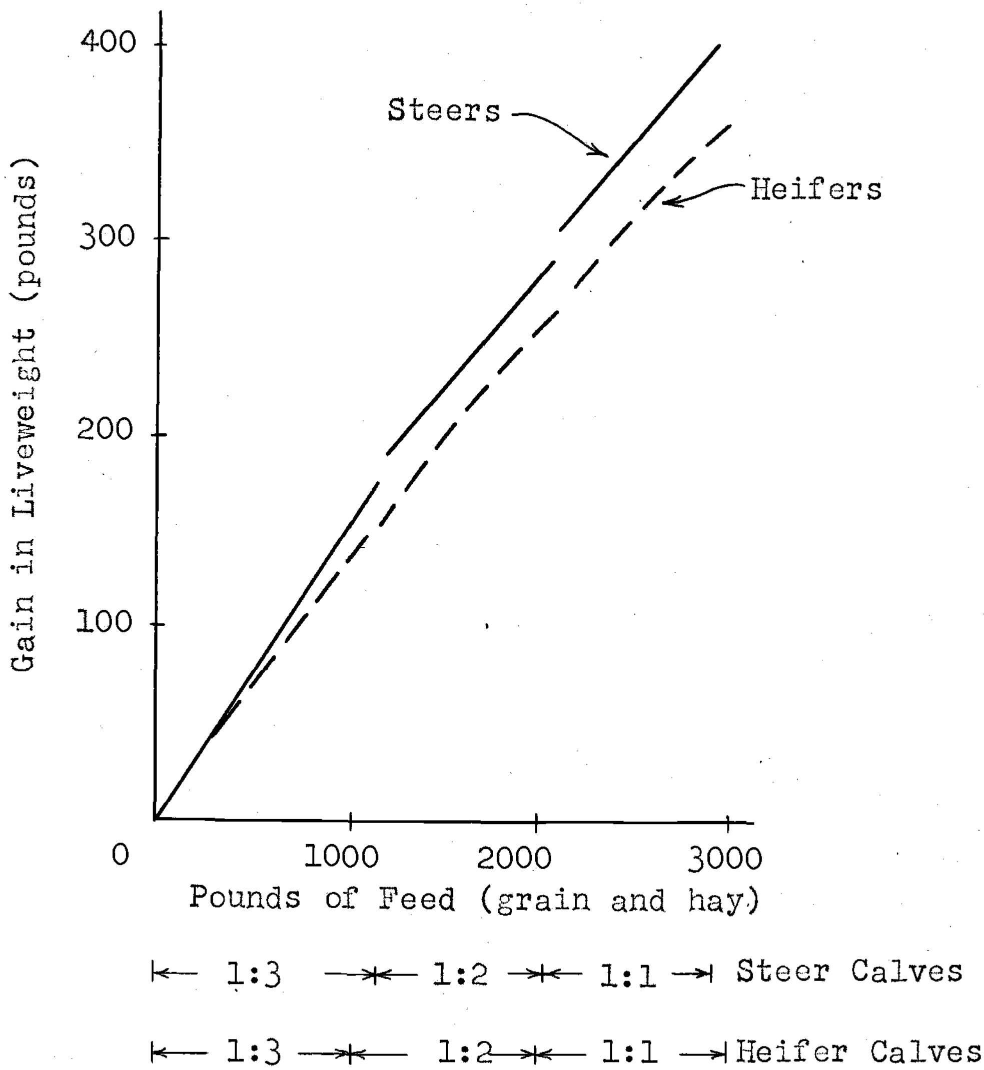

Figure 8. Growth Curves for Steer Calves and Heifer Calves Fed Three Different Ratios of Grain to Hay in The Dry Lot.

in the ration as the feeding period progressed with a constant ratio of grain to roughage. The feeding practice for the first three years of the feeding trials was increasing the proportion of grain. The constant ratio was fed all animals in the 1952-1953 feeding trials. However, different patterns of growth could be expected and partially verified by the data for animals fed the increasing proportion of grain as compared with the constant proportion.

One would expect a change in chemical composition of the ration over the feeding period, such as increasing the proportion of grain, to decrease or eliminate diminishing returns for a considerable period of time. The change in the composition of the ration is equivalent to a change to another (higher) growth or production function. This change in composition of the feed by increasing the proportion of grain could be expected to be an economical practice so long as the cost of the gains in weight did not exceed the increase in value of the animal.

The main reason why growth differences between feeding practices could be only partially verified by the experimental data was the differences in rations under the two feeding practices. The nutrients per 100 pounds of feed were about the same for both rations. However, the ration was in the form of pellets when the constant grain-roughage ratio was fed. One could expect some differences in efficiency with which animals utilize nutrients when in pellet form as compared with ground grain and chopped hay. Also, differences in feed intake could be expected for the two forms in which the feed was fed. Efficiency should be higher for the pellet ration.

In Figure 9 (top portion), the growth schedules are plotted for heifers fed the constant ratio and the changing proportion of grain. It can be noted that growth is higher in the latter half of the feeding period when the increasing proportion of grain is fed. Little difference in growth exists except in the first part of the feeding period.

A greater difference in growth between the two feeding practices than depicted in Figure 9 probably could be expected. The heifers fed the constant ratio of grain to roughage (in pellet form) consumed an average of 19.54 pounds of feed per head per day. The heifers fed the changing proportion of grain consumed an average of 15.39 pounds of feed per head per day. This extra 4 pounds of feed intake for heifers fed the constant ratio should raise the level of this growth schedule. Thus, the actual difference in growth probably may be greater than depicted in the top portion of Figure 9.

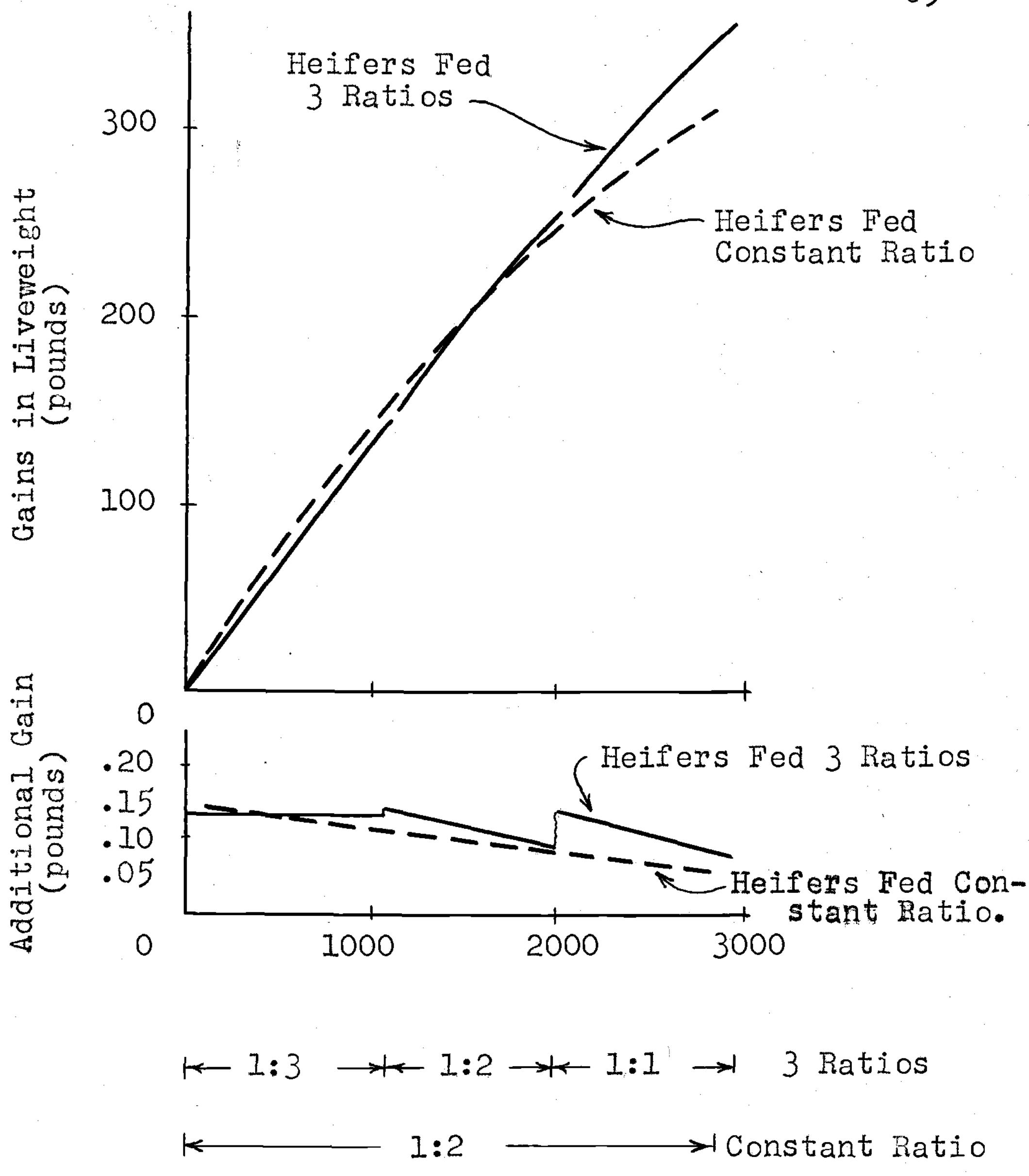

Figure 9. Growth Curves for Heifer Calves Fed Three Ratios, a Constant Ratio of Concentrate to Hay (top portion), and Additional Gains Per Pound of Additional Feed (lower portion).

Additional gains per pound of additional feed is plotted in the lower portion of Figure 9. It can be noted that additional gains are higher over most of the feeding period when the increasing proportion of grain is fed.

Growth of bulls fed the constant and changing ratio was compared (Figure 10). Little difference in the total growth during the feeding period could be detected between animals fed a constant ratio and animals fed the changing ratio. However, there was a difference in feed consumption per animal per day. The bulls fed the constant ratio of grain to roughage (in pellet form) consumed an average of 18.64 pounds of feed per head per day as compared with 15.84 for animals fed the increasing proportion of grain. This difference in feed intake was a factor in a 300 pound gain being attained about 30 days sooner for the animals fed pellets. The length of the feeding period for bulls was reduced by approximately the same amount of time as for the heifers receiving pellets. This reduction in the length of the feeding period decreases the maintenance requirement of the animals, thereby further accentuating the advantage of the pellet ration. Although the bull growth comparison does not verify the hypothesis on differences in growth by feed practices, it does not disprove it.

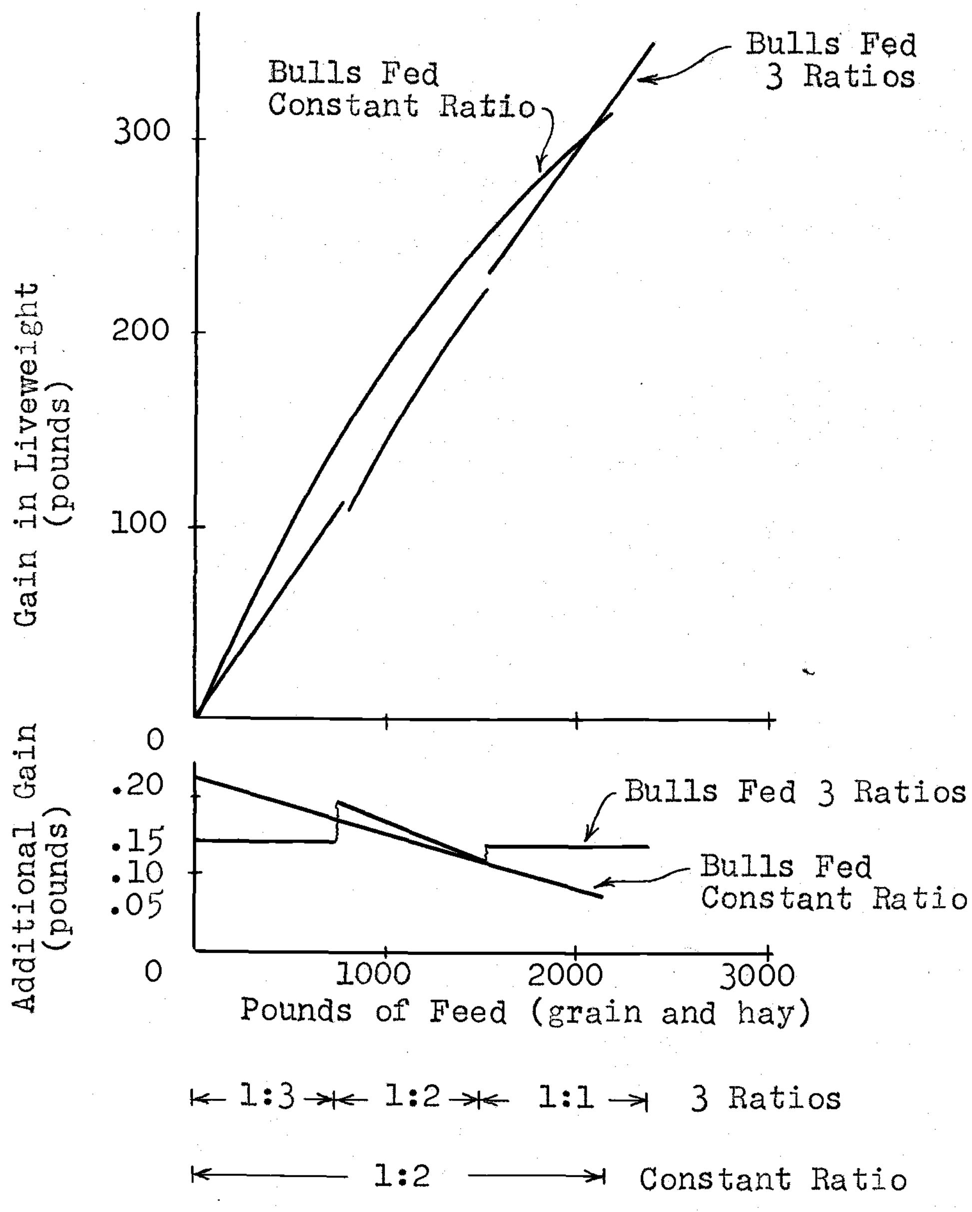

Figure 10. Growth Curves for Bull Calves Fed a Constant Ratio and Three Different Ratios of Grain to Hay in the Dry Lot (top portion), and Additional Gains Per Pound of Additional Feed (lower portion).

Economic Interpretation of Oregon Experimental Results

The derived growth schedules of calves in the previous section of this chapter provide the basis for an economic interpretation. Several assumptions need to be made in regard to prices and costs in order to convert the growth data into income and cost data. These will be set forth when needed in the analysis. Returns above feed cost and factors relating to it first will be discussed. The effect of change in slaughter grade (and price) during the feeding period upon income and optimum grade and weight to market will follow.

Returns Above Feed Cost

With the prices and costs assumed, most of the estimated returns above feed cost for the calves in the Oregon experiment were positive. However, the size of these returns above feed cost did vary. The factors determining the size of the returns above feed cost were:

(1) The efficiency of the animals in converting feed into pound gains (growth differences).

(2) Change in efficiency in converting feed into pounds of growth during the feeding period.

(3) Price of feed.

(4) Price of slaughter animals.

Tables 4 and 5 were constructed in a manner to show the effect of each of these factors upon returns above feed cost. Data in Table 4 were based upon: (1) growth of heifer and bulls fed a constant (1:2) ratio of grain to roughage, (2) selected prices of feed (grain and hay combined) of $2.25, $2.50, and $2.75 per hundredweight, and (3) selected slaughter cattle prices of $20.00, $22.00, and $24.00 per hundredweight. The selected feed price of $2.50 was based upon June 1953 local prices for the ingredients making up the feed mixture. Prices of $2.25 and $2.75 were selected to show the effect of different feed prices upon returns above feed cost. The different cattle prices assumed approximate the range of current prices received for slaughter cattle by producers.

The same price and cost assumptions were used in constructing Table 5. However, the feed prices were handled differently than in constructing Table 4 since three ratios of grain to roughage were fed during the feeding period. The feed prices were made comparable to those used in Table 4 by using the same prices as used previously for the 1:2 grain-hay ratio. On the basis of $2.25 feed for the 1:2 ratio, the 1:3 ratio feed was worth $2.12 per hundredweight and the 1:1 ratio feed was worth $2.54.

Table 4

Returns Above Feed Cost for Heifer and Bull Calves at Selected Feed and Cattle Prices When Fed a Constant Ratio of 1:2 of Concentrates to Hay.

Total Feed (lbs.)	Total Gain (lbs.)	Returns Above Feed Cost (dollars)				
		Selected Feed Prices				
		$2.25		$2.50		$2.75
		$22	$20	$22	$24	$22
		Heifer Calves				
600	91.3	6.59	3.26	5.09	6.91	3.59
800	117.0	7.74	3.40	5.74	8.08	3.74
1000	141.6	8.65	3.32	6.15	8.98	3.65
1200	165.0	9.30	3.00	6.30	9.60	3.30
1400	187.3	9.70	2.46	6.20	9.95	2.70
1600	208.4	9.85	1.68	5.85	10.02	1.85
1800	228.5	9.77	0.70	5.27	9.84	0.77
2000	247.3	9.41	-0.54	4.41	9.35	-0.59
2200	265.1	8.82	-1.98	3.32	8.62	-2.18
2400	281.7	7.97	-3.66	1.97	7.61	-4.03
2600	297.2	6.88	-5.56	0.38	6.33	-6.12
2800	311.6	5.55	-7.68	-1.45	4.78	-8.45
		Bull Calves				
600	128.3	14.73	10.66	13.23	15.79	11.73
800	163.2	17.90	12.64	15.90	19.17	13.90
1000	195.3	20.47	14.06	17.97	21.87	15.47
1200	224.5	22.39	14.90	19.39	23.88	16.39
1400	251.0	23.72	15.20	20.22	25.24	16.72
1600	274.5	24.39	14.90	20.39	25.88	16.39
1800	295.3	24.47	14.06	19.97	25.87	15.47
2000	313.2	23.90	12.64	18.90	25.17	13.90

Table 5
Returns Above Feed Costs for Heifer and Steer Calves at Selected Feed and Cattle Prices When Fed Ratios of 1:3, 1:2, and 1:1 of Concentrates to Hay.

Total Feed (lbs.)	Total Gain (lbs.)	Returns Above Feed Costs (dollars)				
		Selected Feed Prices				
		$2.25[1]	$2.50[2]			$2.75[3]
		Selected Cattle Prices Per Hundredweight				
		$22	$20	$22	$24	$22
		Heifer Calves				
600	83.3	$5.61	$2.50	$4.17	$5.83	$2.73
800	110.5	7.35	3.22	5.43	7.64	3.51
1000	137.7	9.09	3.94	6.69	9.45	4.29
1200*	158.8	9.33	3.26	6.44	9.61	3.55
1400	185.5	10.70	3.60	7.31	11.02	3.92
1600	210.4	11.68	3.58	7.79	12.00	3.90
1800	233.5	12.26	3.20	7.87	12.54	3.48
2000**	249.6	11.22	1.34	6.33	11.32	1.42
2200	276.7	12.00	1.12	6.65	12.19	1.18
2400	301.2	12.41	1.38	6.40	12.43	0.37
2600	323.1	12.15	-.88	5.58	12.04	-1.01
2800	342.4	11.32	-2.66	4.19	11.04	-2.96
		Steer Calves				
600	95.2	8.22	4.88	6.78	8.69	5.34
800	125.6	10.67	6.24	8.75	11.26	6.83
1000	155.9	13.10	7.58	10.70	13.82	8.30
1200*	193.5	17.06	10.31	14.18	18.05	11.29
1400	216.9	17.71	9.99	14.33	18.67	10.94
1600	240.3	18.36	9.67	14.48	19.28	10.59
1800	263.7	19.00	9.35	14.62	19.90	10.23
2000**	287.1	19.65	9.03	14.77	20.51	9.88
2200	324.8	22.93	11.00	17.50	23.99	12.06
2400	347.4	22.82	9.88	16.83	23.78	10.83
2600	370.0	22.71	8.76	16.16	23.56	9.60
2800	392.6	22.60	7.64	15.49	23.34	8.37

* Change in ratio of feed from 1:3 to 1:2.
** Change in ratio of feed from 1:2 to 1:2.
1/ Feed prices by ratios of grain to hay fed: $2.12 for 1:3 ratio, $2.25 for 1:2 ratio, and $2.54 for 1:1 ratio.
2/ Feed prices by ratios of grain to hay fed: $2.36 for 1:3 ratio, $2.50 for 1:2 ratio, and $2.82 for 1:1 ratio.
3/ Feed prices by ratios of grain to hay fed: $2.36 for 1:3 ratio, $2.75 for 1:2 ratio, and $3.10 for 1:1 ratio.

At the $2.50 feed price level for the 1:2 ratio, the 1:3 ratio feed was worth $2.36 and the 1:1 ratio feed was $2.82 per hundredweight. Similarly, for the last selected feed price level, the feed prices were $2.60, $2.75, and $3.10 for the 1:3, 1:2, and 1:1 ratios, respectively.

Effect of growth differences. The differences in levels of efficiency at different feed inputs can be noted by comparing the data in Tables 4 and 5. Returns above feed cost are at a maximum at a higher level of feed inputs for the more efficient animals. For example, in Table 4, the point of maximum returns occurred at a level of 1200 pounds of feed inputs for the heifers and 1600 pounds for the bulls ($2.50 feed and $22.00 cattle). At the same prices and costs, returns above feed cost at the maximum for bulls were higher than that of heifers, or specifically $20.39 for bulls and $6.30 for heifers. Similar differences can be noted between the steer and heifer calves fed three ratios of grain to hay (Table 5). Growth of steers was higher than growth of heifers. This resulted in a higher return above feed cost at the maximum for steers, and this maximum occurred at a higher level of feed inputs. It also can be noted that the heifer calves receiving three ratios of grain to hay attained a higher maximum return above feed cost with greater feed inputs than heifer calves receiving a constant ratio (Tables 4 and 5).

Since these comparisons of returns above feed cost were based on the same prices of slaughter cattle for each sex, these income comparisons may not be realistic. In practice for cattle of comparable grade, steers would usually sell at a higher market price than heifers, and heifers in turn usually sell for a higher price than bulls. However, these comparisons of returns above feed costs do depict the importance of efficiency of the animal in converting feed into gains where feed costs and slaughter cattle prices are the same.

Effect of a change in efficiency. The effect of changing rates of growth on returns above feed cost can be noted from the data in Tables 4 and 5. Returns above feed cost for each class of animals in these Tables change with each change in the level of feed inputs. In Table 4, for any feed price or cattle price assumed, returns above feed cost for heifers and bulls increase to a maximum and then decline. This is brought about by diminishing returns, or change in the efficiency in which the animals convert feed into gains during the feeding period. The same pattern of changing (increasing and then decreasing) returns above feed cost can be noted in Table 5 for steers and heifers fed three ratios of grain to roughage.

Effect of price of feed. Other things remaining constant, an increase in feed price results in lower returns above feed costs, whereas a decrease in feed price increases the returns. For example, with cattle prices at $22.00 per hundredweight and an increase in feed prices from $2.25 to $2.50, and $2.75 per hundredweight, the maximum returns above feed costs for heifer calves fed a constant ratio of grain to hay decrease from $9.85 to $6.30, and $3.74, respectively (Table 4). The pounds of feed inputs corresponding to the maximum returns above feed cost decreased as the feed prices increased. The maximum returns above feed cost for calves fed three ratios of grain to hay also decrease with an increase in feed price (Table 5).

In Table 5, the maximum returns above feed costs with higher feed prices occurred in many cases at the same level of feed inputs. This was because of the discontinuous growth functions for heifers and steers during their feeding periods, which resulted in returns above feed costs being estimated for each, based on three separate equations.

Effect of price of slaughter animals. The middle three columns within "returns above feed cost" in Tables 4 and 5 were constructed to show the effect of different cattle prices. With only cattle prices variable, returns above feed costs increase as the level of slaughter cattle prices increase. Also it can be noted in Tables 4 and 5 that, in general, the point of maximum returns above feed costs occurs at a higher level of feed inputs as cattle prices increase.

Net Value Change of Calves and Optimum Market Grades, Weights

The previous section dealt with the returns above feed cost on the gains of the animals in dry lot. Changes in value of the initial weight due to grade changes of the animals in dry lot were not taken into account. Total increase in net value of the animals in dry lot was estimated by adding together estimated returns above feed cost and change in value of the initial weight. These estimated net value changes were based upon specific assumptions in regard to grades and prices for calves in dry lot. Only the growth functions for the heifer calves were used in estimating the effect of grade changes.

The data in Table 6 were based upon the growth of heifer calves fed a constant (1:2) ratio of grain to hay, and selected prices of feed (grain and hay combined) of \$2.25, \$2.50, and \$2.75 per hundredweight. Slaughter cattle prices of \$20.00, \$22.00, and \$24.00 for commercial, good, and choice grades repectively were assumed. It was assumed that heifers gaining as those did in the experiment would change to a grade of good at 1600 pounds of feed inputs, and to a grade of choice at 2800 pounds of feed inputs. Gradual price changes with the grade changes were assumed. Further, in constructing Table 6, an initial cost of \$20.00 per hundredweight on 450 pound calves was assumed.

The same assumptions were made in constructing Table 7 with the exception of the matter in handling the feed prices and the level of feed inputs corresponding to changes in slaughter grades. Feed prices were handled in the same method as in Table 5 where \$2.25 was the price per hundredweight for the 1:2 ratio of grain to hay, the 1:3 ratio was \$2.12 per hundredweight, and the 1:1 ratio of feed was \$2.54. At the \$2.50 feed price level the 1:3 ratio of feed was \$2.36 and the 1:1 ratio of feed was \$2.82. Prices of \$2.60, \$2.75, and \$3.10 were used for the 1:3, 1:2, and 1:1 ratios of grain to hay, respectively. The assumption was made that the heifers changed to a slaughter grade of good at a feed input level of 1600 pounds and to a grade of choice at 2400 pounds of feed inputs.

Table 6

Estimated Returns Above Feed Cost, Change in Value of Initial Weight, and Total Value Change Per Animal Under Grade Changes in Feeding Period for Heifer Calves Fed a Constant Ratio of Grain to Roughage. (Selected prices for feed, slaughter cattle and feeder calves)

Feed inputs (lbs.)	Returns above feed cost: Cattle prices @ \$20, \$22, and \$24.[1] Feed cost per cwt. \$2.25	\$2.50	\$2.75	Change in value of initial wt.[2]	Total change in value: Feed cost per cwt. \$2.25	\$2.50	\$2.75
600	\$4.76	\$3.26	\$1.76	\$0.00	\$4.76	\$3.26	\$1.76
800	5.87	3.87	1.87	1.80	7.67	5.67	3.67
1000	6.95	4.45	1.95	3.60	10.55	8,05	5.55
1200	7.98	4.98	1.98	5.40	13.38	10.38	7.38
1400	8.96	5.46	1.96	7.20	16.16	12.66	9.16
*1600	9.85	5.85	1.85	9.00	18.85	14.85	10.85
1800	10.52	6.02	1.52	10.50	21.02	16.52	12.02
2000	11.06	6.06	.86	12.00	23.06	18.06	12.86
2200	11.47	5.97	.47	13.50	24.97	19.47	13.97
2400	11.73	5.73	-.27	15.00	26.73	20.73	14.73
2600	11.83	5.33	-1.17	16.50	28.33	21.83	15.33
**2800	11.78	4.78	-2.22	18.00	29.78	22.78	15.78

* Assumed point of change in slaughter grade from commercial to good.

** Assumed point of change in slaughter grade from good to choice.

1/ Assumed prices of slaughter cattle are commerical @ \$20.00, good @ \$22.00, and choice @ \$24.00 per hundredweight. Also it is assumed that these prices change gradually over the given range of feed inputs.

2/ Assumed initial cost of feeders @ \$20.00 per hundredweight. Change in value figured on basis of 450 pounds initial weight.

Table 7

Estimated Returns Above Feed Cost, Change in Value of Initial Weight, and Total Value Change Per Animal Under Grade Changes in Feeding Period for Heifer Calves Fed Increasing Proportions of Grain in the Ration. (Selected prices for feed, slaughter cattle and feeder calves)

Feed inputs (lbs.)	Returns above feed cost: Cattle prices @ $20, $22, and $24.[1] Feed cost per cwt.			Change in value of initial wt.[5]	Total change in value: Feed cost per cwt.		
	$2.25[2]	$2.50[3]	$2.75[4]		$2.25	$2.50	$2.75
600	$3.94	$2.50	$1.06	$0.00	$3.94	$2.50	$1.06
800	5.47	3.55	1.63	1.80	7.27	5.35	3.43
1000	7.22	4.82	2.42	3.60	10.82	8.42	6.02
1200	7.80	4.91	2.02	5.40	13.20	10.31	7.42
1400	9.53	6.14	2.75	7.20	16.73	13.34	9.95
*1600	11.68	7.79	3.90	9.00	20.68	16.79	12.90
1800	13.43	9.04	4.65	11.25	24.68	20.29	15.90
2000	13.72	8.83	3.92	13.50	27.22	22.33	17.42
2200	16.25	10.80	6.33	15.75	32.00	26.55	22.08
**2400	18.44	12.43	6.40	18.00	36.44	30.43	24.40
2600	18.61	12.04	5.45	18.00	36.61	30.04	23.45
2800	18.17	11.04	3.89	18.00	36.17	29.04	21.89

* Assumed point of change in slaughter grade from commercial to good.

** Assumed point of change in slaughter grade from good to choice.

1/ Assumed cattle prices: commercial @ $20.00, good @ $22.00, and choice @ $24.00 per hundredweight.

2/ Feed price varies by ratios of grain to hay fed: $2.12 for 1:3 ratio, $2.25 for 1:2 ratio, and $2.54 for 1:1 ratio.

3/ Feed prices by ratios of grain to hay fed: $2.36 for 1:3 ratio, $2.50 for 1:2 ratio, and $2.82 for 1:1 ratio.

4/ Feed prices by ratios of grain to hay fed: $2.60 for 1:3 ratio, $2.75 for 1:2 ratio, and $3.10 for 1:1 ratio.

5/ Assumed initial weight of 450 pounds and initial cost per hundredweight of $20.00.

Table 8

Estimated Effect of Different Levels of Cattle Prices Upon Returns Above Feed Cost and Total Change in Value Per Animal in the Feeding Period for Heifer Calves Fed a Constant Ratio of Grain to Roughage. (Feed @ $2.75 per hundredweight and selected prices for slaughter cattle and feeder calves)

Feed inputs (lbs.)	Returns above feed cost: Feed @ $2.75 per cwt. Cattle prices of:			Change in value of initial wt.[4]	Total change in value: Cattle prices of:		
	$18-$22[1]	$16-$20[2]	$14-$18[3]		$18-$22	$16-$20	$14-$18
600	$-.07	$-1.89	$-3.72	$0.00	$-.07	$-1.89	$-3.72
800	-.47	-2.71	-5.15	1.80	1.33	-.91	-3.35
1000	-.88	-3.71	-6.45	3.60	2.72	-.11	-2.85
1200	-1.32	-4.62	-7.92	5.40	4.08	.78	-2.52
1400	-1.79	-5.53	-9.28	7.20	5.41	1.67	-2.08
*1600	-2.32	-6.49	-10.66	9.00	6.68	2.51	-1.66
1800	-3.05	-7.62	-12.19	10.50	7.45	2.88	-1.69
2000	-3.89	-8.84	-13.78	12.00	8.11	3.16	-1.78
2200	-4.83	-10.13	-15.43	13.50	8.67	3.37	-1.93
2400	-5.90	-11.53	-17.17	15.00	9.10	3.47	-2.17
2600	-7.11	-13.05	-19.00	16.50	9.39	3.45	-2.50
**2800	-8.45	-14.68	-20.91	18.00	9.55	3.32	-2.91

* Assumed point of change in grade from commercial to good.
** Assumed point of change in grade from good to choice.
1/ Assumed prices: commercial @ $18.00, good @ $20.00, and choice @ $22.00 per hundredweight.
2/ Assumed prices: commercial @ $16.00, good @ $18.00, and choice @ $20.00 per hundredweight.
3/ Assumed prices: commercial @ $14.00, good @ $16.00, and choice @ $18.00 per hundredweight.
4/ Assumed initial weight of 450 pounds and initial cost per hundredweight the same as the prices assumed for commercial slaughter cattle.

The growth of heifer calves on a constant ratio was used in Table 8 to show the estimated effect on total net value returns with the existence of negative returns above feed costs. The feed and cattle prices were selected at levels which would result in negative returns above feed cost. These prices were $2.75 for feed and $14.00 to $22.00 for cattle, depending on grade. The assumption also was made that the initial cost of the cattle was the same as the prices assumed for commercial grades.

Net change in value with positive returns above feed costs. Tables 6 and 7 illustrate the effect of change in slaughter grades during the feeding period upon net value changes of the animals when returns above feed costs are positive. In Table 6, it can be noted that the returns above feed costs for all selected feed and cattle prices accumulate to a maximum, and then decline. Also, it can be noted that the value of the initial weight gradually increases to a total of $18.00 under the assumed conditions. The net change in value (returns above feed cost plus change in value of initial weight) increases to the maximum feed input level in the Table (2800 pounds) for each selected feed price. Although returns above feed cost increase to a maximum before the cattle grade choice, then decline, it is profitable to feed to a choice grade in every case. This is because the increase in value of the initial weight is greater from one grade change to another than the decrease in returns above feed costs beyond the maximums.

At selected feed and cattle prices for heifer calves fed three ratios of grain to hay (Table 7) it is noted that the maximum net increase in value of an animal corresponds to the point of maximum returns above feed cost. This is because changes in value of initial weight terminate when choice grade is attained (as assumed), and returns above feed cost continue to increase until the animal grades choice or better. This indicates that the point of maximum returns above feed costs occurs at the same feed input change in value level as the returns above feed cost increase to a maximum within the highest slaughter grade.

In many cattle feeding operations the returns above feed costs are negative during the entire feeding period. The growth of the calves in the Oregon Experiments were such that current feed and cattle prices gave positive returns above feed costs. The pattern of negative returns above feed cost experienced in many feed lot operations can be approximated with the growth data on heifer calves by assuming high feed prices and low slaughter cattle prices.

The returns above feed costs in Table 8 depict the situation in which losses are incurred on the gains made by the animals and the only way that profits can be realized is through changes in value of the initial weight.

Net change in value with negative returns above feed costs. The data in Table 8 indicate that so long as the change in value of the initial weight with changes in slaughter grade more than offsets the losses on the gains made by the animals, profits will be attained.

In the last column in Table 8, the low assumed cattle prices resulted in negative total value changes in the entire feeding period. This was because the change in value of initial weight did not offset the losses on the gains made in dry lot. The aim of a feed lot operator would be to minimize his losses in this situation. When 1600 pounds of feed had been consumed, losses were at a minimum at the $14.00 to $18.00 level of cattle prices.

Optimum market weights and grades. For a given lot of cattle the optimum market weight will be when the total change in net value is at a maximum. For the heifer calves in Table 6, the optimum weights occur at a grade of choice. Since the feeding period for these cattle was terminated at a weight of approximately 800 pounds, it was impossible to determine how much longer the cattle could have been fed profitably. When the price of cattle is low in relation to the price of feed, it may not be profitable to feed to a grade of choice, but to terminate the feeding period when the cattle have a lower slaughter grade. This is illustrated in the last colum of Table 8 where with a low level of prices the optimum market weight occurs when the animals have a slaughter grade of good.

It may be more profitable for cattle feeders to operate on the basis of a rapid turn over rather than feeding each lot to the optimum market weight. However, the discussion in this section is based upon the feeding of one group of cattle each year.

Also, risk is a factor to take into account in deciding when to market cattle. Where increases in net value of animals from one grade to the next are low, the feed lot operator may choose to market at a lower grade and degree of finish.

CHAPTER 6

ANALYSIS AND INTERPRETATION OF IDAHO EXPERIMENTAL DATA

Constant product contours are useful in determing how to vary the ratios of grain to hay with changes in relative prices of these for maintaining a minimum cost of the ration. A constant product contour is a line depicting the combinations of grain and roughage which will produce the same amount of gain on animals. Product contours of 200 pounds and 300 pounds of gain for yearling and steer calves, respectively, were estimated from the Idaho data. The method of selection of the data for estimating these constant product contours and the limitations are discussed in Chapter 4.

Constant Product Contour for Yearling Steers

The estimation equation for the 200 pound constant product contour for yearling steers was:

$$Y = -210.274 + 36.198X_1 + 28.077X_2 - .752X_1^2 - .510X_2^2 - 1.126X_1X_2$$

where Y referred to pounds of gain, X_1 referred to pounds of grain, and X_2 referred to pounds of alfalfa hay. The coefficients of the X terms were not tested for significance because part of the original data was adjusted to new values.

Combinations of grain and alfalfa hay found to give a 200 pound gain for yearling steers are listed in Table 9. As the amount of alfalfa hay increased in the ration, it substituted for less grain. For example, when the amount of hay was increased from 400 to 500 pounds, 100 pounds of hay replaced 76.8 pounds of grain. However, when the amount of hay was increased from 1800 to 1900 pounds, 100 pounds of alfalfa hay replaced 38.2 pounds of grain. The interpretation also can be made in terms of amount of hay required to replace 100 pounds of grain at the different combinations. As more grain is fed, less hay is needed to replace 100 pounds of grain in the ration.

On the basis of hay at $38.00 per ton and grain at $74.00 per ton, the least cost ratio is found to be at 1600 pounds of hay and 716 pounds of grain (Table 9). This is about two parts of roughage to one part of grain. The costs of the rations at other grain-hay combinations are shown in Table 9.

Constant Product Contour for Steer Calves

The estimation equation for the 300 pound constant product contour for steer calves was:

$$Y = -81.040 + 19.165X_1 + 18.354X_2 - .114X_1^2 - .291X_2^2 - .029X_1X_2$$

where Y referred to the 300 pounds of gain, X_1 referred to

Table 9
Alfalfa Hay and Grain Combinations, Substitution Rates, and Feed Cost in Producing 300 Pounds of Gain on Steer Calves.

Hay-grain Combinations		Substitution Rates[1]		Feed Cost to Produce 300 Pounds Gain (dollars)[2]		
Hay (lbs.)	Grain (lbs.)	Grain for hay (lbs.)	Hay for grain (lbs.)	Hay	Grain	Total
400	1842.1			7.60	68.158	75.758
		101.8	98.23			
500	1740.3			9.50	64.391	73.891
		96.8	103.3			
600	1643.5			11.40	60.810	72.210
		92.0	108.7			
700	1551.5			13.30	57.406	70.706
		87.4	114.4			
800	1464.1			15.20	54.172	69.372
		83.0	120.5			
900	1381.1			17.10	51.101	68.201
		78.6	127.2			
1000	1302.5			19.00	48.193	67.193
		74.4	134.4			
1100	1228.1			20.90	45.440	66.340
		70.4	142.0			
1200	1157.7			22.80	42.835	65.635
		66.3	150.8			
1300	1091.4			24.70	40.382	65.082
		62.5	160.0			
1400	1028.9			26.60	38.069	64.669
		58.6	170.6			
1500	970.3			28.50	35.901	64.401
		54.8	182.5			
1600	915.5			30.40	33.874	64.274
		51.2	195.3			
1700	864.3			32.30	31.979	64.279
		47.5	210.5			
1800	816.8			34.20	30.222	64.422
		43.9	227.8			
1900	772.9			36.10	28.597	64.697
		40.4	247.5			
2000	732.5			38.00	27.103	65.103

1/ Substitution rates are quantities of grain (hay) needed to replace 100 pounds hay (grain) in the ration.

2/ Feed cost computed on basis of $1.90 price of hay per hundredweight and $3.70 price of grain per hundredweight.

the quantity of grain, and X_2 referred to the quantity of hay. Tests of significance of the X coefficients were not made for the same reason as explained earlier for the yearling equation.

The different combinations of grain and hay required for 300 pounds of gain on steer claves are presented in Table 10. The amount of grain required to substitute for a hundred pounds of hay gradually increases as more grain is fed. Also, as the ratio of hay to grain increases, the amount of hay required to replace 100 pounds of grain gradually increases.

The total feed cost for obtaining 300 pounds of gain on calves at the different combinations of grain and hay also is presented in Table 10. The minimum cost ration is when about 1600 pounds of hay and 915 pounds of grain are fed.

The different combinations of hay and grain required for a 200 pound gain for yearling steers differed with the results of Heady and Olson (32, p.9) for yearling steers. Their results were presented on the basis of 100 pounds of gain. Higher feed requirements for comparable gains were reported than obtained in the Idaho trials. This was because of the longer feeding period and larger total gains for steers in the Iowa experiment.

Table 10

Alfalfa Hay and Grain Combinations, Substitution Rates, and Feed Cost in Producing 200 Pounds of Gain on Yearling Steers.

Hay-grain Combinations		Substitution Rates[1]		Feed Cost to Produce 200 Pounds Gain (dollars)[2]		
Hay (lbs.)	Grain (lbs.)	Grain for hay (lbs.)	Hay for grain (lbs.)	Hay	Grain	Total
400	1499.1			7.60	55.467	63.067
		76.8	130.2			
500	1422.3			9.50	52.625	62.125
		74.9	133.5			
600	1347.4			11.40	49.854	61.254
		73.0	137.0			
700	1274.4			13.30	47.153	60.453
		71.0	140.8			
800	1203.4			15.20	44.526	59.726
		69.0	144.9			
900	1134.4			17.10	41.973	59.073
		67.0	149.3			
1000	1067.4			19.00	39.494	58.494
		64.9	154.1			
1100	1002.5			20.90	37.093	57.993
		62.6	159.7			
1200	939.9			22.80	34.776	57.576
		60.2	166.1			
1300	879.7			24.70	32.549	57.249
		57.7	173.3			
1400	822.0			26.60	30.414	57.014
		54.8	182.5			
1500	767.2			28.50	28.386	56.886
		51.6	193.8			
1600	715.6			30.40	26.477	56.877
		47.9	208.8			
1700	667.7			32.30	24.705	57.005
		43.6	229.4			
1800	624.1			34.20	23.092	57.292
		38.2	261.8			
1900	585.9			36.10	21.678	57.778
		31.2	320.5			
2000	554.7			38.00	20.524	58.524

1/ Substitution rates are quantities of grain (hay) needed to replace 100 pounds hay (grain) in the ration.

2/ Feed cost computed on basis of $1.90 price of hay per hundredweight and $3.70 price of grain per hundredweight.

A higher proportion of the feed intake by the animals is utilized for body maintenance and less for gain under a prolonged feeding period. The feeding period for animals in the Iowa experiment varied from about 150 to 230 days. The animals gained from 280 to 375 pounds. The shorter feeding period (126 days) and smaller total gains (200 pounds) for the Idaho yearling could be expected to result in less feed per 100 pounds gain. Another difference between the Idaho and Iowa results was the estimates of substitution rates. In general, more roughage was required to replace 100 pounds of grain in the Iowa experiment as compared with the Idaho tests. This was partly due to the systems of producing gains in the Iowa experiment. The animals in the Iowa experiment were handled in several different systems. These systems for the different lots of yearlings were: (1) full feed of grain in the dry lot, (2) full feed of grain on pasture and finished in dry lot, and (3) grazed under different management practices on pasture, then fed grain on pasture, and finished in the dry lot.

<u>Comparison of Calf and Yearling Constant Product Contours</u>

The similarity of the shape of the estimated product contours for calves and yearlings can be noted in Fig. 11.

The flatness of the contours indicates a wide range of choice in selecting combinations of grain and hay without a marked effect on the cost of the combination. For example, for calves in Table 9, with feed prices of $38.00 per ton and grain at $74.00 per ton, there is only $1.16 difference between the use of 36.4 per cent grain and 49 per cent grain in the feed combination. It is possible that a higher percentage of grain could result in a higher slaughter grade and faster gains for the animals which may more than offset a higher cost of the feed.

Another way of determining the minimum cost ration (other than used in computing feed costs in Table 9 and 10) is a graphic solution. In Figure 11, the lines AB and CD express the same price relationship between grain and roughage ($74.00 per ton grain and $38.00 per ton hay). Where these price ratio lines become tangent to the constant product contour define the minimum cost combinations of grain and roughage to feed. For the assumed feed prices, the minimum cost ratio of grain to roughage for calves and yearlings differ but little. The similarity in shape of the two constant product contours would bring about nearly the same ratios for a minimum cost ration for yearlings and calves at other feed price relationships.

The cheapest combinations of grain and hay are easily determined for any feed price relationship, given the

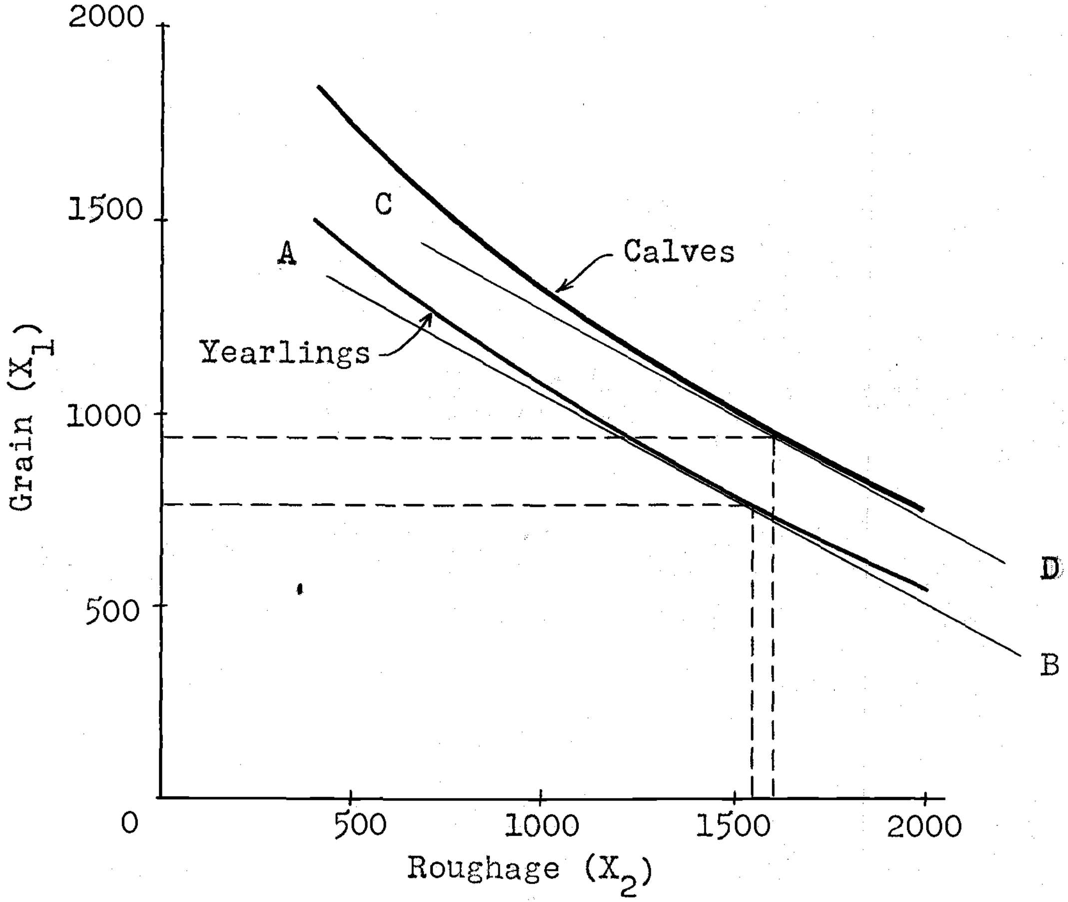

Figure 11. Constant Product Contours of 300 Pounds Gain for Steer Calves and 200 Pounds Gain for Yearling Steers.

substitution possibilities or the product contours. Since these constant product contours were obtained from data on different lots of animals fed different constant ratios, these may not represent the substitution possibilities where the ratio of grain to hay is changed during the feeding period. However, in view of the limited amount of experimental data on grain-roughage substitution possibilities, these calf and yearling constant product contours may be of value in determining about what average ratio of grain to hay to feed.

Different grains and roughages of comparable quality and nutrient content with those fed in the Idaho experiments could be expected to result in contours similar to the product contours estimated from data obtained from the Idaho trials. The use of lower quality hay rather than alfalfa probably would flatten the contours more. This is to be expected because of the larger amounts of poor quality hay required to substitute for a unit of grain when the percentage of roughage in a mixture is high.

CHAPTER 7

SURVEY FINDINGS AND APPLICATION OF EXPERIMENTAL RESULTS

The major portion of this chapter is concerned with the results of a survey of beef feeding operations in Klamath and Umatilla Counties. Throughout the discussion, application of the findings in previous analyses will be made.

Results from the Gilliam County Beef Improvement Association Test will also be discussed and compared with results of the Oregon Feeding Trials. The Gilliam feeding operation was in many respects similar to a farm feed lot operation.

Comparison of Growth of Calves in Gilliam County Trials and Oregon Experiments

Growth curves were estimated from records selected from Gilliam County feeding tests for purebred heifer and bull calves. A discussion of the experiment and analysis was presented in Chapter 4.

Growth of the calves in the Gilliam County tests compared with the growth of calves fed three different proportions of grain in the Oregon feeding trials is shown in Figure 12. Both bulls and heifers are included in these growth comparisons. From the graph, growth of heifers and

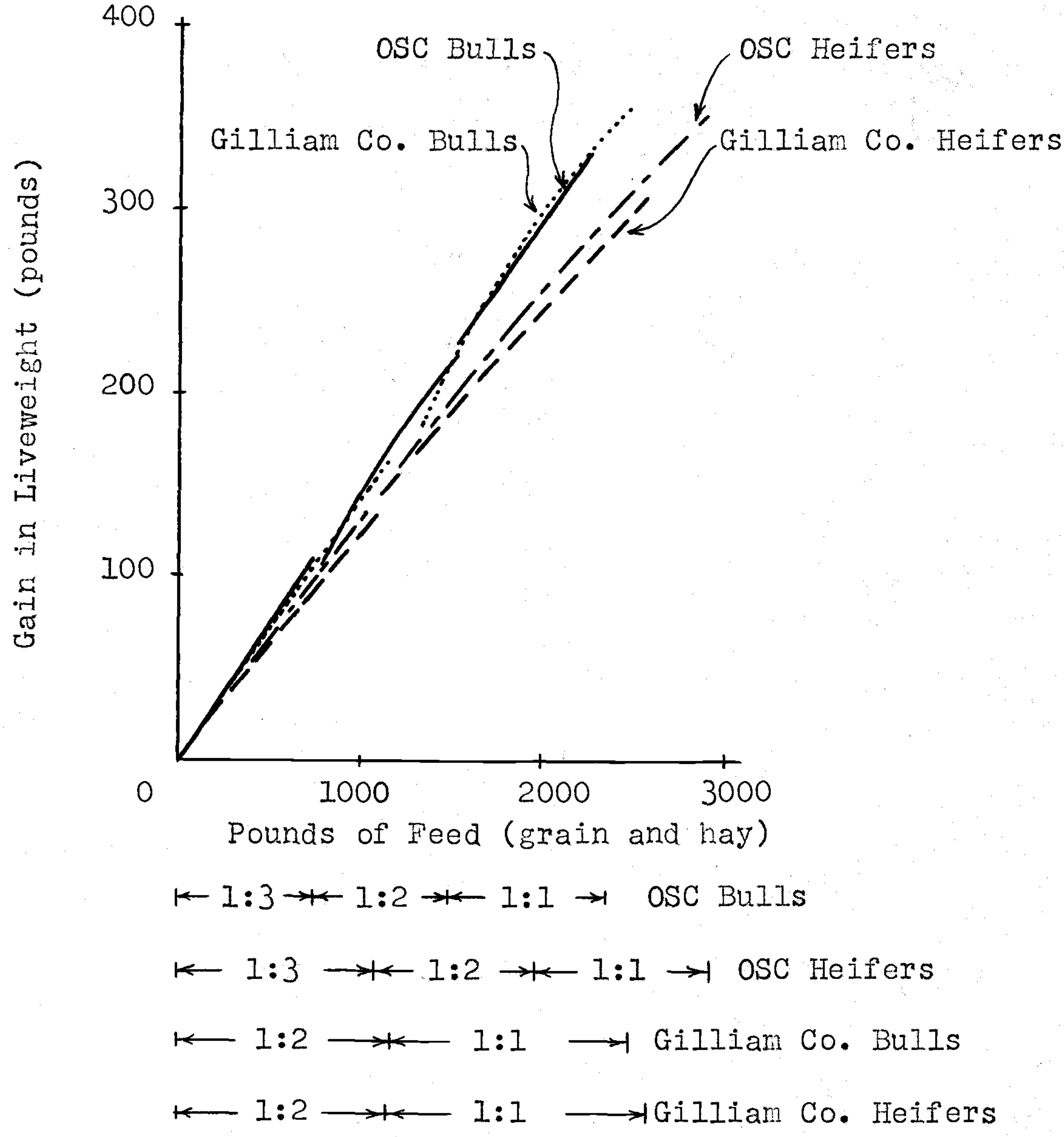

Figure 12. Growth Curves for Bull and Heifer Calves Fed in Dry Lot in Gilliam County and Bull and Heifer Calves Fed in Dry Lot at Oregon State College.

bulls in the Gilliam tests appears to be about the same as the growth of heifers and bulls in the Oregon experiments. However, more grain was fed in the Gilliam tests, and if the rations were comparable in all other respects, higher growth could be expected from the animals in the Gilliam tests. The ration and feeding practices did differ, and it may also be possible that the animals in the Gilliam feeding trials were not comparable to the animals in the Oregon experiment.

From these comparisons, it can be concluded that a high level of growth was attained in the Oregon experiments. Duplication of this growth level was attained in the Gilliam tests, but more grain was fed to do so. The animals fed in the Gilliam tests were farmer owned, thus they may be considered more typical of the kind of animals fed by feed lot operators in the state than those in the Oregon experiments. Also, the ration containing three feed grains, cottonseed meal, mixed alfalfa, and grass hay, can be considered more typical of the rations fed by feed lot operators in the state than the rations in the Oregon experiment. Therefore, growth of calves in the Oregon experiments probably was higher than could be expected by the average cattle feeder in Oregon.

Survey Results with Some Appraisals of Oregon Feed Lot Operations

Data obtained in the survey consist mainly of management practices followed by the operators that were contacted in the two counties. These management practices included such factors as facilities provided for the cattle, kind and quality of cattle fed, length of feeding periods, feeding practices, and marketing procedures.

Feeding Facilities

Most feeding operations surveyed were established with a minimum outlay for feeding and housing facilities. Only one operation had an all paved feed lot, and very few had concrete feeding floors for the cattle. The lack of permanent feeding facilities by the operators indicates that the enterprise was not established on a permanent basis. Many operators had their enterprises planned for the expansion or the contraction of feeding cattle, depending on the availability of low cost feeds and/or the prices of cattle. Contraction could mean going out of business.

Cattle on Feed

The majority of the cattle on feed were yearlings. A few operators were feeding calves and some were feeding two year old cattle. As expected, steers predominated in the number of cattle in the feed lots.

Feeding Practices

The length of the feeding period varied from 90 to 300 days. The most common practice was to feed the cattle for a period of 120 to 160 days. Rations fed by the individual operators varied from a mixture of one grain, minerals, and hay to a more complex mixture of three grains, protein supplement, molasses, alfalfa hay, silage, and minerals. The rate of gains ranged from one pound to approximately two and one-half pounds daily. The lowest gains were obtained when only one grain in limited quantities was fed, whereas the best gains were obtained when a mixture of two or three grains was used. Several kinds of roughages were used, as indicated in Chapter I.

Wheat and barley were the feed grains most commonly used. However, corn and oats were used in many of the feed mixtures. Feeders using only wheat or barley in the ration had more trouble with bloat and cattle going off feed than did those feeding a mixture of two or three grains. The use of more than one grain in the feed mixture (except corn) has usually been found to be a better practice than feeding a single grain. Experiments at Missouri (40, p.2) and Montana (28, p.79) report better gains and less bloating, scouring, and other digestive disturbances when barley and wheat were mixed with each other, or mixed with other grains such as corn or oats. Very few were feeding oats alone for any length of time.

Data obtained in the survey indicated that most cattle feeders were limiting the grain fed. This practice may have accentuated diminishing physical returns during the feeding period. The usual practice was to start the cattle on feed with roughage and a few pounds of grain daily, gradually increasing the grain until the desired quantity was being fed. The level of grain feeding varied from about 6 to 12 pounds per animal per day among the operations. This generally required a period of three to five weeks, occasionally longer. For the rest of the feeding period, the usual practice was to feed the grain at a constant amount per day for each individual animal.

The practice of holding the grain level constant is not the same as feeding a constant ratio of grain to roughage. Under the constant grain level, the percentage of grain in the ration may decrease. The cattle will eat more as liveweight increases, but with the grain feeding level fixed, additional feed intake must be in the form of roughage. The increase in roughage intake decreases the per cent of grain in the ration. It has been noted in the analysis in Chapter 5 that a constant ratio of 1:2 for calves resulted in significantly diminishing returns. It is logical to expect the limited grain feeding practice also to result in significant diminishing returns.

With feeding periods of 120 to 160 days, a gradual increase in the percentage of grain during the latter half of the period probably would result in more efficient gains. Also in the shorter feeding periods, a gradual increase in grain during the complete feeding period probably would result in more efficient gains.

Selling Practices

Culling is the practice of sorting out and selling the cattle early that fail to gain as efficiently as needed for yielding an increase in value greater than costs. Very few operators follow this practice. Those animals not gaining weight efficiently will reach a point whereby it no longer pays to feed them sooner than the efficient gaining cattle. Therefore, they should be marketed sooner than cattle making efficient use of feed. Many feeders were found to be separating these animals from the others and feeding them for a longer period of time, or on a higher level of grain.

There was a distinct tendency for the operators included in the survey to market their cattle at a grade of high good to choice. Several operators were following the practice of "topping", or selling in different groups as the desired market grade was attained.

Possibilities of Expanded Feed Lot Operations in Oregon

The main limiting factor in the expansion of dry lot cattle feeding operations is the small margin of return for each animal. This is due mainly to the high cost of feed grains in relation to the price of cattle, or, stated another way, an unfavorable cattle-grain ratio. The use of low quality roughages in the feeding of cattle needs further investigation as a possibility for lowering feed costs. Low cost roughage is the main factor in the development of the present operations. The low cost roughages compensate, in part, for the relatively high grain cost.

A possibility for increasing the margin of returns over costs in cattle feeding is increasing efficiency of operations. Some of the practices that lead to more efficient operations, as noted in the analysis of experimental results, are: (1) select a minimum cost combination of grain and roughage feed, (2) increase the per cent of grain in the ration as the cattle progress in the feeding period, and (3) sell each animal (if practical) when net returns are highest, or when losses are least.

CHAPTER 8

SUMMARY AND CONCLUSIONS

The objectives of this study were: (1) to appraise the possibility of expanded feed lot operations, and (2) to develop some economic guides for increasing efficiency in cattle feeding. Major emphasis was placed on the latter objective.

Growth curves were estimated by statistical techniques for bull, heifer, and steer calves selected from the 1949-1953 feeding trials at the Oregon Experiment Station. Calves were fed from a weight of a little less than 500 pounds to approximately 800 pounds. Comparison of these growth functions indicated:

(1) Significant diminishing returns occurred during the feeding period for heifer and bull calves when fed a constant ratio of 1:2 grain to hay. Bulls made more efficient use of feed than heifers.

(2) Increasing the ratio of grain to hay for heifer calves from 1:3 to 1:2 and to 1:1 resulted in more efficient gains than for heifers fed a constant ratio. Steers fed three ratios made more efficient gains than heifers fed either a constant ratio, or three ratios of grain to hay.

Selected prices for feed and cattle were used for determining net value increases of animals in dry lot and optimum market weights. The optimum market weight was considered to be the point where net returns per animal were highest, or where losses were at a minimum. It was concluded from this analysis that:

(1) Calves with greatest efficiency of feed utilization resulted in the highest net increase in value and heavier optimum market weights.

(2) Reduction of feed prices and/or increased slaughter prices resulted in higher net returns and heavier market weights.

Constant product contours were estimated for yearlings and steer calves. Use of feed price ratio lines indicated that minimum cost combinations of grain to hay for these steers (at current prices) were approximately one part grain to two parts hay. Little difference occurred between the total cost of feed over a wide range of feed combinations near this minimum cost point.

Growth curves estimated from the animals in the Gilliam County test followed patterns similar to those of bulls and heifers fed three ratios of grain to hay in the Oregon experiments. However, a higher percentage of grain was fed in the Gilliam tests.

A survey of 18 cattle feeders in Umatilla and Klamath

Counties indicated the following:

(1) Most operators planned operations for contraction or expansion by minimum investments in facilities and feeding equipment.

(2) Limited grain feeding was a general practice.

(3) Culling of cattle making inefficient use of feed was not a general practice.

(4) The most efficient operators were selling their cattle at choice grades. Some were "topping" their cattle by selling as soon as they attained the grade of choice.

The main factor limiting the expansion of dry lot feeding operations in Oregon was the low margin of return received per animal. This was due mainly to the high cost of feed grains. Low cost roughages compensated in part for the high grain costs. The net returns per animal could be increased by increasing operating efficiency. Some possible ways of increasing efficiency were: (1) selecting a minimum cost combination of grain and roughage for attaining a given output of beef; (2) increasing the per cent of grain in the ration as the feeding period progressed; and, (3) selling animals at their optimum market weights and grades.

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