# AN ECONOMIC ANALYSIS OF RANCHING IN NORTHWEST OKLAHOMA UNDER VARIABLE FORAGE YIELD AND QUALITY CONDITIONS AND SELECTED BEEF PRICES

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AN ECONOMIC ANALYSIS OF RANCHING IN NORTHWEST OKLAHOMA UNDER VARIABLE FORAGE YIELD AND QUALITY CONDITIONS AND SELECTED BEEF PRICES

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## PREFACE

This study is concerned with determining the most profitable combination of forage and livestock activities for a ranch situation. A linear programming model which represents a 3200 acre ranch in Northwest Oklahoma is used to examine the effects of changes in livestock prices and forage yields on selected ranch organizations.

The author wishes to express his appreciation to his major adviser, Dr. Odell L. Walker, for his guidance and assistance throughout this study. Appreciation is also expressed to the other committee members, Dr. Darrel D. Kletke and Dr. Alan E. Baquet, for their suggestions on the final manuscripts.

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# CHAPTER I

## INTRODUCTION AND LITERATURE REVIEW

The continued existence of a ranch is not dependent on producing more beef per acre, but on the manager's ability to produce that beef while receiving an acceptable return to his resources. This study is undertaken to examine the economic implications of various forage use alternatives and ranch organizations under the changing conditions encountered in actual operation.

Producers of beef cattle have historically been faced with changing conditions which can adversely affect their ability to produce beef at a profit. The events of recent years, including the buildup of large cattle numbers in the early 1970's, high feed grain prices, the resulting fall in cattle prices, and the inflation of critical input prices, have emphasized these variations and the problems associated with them.

As grain production became increasingly profitable compared to livestock, those operators with land suited to farming turned to the production of cash grain. This often included the breaking-up of established tame grass pastures and, at times, placing marginal land under cultivation. The very nature of the land resources enabled those operators with the capability of increasing cultivation to take advantage of the relative profitability of grain crops.

The producers utilizing large amounts of native rangelands for livestock production had less room for adjustment. Because their land was not suited to farming (at least not on a large scale) they were faced with the problem of using their rangelands in the most profitable manner. Since feed costs are the largest single component in the production of beef, and grass is the cheapest of all feeds to produce, the problem of profitability centered on the most efficient use of the grass produced by these rangelands.

Beef producers faced the predicament of determining the "best" way to handle the problem. Ranching "by the seat of the pants" was the rule rather than the exception. Those operators best able to cope with these circumstances were those who were able to adjust their operation to take advantage of profitable opportunities.

Recent dry years and their impact upon forage production have further emphasized the importance of the operator's ability to adjust. A rancher with too little grass simply must reduce livestock numbers. A cow-calf operation may have to sell stock selectively bred to a high level of productive performance. Not only can this be psychologically painful, but it can be damaging in that it may literally require years to replace the cows and return the operation to the past level of performance.

Some ranchers operate a cow-calf and yearling program, keeping the calves produced to graze as feeders in good grass years and selling the calves in poor grass years. This type of operation focuses on harvesting the grass on hand. However, maximum beef production per acre does not ensure that maximum returns to the ranch operation will be realized.

The conditions described above present a challenge to effective ranch management. Due to varying circumstances, an operation which profits in one year may be subject to loss in the following year. This does not imply that profitable opportunities do not exist or that the operation is being mismanaged. All too often the ranch organization either cannot be adjusted to deal with these situations, or the manager has no information concerning how to adjust his operations.

There is a need for management tools to analyze ranch organizations and to guide in forming operational plans which can be profitably adjusted to meet the situation. Such tools can aid the individual ranch manager in utilizing his resources (particularly grass) in producing beef while maintaining returns to those resources.

## Objectives

The changing conditions which affect ranch profitability and the need for a means of evaluating alternative plans and organizations in the light of those variations form the basis for this study. Its objectives are:

1. To determine the profit-maximizing mix of forage and livestock activities for a representative ranch in Northwest Oklahoma.
2. To estimate the effects of changes in prices and weather on the ranch organization.
3. To establish guidelines for organizing and operating ranches in Northwest Oklahoma emphasizing flexibility of operation.

## The Forage Resource

Northwestern Oklahoma is the general area upon which this study is based. Feed is the single most important input in a livestock operation and a ranch operation is based upon forage as the primary feed source. Thus, it is useful to examine the factors which influence forage production and utilization as they relate to the study area.

Native Range

In the words of Harold Heady (18, p. 4):

> Rangeland vegetation includes shrublands, grasslands, and open forests where dry, sandy, saline, or wet soils; steep topography; and rocks preclude the growing of commercial farm and timber crops.

Such land occupies approximately 40 percent of the land surface of the United States.

The native rangelands of the Great Plains (which includes Oklahoma) are a unique resource mix. According to Harlan (15), one of the most characteristic features of native range forage production is the comparability of average forage yields over a wide area. Throughout the Great Plains, soil types and topography are widely variable, as are the extremes of temperature and rainfall. Yet, given these differences, the average amount of forage produced per acre by native rangelands is remarkably similar. No other crop yields so consistent an average over such a wide range of climatic conditions. However, production of forage on any given range site can vary considerably from year to year. Harlan (15, p. 8) states that, ". . . seasonal variation in production of native range is found to vary from 25 to 30 percent of the mean in poor years to 160 to 165 percent of the mean in favorable years." It takes a very bad year to yield so little, and a very good year to yield so much.

Several factors can limit the forage production capacity of native rangelands in a given area. Harlan (15) lists the principle ones as:

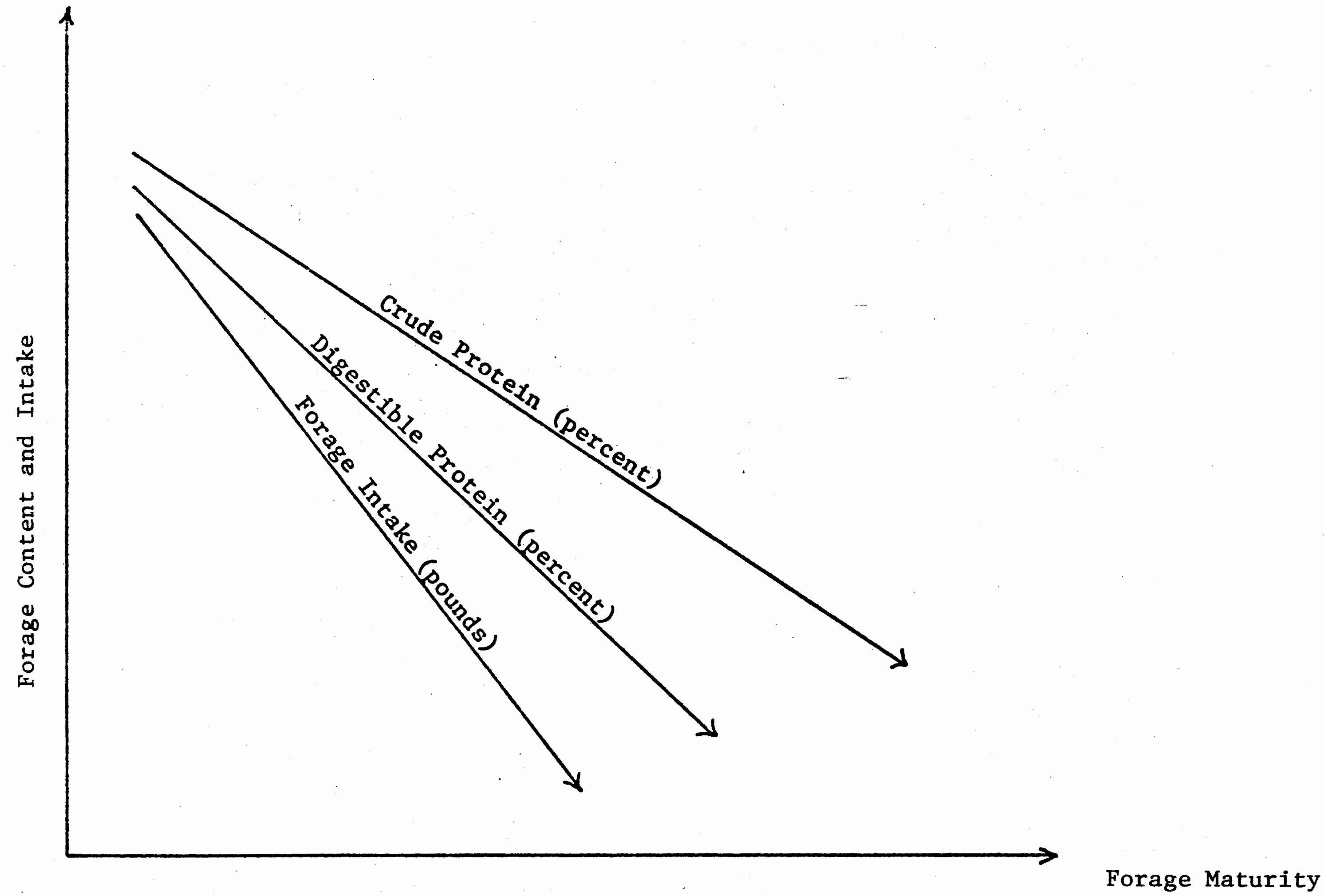
1) Amount and Distribution of Rainfall. Most seasonal variations in forage yield are due to changes in the timing and amount of precipitation.

2) Soil Characteristics. The two primary soil characteristics which limit forage production are the fertility level of the soil and its texture. Limited production capability on the whole causes fairly uniform average forage yields over wide geographic areas. Texture is the the primary factor in moisture retention, thus influencing the amount of moisture available to the plants.

3) Management. Management practices have a long-run effect on rangeland forage yields. Overgrazing reduces yields as it changes the mix of grass species present, promoting the growth of less desirable grasses. Chronic overgrazing can virtually destroy the productivity of a range site in the long run (p. 10).

The nutritional characteristics of forages produced from native rangeland vary according to the season of the year. In Western Oklahoma, from the time that the warm season grasses begin growing in late April until the end of June, native ranges provide high-quality forages capable of producing weight gains of two to three pounds per day on stocker steers, depending upon size, age, and condition of the steer. As summer progresses and forages mature, the digestibility of the forage declines. By late summer, protein can become a limiting factor on steer gains as a result of decreased digestibility reducing forage intake. By October or November weight loss is likely for steers on native ranges unless protein supplements are provided.

The relationship of protein content and intake is illustrated by Figure 1. These relationships as illustrated have been generalized from research results (38). The focus is on the relationship illustrated, not on the actual numbers. The crude protein content of the forage declines as the forage matures. As the forage matures, the nutrients also become less digestible, further accentuating the decline in protein content. When forage digestibility decreases, forage intake is adversely affected since the less digestible forage is slower to move through the




Source: (38).

Figure 1. The Relationship of Forage Protein Content and Intake

animal. Thus, as forage matures, nutrient content declines and the nutrients present are less digestible. This results in decreased forage intake by the animal.

In summary, native rangelands provide excellent quality forage for three months, forage declining in digestible energy and protein content for an additional three to four months, and low quality forage in the remaining five to six months.

Farmed Forages

In the Great Plains, native rangelands are often intermingled with land that is suitable for careful cultivation. In Western Oklahoma, this land can be used as a forage resource or for the production of various grain crops. The mix of grain crops and forage production on this land is influenced by the livestock activities possible and the relative profitability of the grain crops.

This land is capable of producing high-quality forages in different time periods or in greater amounts than the native rangelands. Forages produced on this land can be classified into two groups:

1) Introduced Perennial Grasses. The species of grass included here are those such as Bromegrass, Crested Wheatgrass, and Weeping Lovegrass. These are range grasses native to other areas of the world which offer increased response to fertility improvement practices and higher forage yields than the native rangelands. Once established these grasses provide forage which can be intensively grazed or harvested for hay. They are managed much like native range, except for certain differences relating to plant growth, fertilizer response, and forage quality characteristics.

2) Small Grains and Forage Sorghum-Sudan. These are crops requiring annual cultivation for forage production. Although capable of producing large quantities of high-quality forage, these activities also require increased inputs of fertilizer, machinery, labor, and management. Wheat, rye, and oats can be used to produce high-energy, high-protein forage during the

> winter and early spring. Forage sorghums and sorghum-sudan hybrids can produce high-energy, high-protein forages during the late summer months.

The coexistence of these forage resources with their differing forage production characteristics provides the opportunity for combining them in a livestock program. McIlvain and Shoop (27) use the term "complementary pasture" to describe the situation where such pastures are mutually dependent, each providing what is lacking in the other. They observe that:

> . . . the essence, or major value, of tame pasture such as weeping lovegrass is quantity, the essence of farmed forage such as wheat and sudan is quality, and the essence of native range is stability and flexibility (27, p. 2).

The production characteristics of the various forages limit the types of livestock activities possible in the ranch organization. In the words of Cook (6, p. 1), ". . . the production capability of a ranch depends, to a large degree, upon the amount of forage or feed available for each season." Thus, the possible mix of livestock activities is directly dependent upon the forages available for their use.

## Forage Quality Measurement

In order to compare forage production with forage consumption, it is necessary to use a common measure of forage production and livestock requirements. This measure should reflect the nutritive value of the forage as it is utilized by livestock. Animal Unit Months (AUM's), Total Digestible Nutrients (TDN) and more recently measures of Net Energy (NE) have been used to equate forage production with livestock requirements. Dillard (10) contends that:

> . . . since beef cattle must satisfy their nutritional requirements daily, and production of forage is highly seasonal, any model used to analyze the forage-beef production problem must

> reflect differences in forage production and differences in nutritional requirements of beef cattle in the different production cycles (p. 7).

It is thus advisable to examine these measures of forage production and consumption to determine their adequacy in analyzing forage-beef production.

Animal Unit Months (AUM's)

The animal unit month (AUM) is based on the concept of an animal unit (AU). An AU is widely accepted as a mature cow and her calf, or their equivalent. This base can be adjusted to reflect the needs of other livestock. For example, a mature bull is 1.25 AU, a young beef animal .6-.9 AU, and a horse 1.25 AU (18). These figures reflect the requirements of different kinds and classes of domestic animals with similar diets.

An AU can also be defined in terms of metabolic weight. Using a 1000 pound cow as a base, Kearl (21) defines an AU in relation to its basic metabolic requirements as:

$$AU = \frac{W^{.75}}{1000^{.75}}$$

where W is the weight of the animal in pounds, and the denominator represents the weight of a mature cow. AU equivalents can be estimated for any weight of animal in this way, but the results still indicate equivalent amounts of forage required by different weights of livestock with similar diets.

An AUM uses these AU estimations, and is defined as the amount of forage required by an AU for one month's grazing.

The use of AUM's to equate forage production and livestock consumption presents several problems. Harold Heady (18) warns that coordination of varying AUM requirements and forage increments in day to day livestock management still is a matter of judgment by the manager. Powell (30) further states that to effectively use AUM's for diet formulation, differentiations of forage must be made. AUM's as structured do not account for forage quality differences, or differences in livestock requirements unless altered by the user for this purpose. In using the AUM approach, researchers have generally been careful to force in additional protein supplement during winter periods to meet protein needs. Another research practice has been to construct different enterprises for different forage types to account for quality differences in the forage. Jones (20) concludes that this exogenous AUM approach assures neither an optimum ration nor a feasible ration.

## Total Digestible Nutrients (TDN)

Total Digestible Nutrients (TDN) measure the sum of all digestible organic nutrients; protein, fiber, nitrogen-free extract, and fat. The TDN of a feed measures the digestible energy of the feed in terms of carbohydrate equivalent. In this way it uses the energy content of carbohydrates as a base.

The digestible energy of a feed is equal to the caloric content of the feed consumed less the caloric content of the feces excreted by an animal. TDN is thus a measure of the energy made available to the animal for maintenance or conversion to milk or meat.

TDN, as a measure of feed energy, does not account for other energy losses such as the gas produced and heat lost through physiological processes. Since these losses are relatively larger for roughages than for concentrates, a pound of TDN in roughage does not have the same value for productive purposes that a pound of TDN in concentrates does.

Crampton and Lewis (7) warn that TDN values for roughages consistently and appreciably overestimate the usable energy of such feeds by ruminant animals. This has particular effects when forage is the main feed source. Jones (20) found that the use of TDN as the specified measure in a forage-beef model sometimes "forced" the livestock to consume more forage than was physically possible.

## Net Energy (NE)

The net energy system is based upon the energy content of feeds and the energy requirements of livestock as measured in calories. As feeds are digested by livestock, a portion of the energy contained is lost, the remainder is available for animal maintenance, milk production, or weight gain. This energy remaining after losses due to the various physiological processes is called net energy.

Net energy consists of net energy for maintenance ($NE_m$) and net energy for gain ($NE_g$). $NE_m$ is a measure of the amount of feed required to maintain an animal in energy balance with no weight gains or losses. It expresses the relative value of a given feed for maintaining animal weight. $NE_g$ is a measure of the energy stored in new body tissue by the addition of feed above the maintenance requirement of the animal. It expresses the relative value of a given feed for producing weight gain given good forage data (37). The net energy system can be used to precisely calculate the energy requirements of animals and the energy supplied by the feed.

The data requirements of this system are extensive. The National Academy of Sciences (NAS) publishes a manual of the Nutrient Requirements of Beef Cattle (NRC). This manual contains estimates of the nutrient requirements for different classes of cattle with varying rates of gain over specified weight ranges, including the requirements for dry pregnant and lactating cows. The cattle requirements are reasonably accurate, though there is some averaging over individual breeds of cattle.

The NAS-NRC also contains data on the nutrient composition of common feedstuffs, and the energy value of these feeds for maintenance and weight gain. These data are averaged over forage types and growth conditions for the feeds listed. As discussed earlier, the nutrient composition of forages can change over the growing season. These changes are not presented clearly in the NAS-NRC. Other data for specific areas are available for forages as forage clipping yields and steer gains. These data are transformed for use in terms of nutrient composition.

Fox and Black (12) state that:

> . . . The net energy system has become the most widely used energy system for ration formulation and gain prediction. The predictive performance appears to be superior to other systems when evaluated across a wide range of situations (p. 1).

However, meeting energy needs of an animal in ration formulation does not guarantee that sufficient protein will be provided.

## Summary

Each of the measures discussed can be used to equate forage quality with livestock use. Each also contains certain weaknesses which can limit its effectiveness.

The AUM approach fails to differentiate between forages by quality or by season of use. It often requires transformation from dry matter clipping data, and necessitates considerable manipulation for effective use.

The TDN approach tends to overvalue roughages, particularly in stocker and feeder rations. It is also unable to express changes in forage nutrient compoistion which occur during the growing season without adjusting the TDN value.

Jones (20) further discusses the relative problems of these measures of forage for research use. He found that both the TDN and AUM approaches when used in a linear programming model can yield forage organizations which are not physically feasible.

The NE approach requires the monitoring of protein as well as energy, and requires good data for effective use. Its major advantage is that forage quality can be accounted for.

Anderson (2) developed a linear programming approach utilizing net energy density of dry matter with protein monitored to assure a balanced ration. Using steer gain data and the NAS-NRC, he estimated forage quality groups and defined livestock nutritional requirements by calendar period. This treatment was effective in yielding realistic forage consumption figures and stocking rates.

Any realistic investigation of optimal forage use must account for forage quality changes over time. The net-energy approach seems more exact in its treatment of these changes, and yields realistic research results in situations modeled, while AUM and TDN specifications must be adjusted to reflect these changes, and may still fail to yield realistic results.

## Flexibility

The ranch manager is constantly faced with a variety of situations resulting from the somewhat uncertain movements of input and output prices and changes in weather conditions which influence the production of forage.

The way the ranch organization responds to these changing conditions was recognized as a major research problem area by the Great Plains Agricultural Research Committee (GPARC). It stated:

> . . . Current systems of forage and livestock production need re-evaluation and improvement of efficiency in terms of profitability and flexibility in relation to changes in prices, weather, and technology (13, p. 7).

Where native rangelands and farmed forages are the major source of livestock feed, the production and nutritional characteristics of the forages grown have a major impact on the flexibility of the ranch organization. Native rangelands are of particular interest when they are the major component of the forage resource. The GPARC (13) notes that:

> . . . native range expresses its dynamic capabilities for change in response to grazing intensity, season of grazing, length of grazing season, and the interaction of grazing management, soil, and climatic factors. At the same time, animal productivity changes as the grazing animal matures and responds to environmental factors including quantity and quality of forage (p. 43).

Cook et al. (6) further observed that:

> . . . the quantity and quality of forage supplied varies from season to season and from year to year. The amount or extent of fluctuation will influence the type of operation that will be most lucrative to the area (p. 3).

Changes or variations in weather from season to season and year to year magnify the managerial problem because they affect the quality and quantity of forage produced. The ranch may need to adjust stocking rates and livestock numbers between seasons or years. Good years can result in too much grass, and poor years in too many cattle. The intensity of forage utilization is reflected in the number and type of animals grazed per acre, i.e., the stocking rate.

According to Coleman and Horn (5, p. 69), ". . . when considering which stocking rate is most economical, two factors must be examined: 1) gain per animal and 2) gain per acre." Ranches often express little interest in gain per animal, and concentrate on maximum production per acre. Yet, as Coleman and Horn (5, p. 70) conclude, ". . . maximum beef production per acre does not necessarily ensure that maximum return per acre will be achieved."

As changes in forage production occur the operational plan presents a multitude of difficulties. The GPARC (13) notes that:

> . . . ranch organization problems center on choosing the production mix of stockers, cows and calves, and feeders while planning to avoid the adverse effects of product prices and weather variability and selecting among a wide variety of range and other production practices (p. 51).

In practice, combinations of cow-calf and stocker-feeder activities have been utilized by ranchers in varying ways. A common practice is the use of an established cow herd as a base and holding calves produced to harvest excess forage. These practices and possible combinations need to be evaluated on the basis of profitability as well as forage utilization.

The ranch organization is also faced with variations in price relationships. Livestock prices cycle through time, and the price relationship between types of livestock (calves versus feeders) is also subject to variation. The prices of inputs such as fertilizer, fuel, and capital which are critical to the production of forage crops experience similar fluctuations. A flexible ranch operation capable of at least partially compensating for these short-run changes in operating conditions would be desirable.

The flexibility of the ranch unit in responding to these changes depends upon the relationship of the livestock activities possible within the ranch operation. These relationships affect flexibility to the extent that they can be altered within the production process. Consider two possible ranch organizations with equivalent resource bases producing calves and steers in a two-good framework illustrated in Figures 2 and 3. Ferguson and Gould (11) and Heady (16) present theoretical discussions of production in a two-good economy. Figure 2 represents the specialization of these resources in the production of steers, while Figure 3 represents a specialization in the production of calves. In both figures, iso-revenue lines $P_1$ and $P_2$ represent different price relationships between steers and calves. In each case, a change in the price relationships from that represented by $P_1$ to that represented by $P_2$ results in small relative changes in livestock numbers. The organization depicted in Figure 2 is more profitable when steers are profitable, and the organization depicted in Figure 3 is more profitable when calves are profitable.

Figure 4 illustrates a comparison of Organizations 1 and 2 with a third, Organization 3, which is not specialized in the production of either steers or calves. Outside of the price variations represented by iso-revenue lines $P_{11}$ and $P_{12}$, the inflexible organizations (1 or 2) provide greater total revenue than the flexible organization (3).

As illustrated, Organization 3, which is not capable of producing as many calves as 2, or as many steers as 1, is the most profitable over the range of price relationships between those illustrated by $P_{11}$

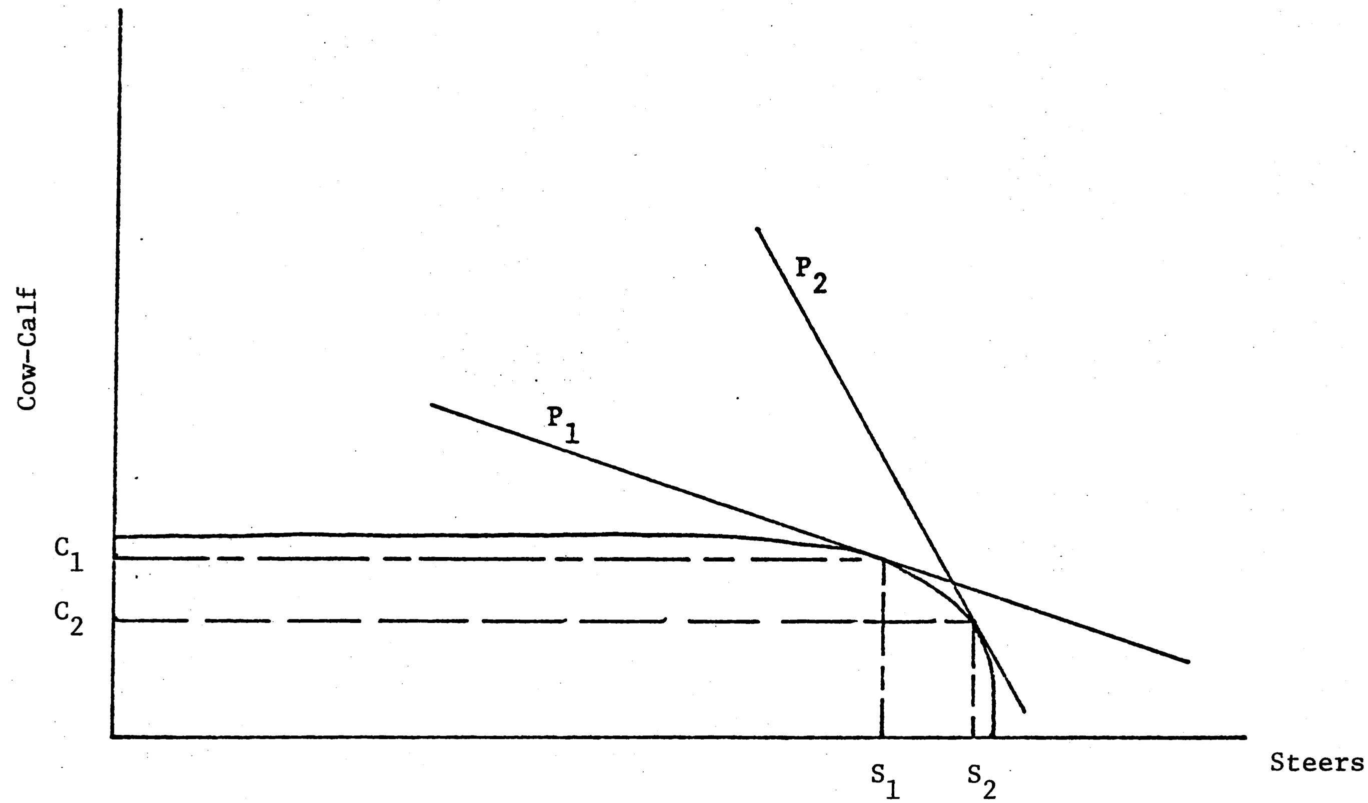



Figure 2. Organization 1--Production Possibilities Curve Illustrating a Specialization in the Production of Steers

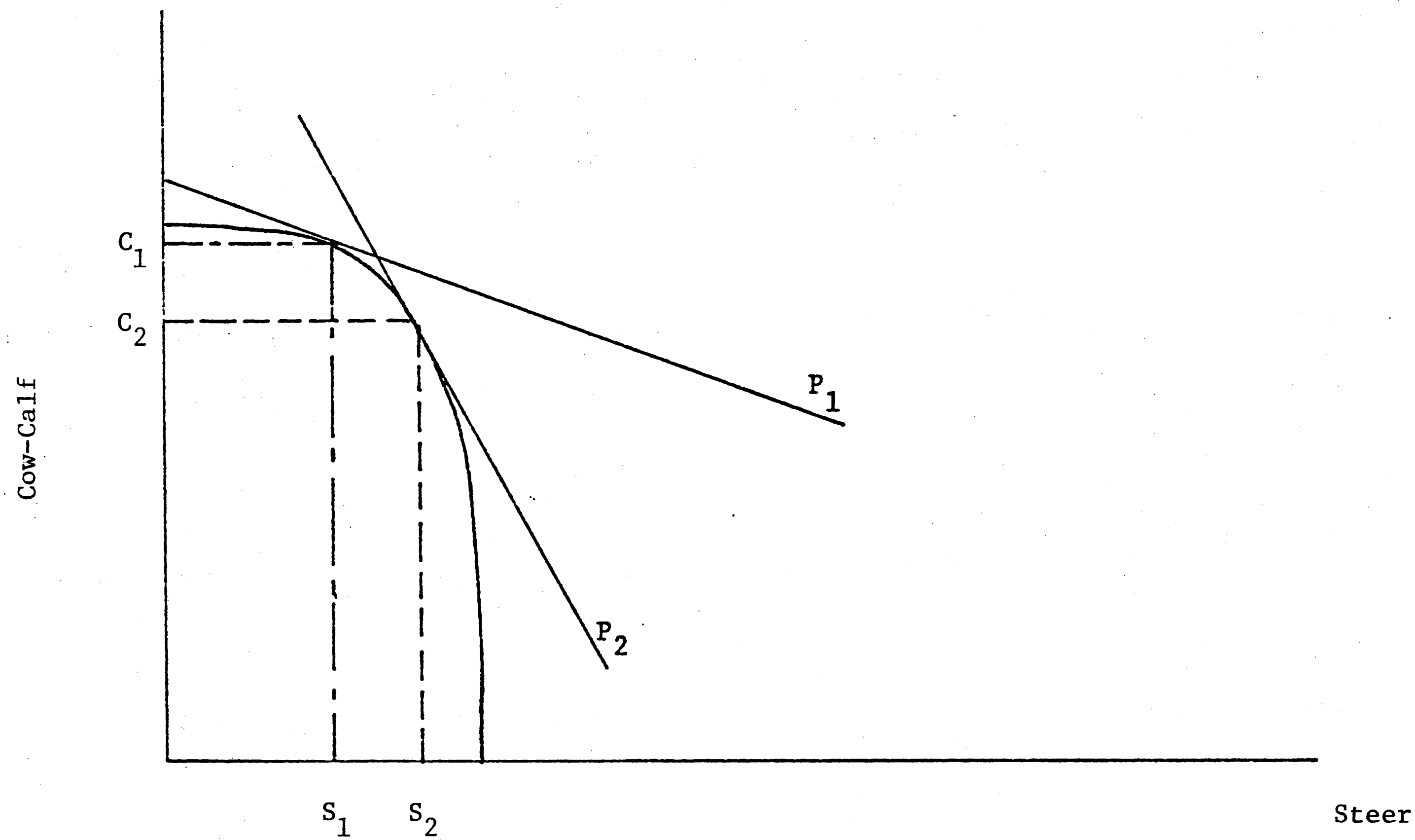



Figure 3. Organization 2--Production Possibilities Curve Illustrating a Specialization in the Production of Calves

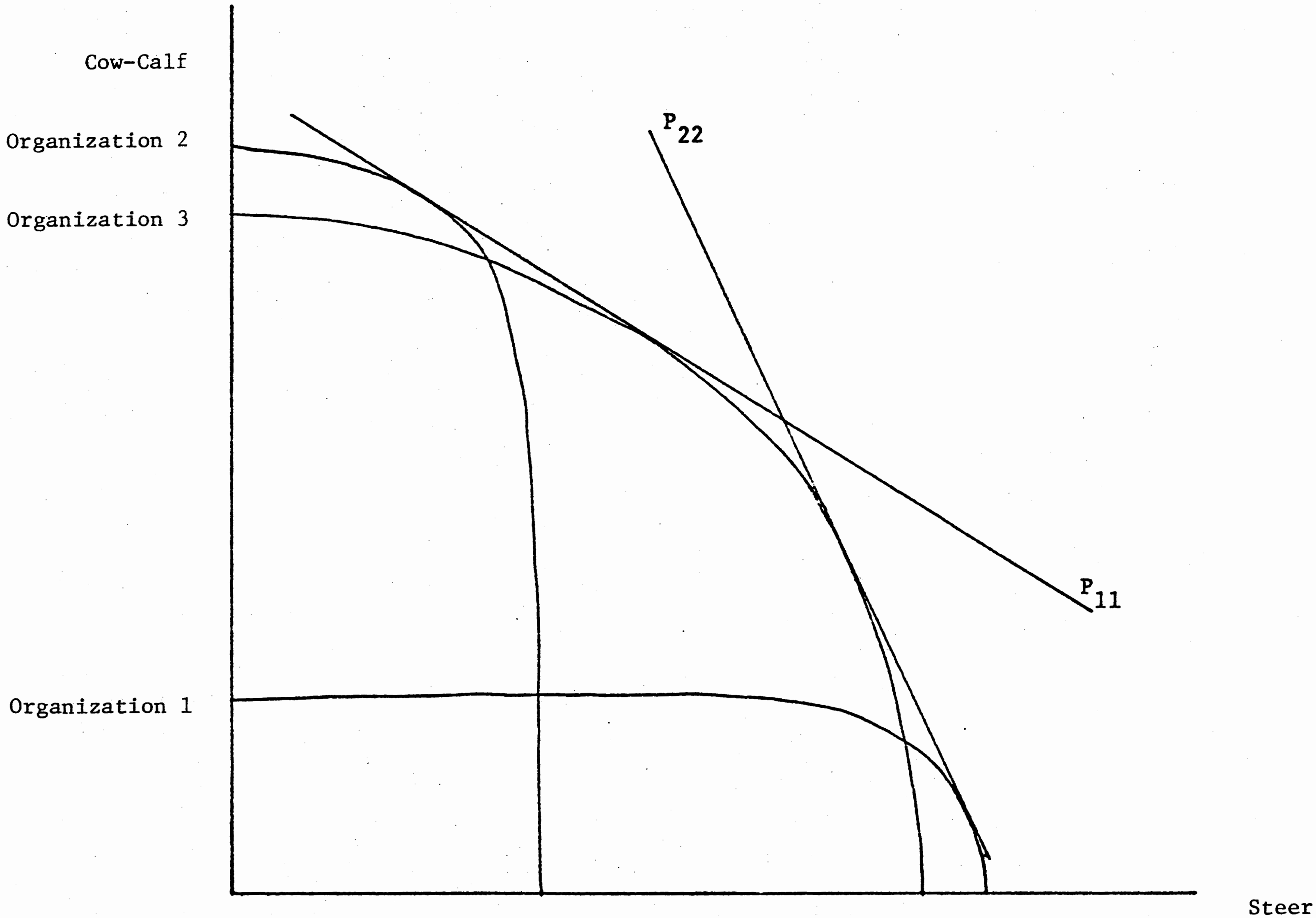



Figure 4. Alternative Production Possibilities Cures Illustrating Specialization of Production and Flexibility of Production

and $P_{12}$. Within the variations shown, the flexible organization provides a higher level of returns than the inflexible organizations. Heady (16) reasons that a firm which expects its output combination to vary from one extreme to another would employ the flexible organization.

The attractiveness of one organization over another may ultimately involve the degree of risk and uncertainty present. With uncertain fluctuations in weather and prices, the ranch operator may choose to operate so as to allow himself greater flexibility in responding to these variations. In so doing, he may prevent himself from obtaining the maximum production possible given his resources. Heady (16) states:

> . . . while product flexibility has its obvious costs it again represents an outlay which the operator as a resource administrator can select to be able to alter his course in a dynamic world where the exact one of alternative directions cannot be forefold with certainty (p. 528).

These representations are not empirical in nature, but have been constructed to represent the situation in a theoretical framework. Such representations can assist in examining real world problems from a theoretical standpoint. The response of the manager to past events may also influence his decision choices. Halter and Dean (14) argue that each manager in fact has a subjective probability of the occurrence of a given event, i.e., a dry year. Given those subjective probabilities, a reasonable manager may make a decision on the basis of expected value. Assuming the operator is a profit maximizer, the maximum expected value of a particular decision may be used as the criterion for making organizational decisions.

The flexibility and responsiveness of the ranch operation in dealing with changing conditions is ultimately subject to profitability. If a flexible ranch organization can minimize yearly income variation while maintaining acceptable returns to the operation, as compared to the "boom and bust" cycle often observed in livestock operations, then flexibility of organization becomes a major consideration. Production variables need to be examined to determine the effect which their variability has upon the profitability of the ranch organization. Ranch organizations which are less susceptible to such variations need to be defined and evaluated on the basis of returns to the operation, and not merely forage utilization.

# CHAPTER II

# MODEL SPECIFICATION

The assumptions and data utilized in examining the problem are presented in this chapter. Analysis is to be made of a 3200 acre ranch situation in Northwest Oklahoma. Preliminary study resulted in the establishment of basic assumptions to be reflected in the analysis. The land resource is defined, and assumptions are made concerning the amount of operator labor available and the level of management present. Pasture forage and livestock activities applicable to the area are also defined. The activities considered use management practices recommended from research conducted at the USDA Southern Great Plains Research Station (USDA-SGPRS) on the production and use of forage crops and native rangelands.

## Linear Programming

Linear programming uses the same basic concepts as marginal analysis to determine the optimal allocation of resources to those activities yielding the highest returns. Dantzig (8) or Heady and Candler (17) present the theoretical analysis of linear programming. Jobes (19), Dillard (9), Jones (20), and Anderson (1) have applied linear programming to solve resource allocation problems involving forage utilization in beef production.

The Mathematical Programming System-Extended (MPSC) is used due to its usefulness in analyzing the linear programming problem. The MPSX system is technically efficient in evaluating the profitability of the activities, and the shadow prices of the resources. It gives a comprehensive indication of the sensitivity of the activities to changes in the price of resources or products. The model is constructed to allow manipulation of certain variables in order to examine their effect on alternative ranch organizations.

A linear programming model of a ranch organization can be used to examine the effects of price and weather variations upon ranch organization. In examining the question of organizational flexibility the base organization, or any hypothetical organizational plan, can be held constant to examine the effect of introduced variabilities upon the level of returns to the resources of the ranch. In this way organizational plans can be compared and evaluated with respect to their performance under such variations.

Objective functions can be constructed to maximize return above the costs specified by the operator. For example, function OBJ1 can be designated to maximize return to land, operator labor, management, fixed machinery and equipment, and risk. In this case, the machinery and equipment resources are considered part of the ranch operation's fixed resources. If the fixed and variable machinery and equipment costs are constructed into the cost coefficients of the model, returns are maximized to land, operator labor, management, and risk. This objective function is designated OBJ2.

The specification of the objective function to be maximized depends upon the situation faced by the manager. If, for example, machinery and equipment are owned, he may maximize returns in the "short run" as specified by OBJ1. If returns are to be maximized in the "long run", where all inputs and costs can be considered as variable, OBJ2 may be used.

Within this study the opportunity cost of capital, defined as the average amount invested times the interest rate, will be paid within both objective functions. This will guarantee interest payment to the capital used by the activities. Ownership costs, which include depreciation, insurance, and taxes, will not be included in OBJ1. In OBJ2 these costs will be considered as variable costs, and so reflected in specification of OBJ2. These objective functions are similar to those found in the LP-Farm programs utilized by Oklahoma Extension.

## The Feeding Standard

A specification of forage produced and livestock requirements must be made to coordinate production and consumption. Jones (20) used three alternative specifications of forage usage in determining optimum range rations. They were 1) TDN, digestible protein, and dry matter (a balanced ration), 2) TDN as the only unit of measure for the ration, and 3) AUM as the only unit for measuring the ration. He found that both the TDN and AUM approaches can yield forage organizations which are not physically feasible for livestock. This was especially important with stocker activities, which require high ratios of digestible protein and TDN to dry matter.

Anderson (2) developed an approach using the energy density of the forage to classify quality. The energy density of forages was expressed as metabolizable energy per unit weight of forage dry matter. He estimated forage quality groups and defined livestock energy needs in terms of these groups by calendar period. Digestible protein was monitored to ensure that all nutritional requirements were met.

The energy density approach combines the TDN and dry matter specifications to measure qualitative forage characteristics and animal requirements. It combines the predictive advantages of the net energy system with the capability of yielding feasible realistic results in an LP model framework.

This study will use the energy density approach as developed by Anderson (1) as the feeding standard to measure forage quality and animal requirements. Digestible protein will be monitored to ensure that protein requirements are met within the model.

## Machinery and Equipment Costs

A ranch operator must invest in machinery and equipment for use in operation of the ranch unit. Machinery includes self propelled units such as pickups and trucks and the implements utilized in performing machinery tasks. Equipment includes the non-machinery items such as mineral feeders and corrals required to maintain and care for livestock.

In the situations examined by this study, the large relative amounts of native range involved indicate low machine intensity. Machine use apart from pickups is usually confined to improved pasture or forage crops, and those occupy only 240 acres out of the 3200 acres used as the land resource. Particular attention will be given to defining minimum machinery and equipment requirements of the 3200 acre ranch used as the base unit. The estimates will be based on cost and return budgets for pasture and livestock activities in Northwest Oklahoma and the practices used where activities have not been previously budgeted.

The expected requirements of the ranch are considered in deriving the machinery complement so that the requirements are coordinated in terms of machine capability. Where machinery capabilities exceed expected machine use, timeliness of operation is also considered.

The Oklahoma State University Enterprise Budget Generator (22) is used to estimate machine and equipment costs. The coefficients stored in the budget generator are used in determining the fixed, variable, and total costs associated with specified levels of machinery or equipment use. These costs are based upon the hours of annual use, the number of years owned, and the hours of actual life of the item.

Fixed costs are those costs which do not vary with the level of use over a given time span. They are depreciation, interest, insurance, and taxes.

Depreciation costs for machines on a per hour basis (DCPH) are calculated by the equation:

$$\text{DCPH} = \frac{\text{Purchase Price} - \text{Salvage Value}}{\text{Years Owned} \times \text{Hours of Annual Use}}$$

Insurance cost per hour (ICPH) is computed by multipying average investment times the insurance rate so that:

$$\text{ICPH} = \frac{\text{Purchase Price} + \text{Salvage Value}}{2 \times \text{Hours of Annual Use}} \times \begin{matrix}\text{Insurance} \\ \text{Rate}\end{matrix}$$

Tax costs per hour (TCPH) are based on the purchase price of the machine so that:

$$\text{TCPH} = \frac{\text{Purchase Price} \times \text{Tax Rate}}{\text{Hours of Annual Use}}$$

The interest charge is based on the average amount of capital investment in the equipment over the number of years the item is owned. Interest cost per hour (ICPH) is calculated as:

$$ICPH = \frac{\text{Purchase Price + Salvage Value}}{\text{2 x Hours of Annual Use}} \times \begin{matrix}\text{Interest}\\ \text{Rate}\end{matrix}$$

The ownership costs for machinery are considered as the sum of depreciation, insurance, and taxes. Interest is considered as an opportunity cost rather than a direct cost incurred by ownership.

Machinery

The machinery set presented in Table I for the 3200 acre ranch in Northwest Oklahoma is based on the assumption that the individual ranch operator will prefer to own the necessary machinery as opposed to hiring custom work for the crop activities. In practice it can be argued that ranchers prefer to use their own machinery rather than hire custom work.

Actual usage of the tractor and farm implements may not approach the expected use of these items as built into the budgets. The possible overestimation of machine use as calculated may result in the activities needing to bear higher costs than those estimated. In the model using OBJ2, this can cause an underpayment of the actual fixed costs.

A rancher may elect to hold equipment over a longer time period while using it at a low number of hours per year. Tables I and II present the ownership and fixed costs for the same machinery set under alternative assumptions concerning annual use. Ownership costs include depreciation, insurance, and taxes paid annually for each machine. Total fixed costs include interest charges. Ownership and fixed costs per

## TABLE I

## MACHINERY COMPLEMENT OWNERSHIP AND INTEREST COSTS WITH HIGH ANNUAL USE--MACHINERY I

| Item | Size | List Price | Salvage Value | Years Owned | Annual Hours Used | Depre-ciation Cost/ Hour | Insur-ance Cost/ Hour | Tax Cost/ Hour | Total Ownership Cost/ Hour | Total Annual Ownership Cost | Interest Cost Per Hour | Total Annual Interest Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tractor 3 | 100 hp | $20,500 | $6,055 | 10 | 600 | $2.41 | $.13 | $.51 | $3.05 | $1,830.00 | $1.99 | $1194.00 |
| Offset Disc | 16 ft. | 5,200 | 920 | 10 | 100 | 4.28 | .18 | .78 | 5.24 | 524 | 2.75 | 275 |
| Tandem Disc | 24 ft. | 6,000 | 1,061 | 10 | 150 | 3.29 | .14 | .60 | 4.03 | 604.50 | 2.12 | 318 |
| Sweep | 18 ft. | 3,200 | 566 | 10 | 100 | 2.63 | .11 | .48 | 3.19 | 319 | 1.69 | 169 |
| Springtooth | 30 ft. | 2,500 | 442 | 10 | 175 | 1.18 | .05 | .21 | 1.44 | 252 | .76 | 133 |
| Drill w/o Fert.(2) | 13.3 ft. | 3,400 | 601 | 10 | 100 | 2.80 | .12 | .51 | 3.43 | 686 | 1.80 | 360 |
| Bale Loader | 14 ft. | 7,000 | 1,238 | 8 | 100 | 6.77 | .26 | 1.05 | 8.08 | 808 | 3.86 | 386 |
| Pickup | .5 ton | 5,250 | 1,185 | 8 | 500 | 1.02 | .04 | .16 | 1.22 | 610 | .58 | 290 |
| Pickup | .75 ton | 6,200 | 1,400 | 8 | 500 | 1.06 | .05 | .18 | 1.29 | 645 | .64 | 320 |
| Truck | 2.0 ton | 13,000 | 2,606 | 8 | 500 | 2.60 | .09 | .39 | 3.08 | 1,540 | 1.48 | 700 |
| G-Neck Trailer | 20 ft. | 4,000 | 707 | 10 | 100 | 3.16 | .15 | .60 | 3.91 | 391 | 2.18 | 218 |
| Mist-Blower | 12.0 ft. | 1,000 | 0 | 20 | 100 | .50 | .03 | .15 | .68 | 68 | .45 | 45 |
| Fence (25) | 1 mile | 1,750 | 0 | 25 | 1 | 70.00 | 5.25 | 26.25 | 101.50 | 2,537.50 | 78.75 | 1968.75 |
| TOTAL | | $124,400 | $16,781 | | | | | | | $10,815.00 | | $6376.75 |

TABLE II

MACHINERY COMPLEMENT OWNERSHIP AND INTEREST COSTS
WITH MODERATE ANNUAL USE--MACHINERY II

| Item | Size | List Price | Salvage Value | Years Owned | Annual Hours Used | Depre-ciation Cost/ Hour | Insur-ance Cost/ Hour | Tax Cost/ Hour | Total Ownership Cost/ Hour | Total Annual Ownership Cost | Interest Cost Per Hour | Total Annual Interest Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tractor 3 | 100 hp | $20,500 | $3,920 | 15 | 400 | $2.76 | $.18 | $.51 | $3.45 | $1380 | $2.74 | $1096 |
| Offset Disc | 16 ft. | 5,200 | 271 | 20 | 50 | 4.93 | .33 | .78 | 6.04 | 302 | 4.92 | 246 |
| Tandem Disc | 24 ft. | 6,000 | 313 | 20 | 75 | 3.79 | .25 | .60 | 4.64 | 348 | 3.79 | 284.25 |
| Sweep | 18 ft. | 3,200 | 167 | 20 | 50 | 3.03 | .20 | .48 | 3.71 | 185.50 | 3.03 | 151.50 |
| Springtooth | 30 ft. | 2,500 | 130 | 15 | 115 | 1.37 | .07 | .21 | 1.65 | 189.75 | 1.03 | 118.45 |
| Drill w/o Fert.(2) | 13.3 ft. | 3,400 | 177 | 15 | 70 | 3.41 | .15 | .51 | 4.07 | 569.80 | 2.30 | 322 |
| Bale Loader | 14 ft. | 7,000 | 365 | 16 | 50 | 8.29 | .44 | 1.05 | 9.78 | 489 | 6.63 | 331.50 |
| Pickup | .5 ton | 5,250 | 1,185 | 8 | 500 | 1.02 | .04 | .16 | 1.22 | 610 | .58 | 290 |
| Pickup | .75 ton | 6,200 | 1,400 | 8 | 500 | 1.06 | .05 | .18 | 1.29 | 645 | .64 | 320 |
| Truck | 2.0 ton | 13,000 | 780 | 16 | 250 | 3.06 | .17 | .39 | 3.62 | 905 | 2.48 | 620 |
| G-Neck Trailer | 20 ft. | 4,000 | 707 | 10 | 100 | 3.16 | .15 | .60 | 3.91 | 391 | 2.18 | 218 |
| Mist Blower | 12.0 ft. | 1,000 | 0 | 20 | 100 | .50 | .03 | .15 | .68 | 68 | .45 | 45 |
| Fence | 1 mile | 1,750 | 0 | 25 | 1 | 70,00 | 5.25 | 26.25 | 101.50 | 2357.50 | 78.75 | 1968.75 |
| TOTAL | | $124,400 | $9,415 | | | | | | | $8620.55 | | $6011.45 |

hour for each machine are calculated by dividing the ownership costs and fixed costs by the hours of annual use as estimated.

The annual machinery ownership costs are larger on a per hour basis for Machinery II, but total ownership and interest costs per year are less than for Machinery I. The assumptions for Machinery I are those used within the model. Machinery II has been estimated to illustrate the effect of alternative machine use patterns on costs per hour and per year. In recognition of these alternatives, machinery use within the model will be monitored to test the validity of the base assumptions. If the long term ranch organization requires low machine use per year, the costs estimated in Table II could be used as an alternative to those in Table I.

Fixed costs can be considered in two ways. The first assumes that the amount of use for each machine is known and the fixed costs are allocated according to the number of hours of use for each activity budgeted within the model through OBJ2. The second considers total fixed costs as calculated for machinery to be charged directly to the ranch unit and OBJ1 is used. Each separate activity is charged only the variable costs associated with the machine uses required.

Fence requirements are considered as a part of the input cost of pasture activities rather than livestock activities. Thus, the fence is included in the machinery complement. Fence costs are calculated on a one mile basis in the machinery complement rather than on a per hour basis. The 3200 acre ranch in Northwest Oklahoma will contain approximately 25 miles of fence. This assumes 20 acres per field for improved pastures or forage crops, and 320 acres per pasture for native rangeland.

The total annual ownership cost for machinery (Machinery I) is estimated at $10,815.00. Total annual interest costs at 9.5% are $6,376.75 (Table I).

Equipment

The equipment set for the ranch operation includes the equipment and facilities required by the livestock activities. Equipment costs are made up of fixed costs, including depreciation, taxes, insurance, and interest, and variable costs. The variable costs are determined by the level of use of the item. When machinery is considered, use is the limiting factor since machine life can be defined in terms of total hours of use. Equipment life tends to be more accurately defined in terms of age. The level of use for equipment is reflected in the annual equipment repair costs (variable costs).

Equipment costs are calculated in the same manner as machinery costs. The coefficients used in calculating the fixed and variable equipment costs are stored in the equipment set in the Budget Generator. These coefficients are used in deriving the fixed and variable costs for equipment as required by the livestock activities.

The estimated fixed costs associated with the equipment set are shown in Table III. The equipment set is constructed on the assumption of a fixed land base, and is sufficient to provide the minimum necessary equipment for carrying out the possible livestock activities. Ranch buildings such as sheds and barns vary according to individual operator preference and operational size. For this reason the buildings are considered as part of the land resource, and are not included in the base equipment set. The corral size included is sufficient to handle

## TABLE III

## OWNERSHIP AND INTEREST COSTS FOR AN EQUIPMENT COMPLEMENT FOR A NORTHWESTERN OKLAHOMA 3200 ACRE RANCH

| Item | Size Unit | Purchase Price | Years Life | Depreciation | Insur-ance | Taxes | Total Ownership Cost/Unit | Number Units | Total Annual Owner-ship Costs | Interest Cost/Unit | Total Annual Interest Costs |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mineral Feeder | 1.00 ft. | $ 50.00 | 5 | $ 10.00 | $.15 | $.25 | $10.40 | 6 | $62.40 | $2.25 | $18.50 |
| Water Tank | 250 gallon | 200.00 | 10 | 18.00 | .54 | .90 | 19.44 | 6 | 116.64 | 8.10 | 48.60 |
| Corral 200-400 | 1.00 ft. | 2500.00 | 20 | 125.00 | 7.50 | 12.50 | 145.00 | 1 | 145.00 | 112.50 | 112.50 |
| Loading Chute | 1.00 dol. | 200.00 | 10 | 20.00 | .60 | 1.00 | 21.60 | 1 | 21.60 | 9.00 | 9.00 |
| Squeeze Chute | 1.00 dol. | 400.00 | 10 | 40.00 | 1.20 | 2.00 | 43.20 | 1 | 43.20 | 18.00 | 18.00 |
| Table Chute | 1.00 dol. | 400.00 | 10 | 40.00 | 1.20 | 2.00 | 43.20 | 1 | 43.20 | 18.00 | 18.00 |
| Misc. Tools and Equipment | 1.00 dol. | 200.00 | 10 | 20.00 | .60 | 1.00 | 21.60 | 1 | 21.60 | 9.00 | 9.00 |
| Horse with Tack | 1.00 head | 800.00 | 8 | 100.00 | ---- | ----- | 100.00 | 4 | 400.00 | 36.00 | 144.00 |
| Total Investment | | $8400.00 | | | | | | | $853.64 | | $372.60 |

200-400 animals. Given ranch size, stocking rates, and possible organizational plans, this facility can be used for all possible combinations of the livestock activities. The equipment set also includes three chutes for use with the corral; a loading chute, a table chute, and a spueeze chute. The costs associated with the chutes have been separated from the corral costs to allow for variations in livestock requirements and chute usage associated with various activities. For example, a stocker steer operation would not require a table chute.

Miscellaneous tools and equipment include small tools and fencing equipment, etc., regularly used in ranch operation. A horse with tack is also included for each 100 head of cattle. Ninety percent of the cost of the horses is allocated to the livestock activities, and 10% to the ranch unit. This allows costs associated with using the horses for other purposes (i.e., pleasure) to be paid by the ranch unit, not the individual activities.

The total annual ownership cost and interest cost for each item of equipment is determined by multipying the respective cost per unit times the number of units required by the ranch. For example, the ownership cost of a water tank is \$19.44. Since six water tanks are required, the charge is \$19.44 x 6 = \$116.64 (Table III). If the model fails to pay all equipment interest and ownership costs, the remainder must be charged for. In a forage situation, such items as tanks and mineral feeders must be placed so as to assure proper forage use. For a given land resource the equipment included cannot be effectively changed as livestock numbers vary. Total ownership costs for the equipment set are \$853.64, and total annual interest costs at 9.5% are \$372.60.

Total Annual Ownership and Interest Costs

The total annual ownership and interest costs for the equipment and machinery owned by the 3200 acre ranch can be totaled from Tables I and III. The total annual ownership cost for machinery is $10,815.06 and the total annual ownership cost for equipment is $853.64, thus total annual ownership costs for machinery and equipment are $11,668.64. This amount must be paid each year to own the machinery and equipment assumed in this study. Annual machinery interest cost is $6,476.85 and annual equipment interest cost is $372.60. Thus, the total annual interest cost (opportunity cost) for investment in machinery and equipment is $6,749.35 in this study.

## The Land Resource

Within this study, land is classified as either native rangeland or cropland. Harlan (15) found that native rangelands as a whole are not highly variable in yield relative to the geographic average yield for a season. Although soil types and range sites occur in a very mixed manner, since average yields are similar, the acreage in native range pastures in the model was assumed to have the same productive capacity on a per acre basis.

In the area considered, cropland is intermingled with native rangelands. Due to the small relative amounts of cropland and the fact that the most apparent difference between it and the native rangelands is that the terrain makes it suitable for cultivation, soil type is assumed to be similar. In this analysis, cropland is considered only as a forage resource and is assumed to be of the same productivity as the native rangeland.

## Management

This study assumes that the ranch operator is an efficient and knowledgeable manager whose primary goal is to maximize net returns to the operation. When organizations are specified for flexibility analysis, this assumption will be adjusted to reflect rationale associated with the variations considered. The manager is assumed to be capable of adjusting livestock numbers and the mix of livestock activities in anticipation of changes in weather conditions and livestock prices. Such changes are made within the context of the organizational limitations imposed in the model.

The pasture and crop forage yields reported in this study are representative of an above-average level of management expertise in determining stocking rates as pasture conditions change throughout the grazing season. The manager is assumed to be capable of maintaining forage yields on native rangelands within the limits imposed by varying weather conditions. It is also assumed that the manager is capable of combining introduced pastures and forage crops with native rangelands so that the forage produced is used during the time periods when it is of highest quality. The manager is assumed to be competent to adjust the stocking rates on these various pastures as necessary to achieve efficient forage utilization.

Machinery and equipment costs as presented also represent an above-average level of management. It is assumed that both machinery and equipment are maintained when not is use, and that such maintenance and repair work are done when needed.

## Labor

It is assumed that 2,700 hours of operator labor are available for use in the activities. This labor is allocated on the basis of 225 hours per month to each time period. Thus, 450 hours are available in April-May, June-July, August-September, and October-November. In December-March, there are 900 hours of labor available. Additional labor is available in each time period at a cost of $3.50 per hour.

## Prices

The input prices used in the base model are estimates of current prices paid by ranchers in Northwest Oklahoma. These prices were obtained from the price information published for the Budget Generator. The prices are estimated for the current period, and have been adjusted or estimated using other data only when these prices do not coincide with those actually observed or are not available from the published price information. The prices paid by the operation in the base model are shown in Table IV.

The prices received by ranchers for livestock are presented in Table V. These base prices are taken from the vector of livestock prices estimated for the Budget Generator in the Fall of 1977. Prices are adjusted for seasonality so as to reflect the sale dates for the various livestock activities. Adjustments are made based upon the weight, grade, and sex of the animal bought or sold. Table VI contains the indices used in making these adjustments. Cow and bull prices are not adjusted due to the variations in sale dates for cows and bulls within any given livestock activity. The three sets of livestock

TABLE IV

BASE PRICES ASSUMED FOR SELECTED INPUTS

| Item | Units | Price |
|---|---|---|
| Seed | | |
| Wheat | bu. | 3.40 |
| Hybrid Sorghum-Sudangrass | lb. | .20 |
| Sorghum | lb. | .30 |
| Fertilizer | | |
| Nitrogen | lb. | .18 |
| Phosphate | lb. | .15 |
| Potash | lb. | .08 |
| Miscellaneous-Forage Budgets | | |
| Sagebrush Control* | acre | 1.22 |
| Custom Haying | ton | 12.00 |
| Custom Silage Making | ton | 4.80 |
| *includes 2-4-D and maintaining spray trails. | | |
| Miscellaneous-Livestock Budgets | | |
| 44% Cottonseed Cake | cwt. | 10.00 |
| Salt and Minerals | lb. | .06 |
| Vet. and Med. | hd. | 3.50 |
| Personal Taxes | hd. | 3.00 |
| Hauling and Marketing | hd. | 5.00 |
| Hay 2.2 (e.g., Sudan Hay) | ton | 45.00 |
| Hay 1.8 (e.g., Lovegrass Hay) | ton | 35.00 |
| Miscellaneous | | |
| Hired Labor | hr. | 3.50 |
| Interest Rates | dol. | .095 |
| Replacement Heifer | hd. | 275.00 |
| Cow | hd. | 350.00 |
| Bull | hd. | 750.00 |
| Horse with Tack | hd. | 800.00 |

TABLE V

BASE LIVESTOCK PRICE VECTORS

| Class | Base | | |
|---|---|---|---|
| | Spring 1978 | Fall 1977 | Fall 1975 |
| Steer Calf 3-5 (Choice) | 66.00 | 49.00 | 26.00 |
| Heifer Calf 3-5 (Choice) | 55.00 | 43.00 | 23.00 |
| Steer 5-7 (Choice) | 59.50 | 46.00 | 29.00 |
| Heifers 5-7 (Choice) | 54.00 | 41.00 | 25.00 |
| Steers 800-1000 (Choice) | 55.00 | 44.00 | 43.00 |
| Cows | 37.00 | 30.00 | 18.00 |
| Aged Bull | 42.00 | 37.00 | 20.00 |

TABLE VI

SEASONAL PRICE INDICES FOR OKLAHOMA LIVESTOCK: TEN-YEAR AVERAGES, CALENDAR YEAR 1967-1976

| | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 400-500 lb. Choice Steers | 95.8 | 99.1 | 101.2 | 104.6 | 103.4 | 102.2 | 101.1 | 102.2 | 99.2 | 97.3 | 96.8 | 97.1 |
| 400-500 lb. Choice Heifers | 94.8 | 98.6 | 100.5 | 104.6 | 103.6 | 104.9 | 103.5 | 103.8 | 99.5 | 96.7 | 94.6 | 94.9 |
| 500-800 lb. Choice Steers | 98.3 | 99.5 | 100.3 | 102.8 | 102.2 | 102.9 | 102.1 | 102.3 | 98.9 | 97.0 | 96.7 | 97.8 |
| 500-800 lb. Choice Heifers | 96.8 | 100.3 | 101.6 | 104.1 | 105.0 | 105.9 | 103.7 | 102.3 | 98.2 | 95.4 | 93.0 | 94.7 |
| 800-1000 lb. Choice Steers | 98.4 | 99.6 | 100.2 | 102.7 | 102.2 | 101.8 | 102.4 | 102.9 | 98.9 | 97.1 | 97.0 | 96.9 |

Source: (3).

prices received and paid to be used in the analysis are presented in Table VII. These price sets are based on the three livestock price vectors in Table V adjusted by using the seasonal indexes in Table VI. These price sets will be used to examine the response of the ranch organization to changes in livestock prices and price relationships. The prices are presented according to weight of the animal and the dates bought or sold.

## Forage and Livestock Activities

The pasture and livestock activities included in the model are constructed to reflect current or feasible management practices in Northwest Oklahoma, and to provide for variation of these practices. Each activity is presented with its appropriate input use. Input use was derived from the recommendations of personnel at the USDA-SGPRS and from previously budgeted activities. The activities used were discussed with these personnel, as were preliminary model results, to check the validity of the solutions.

Cost and return budgets for each of the pasture and livestock activities were constructed using the Budget Generator.

## Data Sources

Data pertaining to pasture forage yields and livestock production was obtained from the USDA-SGPRS (36), published forage clipping data for Northwest Oklahoma, and previously budgeted activities. The digestible protein and energy density requirements of the various livestock activities were based upon those reported by the National Research Council (NRC), Washington, D. C.

TABLE VII

LIVESTOCK BUY AND SELL PRICES

| Class | Date | Base | | |
|---|---|---|---|---|
| | | Spring 1978 | Fall 1977 | Fall 1975 |
| Buy: | | | | |
| 400 lb. Choice Steer Calf | Oct. 15 | 64.22 | 47.67 | 25.30 |
| 485 lb. Choice Steer Calf | Oct. 15 | 57.80 | 44.69 | 28.17 |
| 500 lb. Choice Steer Calf | May 1 | 60.99 | 47.15 | 29.73 |
| Sell: | | | | |
| 420 lb. Steer Calf | Oct. 1 | 64.85 | 48.14 | 25.55 |
| 400 lb. Heifer Calf | | 53.96 | 42.18 | 22.56 |
| 485 lb. Steer Calf | Oct. 1 | 58.46 | 45.20 | 28.49 |
| 460 lb. Heifer Calf | | 52.97 | 40.22 | 24.52 |
| 500 lb. Steer Calf | May 1 | 60.99 | 47.15 | 29.73 |
| 500 lb. Heifer Calf | | 56.46 | 42.86 | 26.14 |
| 690 lb. Steer Calf | June 1 | 60.75 | 46.97 | 29.61 |
| 660 lb. Heifer Calf | | 56.70 | 43.05 | 26.25 |
| 500-800 lb. Steers | May 15 | 60.81 | 47.00 | 29.64 |
| 500-800 lb. Steers | Sept. 15-Oct. 15 | 57.98 | 44.83 | 28.26 |
| 800-1000 lb. Steers | Sept. 15-Oct. 15 | 53.63 | 42.90 | 41.93 |

The Oklahoma Agricultural Experiment Station publishes research, including yield data, for forage crops in research reports, bulletins, and fact sheets. Data compiled from research stations at Mangum, Goodwell, and Lahoma were used in estimating some of the crop and grass forage yields. Native pasture and other forage yield data were obtained from the USDA-SGPRS at Woodward.

Forage content in terms of digestible protein (DP) and energy density were obtained from the Atlas of Nutritional Data on United States and Canadian Feeds--NRC. USDA-SGPRS data estimating energy and DP content of the forages were used to check the NRC figures. Concepts of nutritional content and rules of thumb concerning energy and protein content at different seasons of the year, as presented by Wagner (38) were also used in these estimations.

The livestock production data used as a basis for constructing the livestock activities were derived from experimental data obtained from the USDA-SGPRS. The data for calves and stockers steers were reported as average daily gain (ADG) and livestock numbers per acre for the difference pasture and management systems in experimental results (36).

The figures reflecting metabolizable energy (ME) and DP requirements for the cow-calf unit, and the various weight gain patterns assumed for stocker steers were derived using a computer program developed by Dillard (9). These figures were double-checked using NRC data.

## Forage Activities

As discussed in Chapter I, management can be a key variable affecting pasture forage yields, and ultimately livestock production. For the pasture forage activities contained in the model, management intensity and practices are the determining factor in attaining consistency of forage yields.

The forage yields of native rangelands in the long run are particularly subject to management practices. Prolonged overgrazing results in steadily decreasing forage yields and forage quality. This results from the proliferation of less desirable forage species as preferred grasses are weakened from pressures due to overgrazing. Native rangelands have not been shown to be sufficiently responsive to fertilization to warrant the use of fertilizer from the economic view. However, management practices which limit the growth of undesirable plants such as brush (sagebrush, shinnery, mesquite) are included in the activities (25).

Three methods of forage removal by grazing are considered for native rangelands. They are 1) continuous grazing, 2) deferred grazing, and 3) summer grazing. Continuous grazing removes forage at a rate which will not damage the productive capacity of the rangeland. Deferred grazing removes the forage after the growing season has effectively ended. This practice is comparable to "making hay on the stem". Summer grazing allows for the forage to be grazed during the summer when energy and protein content of the forage are relatively high. Each of these grazing practices requires high levels of management to estimate forage conditions and alter stocking rates as required. The operator is assumed to manage native range so as to leave 20-25% of annual forage production standing at the end of the grazing season (27).

Weeping lovegrass is the only type of permanent improved pasture considered in the model. The forage is removed by a rotational grazing scheme. Lovegrass has the capability of producing three to four times the usable forage of native rangelands, but its quality is subject to rapid deterioration in a matter of days if not correctly utilized. Spot grazing can also be a problem. A grazed leaf can grow from one to two inches per day, and can thus be regrazed in one to three days. Since this growth is the most palatable forage in the pasture, livestock will tend to regraze it. This can result in a depletion of the plants' root reserves and a general weakening of the stand. Management is assumed capable of adjusting stocking rates sufficiently to remove the forage before quality deteriorates without damage to the stand of grass.

The forage crops of wheat and hybrid sorghum-sudan are allowed to be used on a limit grazing basis. Wheat can be used as a winter protein source by grazing it one day in every three or four. It can also be used as a "green creep" for calves born in the fall. The hybrid sorghum-sudan provides high-quality, high-protein forage in the late summer months as the forage produced by native rangelands begins to deteriorate in quality. Both wheat and sorghum-sudan have tremendous forage production potential with favorable weather conditions. Because the forage crops contain higher energy and protein levels than native rangelands in similar time periods, the manager is assumed to be capable of adjusting stocking rates as necessary to efficiently use the forage produced.

The pasture and forage crop activities, and the codes used to identify each are presented in Table VIII.

Pasture Labor Requirements

The labor required by the pasture activities is related to pasture size, rates of fertilization, and brush control practices. Since the native pastures are larger than improved and forage crop pastures, they require less fence per acre, and less labor for fence maintenance than

TABLE VIII

PASTURE ACTIVITY CODES

| Pasture Activity | Code |
|---|---|
| Native Range | |
| Continuous Grazing | NATR-CG |
| Deferred Grazing | NATR-DG |
| Summer Grazing | NATR-SG |
| Lovegrass | |
| Rotation Grazing | LOVEG-RG |
| Hay 1.8 + Grazing | LOVEG-HY |
| Alfalfa | |
| Hay 2.2 | ALFHAY |
| Crop Grazing | |
| Wheat Graze-Out | WHT-GO |
| Wheat - Sorghum-Sudan Double Crop - Graze-Out | WHTSD-GO |
| Sorghum-Sudan Graze-Out | SOSUD-GO |
| Sorghum-Sudan Hay + Grazing | SOSUD-HY |
| Sorghum Silage | SOSD-SIL |

the smaller pastures. Labor is required for the field operations and fertilization of the improved pastures and forage crops and is included in the activity as machinery labor. Labor is also required for brush control practices on the native rangelands. Labor requirements associated with forage management practices necessary for the various livestock activities are included within those activities.

Pasture Production

Total forage production levels for the pasture activities contained in the model are presented in Table IX. Forage production is first estimated in terms of the total units of dry matter (DM) produced per month. The result is the Total DM row in Table IX. The total amount of DM produced is then adjusted according to estimated forage utilization by livestock to obtain pasture DM. These adjustments are made in recognition of the fact that some forage is lost due to trampling and other factors associated with grazing by livestock. The utilization coefficients used to make these adjustments are shown in Table X. Pasture DM is then separated into the three forage quality groups. The forage can be utilized in these groups as Pasture DM 2.6, Pasture DM 2.2, Pasture DM 1.8, or hay. Forage utilization is based upon assumed management capabilities, forage quality, and the particular season of use.

Available research data on pasture forage production is normally reported in two forms. It is presented in some reports as the total pounds of DM produced on a per acre basis during the growing season. Production is also reported as the DM yielded by cutting periods. These reports are usually made on the basis of two or three cuttings per season. Data are not readily available on monthly forage production.

TABLE IX

FORAGE ACTIVITIES AND YIELDS BY MONTH MEASURED IN HUNDREDWEIGHTS

| Activity | | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NATR-CG | TOTAL DRY MATTER | | | | 1.05 | 2.50 | 2.00 | 1.75 | 1.25 | 1.50 | | | |
| | Pasture DM 2.6 | | | | .10 | .70 | .80 | .70 | | | | | |
| | Pasture DM 2.2 | | | | | | | | .50 | .50 | .10 | | |
| | Pasture DM 1.8 | .32 | .29 | .32 | .25 | | | | | | .10 | .20 | .32 |
| | Pasture DP | .007 | .007 | .005 | .01 | .08 | .07 | .05 | .04 | .03 | .01 | .01 | .01 |
| NATR-DG | TOTAL DRY MATTER | | | | 1.05 | 2.50 | 2.00 | 1.75 | 1.25 | 1.50 | | | |
| | Pasture DM 2.2 | | | | | | | | | | .35 | | |
| | Pasture DM 1.8 | .75 | .75 | .75 | .75 | | | | | | .40 | .75 | .75 |
| | Pasture DP | .015 | .015 | .015 | .02 | | | | | | .03 | .03 | .015 |
| NATR-SG | TOTAL DRY MATTER | | | | 1.05 | 2.50 | 2.00 | 1.75 | 1.25 | 1.50 | | | |
| | Pasture DM 2.6 | | | | .20 | .80 | .80 | .25 | | | | | |
| | Pasture DM 2.2 | | | | | | | .75 | .80 | .90 | | | |
| | Pasture DP | | | | .03 | .07 | .09 | .08 | .05 | .06 | | | |
| LOVEG-RG | TOTAL DRY MATTER | | | | 2.00 | 8.00 | 11.00 | 10.00 | 8.00 | 8.00 | 3.00 | | |
| | Pasture DM 2.2 | | | | | 8.00 | 8.50 | 8.40 | 8.30 | | | | |
| | Pasture DM 1.8 | 4.70 | 4.60 | | | | | | | | | | |
| | Pasture DP | .36 | .33 | | | .80 | .85 | .84 | .83 | | | | |
| LOVEG-HY | TOTAL DRY MATTER | | | | 2.00 | 8.00 | 11.00 | 10.00 | 8.00 | 8.00 | 3.00 | | |
| | Hay 1.8 (Tons) | | | | | | .75 | | | | | | |
| | Pasture DM 2.2 | | | | | | | 8.40 | 8.30 | | | | |
| | Pasture DM 1.8 | 2.33 | 2.31 | 2.33 | | | | | | | | | 2.33 |
| | Pasture DP | .18 | .15 | .16 | | | | | | | | | .18 |
| ALFHAY | TOTAL DRY MATTER | | | | | | | | | | | | |
| | Hay 2.2 (Tons) | | | | | | 1.50 | | | 1.00 | | | |
| | Pasture DP | | | | | | 4.23 | | | 2.83 | | | |

TABLE IX (Continued)

| Activity | | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WHT-GO | TOTAL DRY MATTER | 1.00 | 2.50 | 6.50 | 9.50 | 3.00 | | | | | 2.00 | 5.00 | 1.00 |
| | Pasture DM 2.6 | 2.30 | 2.30 | 4.90 | 4.90 | 4.90 | | | | | | 2.30 | 2.30 |
| | Pasture DP | .34 | .34 | 1.08 | 1.08 | 1.03 | | | | | | .34 | .34 |
| WHTSD-GO | TOTAL DRY MATTER | .50 | 1.25 | 3.00 | 6.00 | 3.00 | | 4.00 | 6.00 | 5.00 | .75 | 2.25 | .75 |
| | Pasture DM 2.6 | | | 3.00 | 5.50 | 5.50 | | | 5.30 | 5.20 | | | |
| | Pasture DP | | | .60 | 1.10 | 1.10 | | | .53 | .52 | | | |
| SOSUD-GO | TOTAL DRY MATTER | | | | | 2.80 | 15.00 | 24.00 | 11.50 | 6.70 | | | |
| | Pasture DM 2.6 | | | | | | | 14.00 | 7.00 | | | | |
| | Pasture DM 2.2 | | | | | | | | 7.00 | 14.00 | | | |
| | Pasture DP | | | | | | 1.26 | 1.68 | 1.22 | .77 | | | |
| SOSUD-HY | TOTAL DRY MATTER | | | | | 2.80 | 15.00 | 24.00 | 11.50 | 6.70 | | | |
| | Hay 2.2 (Tons) | | | | | | | 1.75 | | | | | |
| | Pasture DM 2.2 | | | | | | | | 6.40 | 6.40 | | | |
| | Pasture DP | | | | | | | | .64 | .64 | | | |
| SOSD-SIL | TOTAL DRY MATTER | | | | | 2.80 | 15.00 | 24.00 | 11.50 | 6.70 | | | |
| | Silage DM (Tons) | | | | | | | | | 47.80 | | | |
| | Pasture DP | | | | | | | | | 2.68 | | | |

[1]Monthly Pasture DM figures by quality group reflect actual forage utilization by livestock and have been placed in time periods according to management goals associated with each particular activity.

TABLE X

ESTIMATED FORAGE UTILIZATION COEFFICIENTS TO CONVERT FORAGE DRY MATTER TO PASTURE DRY MATTER

| Forage | Conversion Index |
|---|---|
| Native Succulent* | 50 |
| Native Dry | 75 |
| Weeping Lovegrass | 85 |
| Small Grains | 80 |
| Sorghum-Sudan | 70 |

Source: (20).

*Required for longevity of the native grass.

The data available on a monthly basis is usually reported implicitly as steer gains per day or steer days per month. Estimates of montly forage production can be derived from these data using NRC specifications. The Soil Conservation Service also estimates pasture forage yields in terms of the total pounds of forage produced or AUM's per month for native rangelands in some county soil surveys (35).

The total monthly DM production for the forage activities considered was derived from available clipping data and by converting available data on steer gains per day and steer numbers per month reported for these forages. The steer data was converted to forage yield data by using the NRC tables to estimate the amount and quality of forage required to produce the steer gains and numbers as reported for each month of the grazing season. When available, forage clipping data was compared with these derived estimates as a check. The monthly pasture forage production for each pasture activity in terms of total DM, pasture DM by quality group, and digestible protein produced is presented in Table IX. Hay and silage yields are shown in terms of hundredweights of DM.

Pasture DM is classified into quality groups on the basis of energy density, the metabolizable energy (ME) contained per kilogram expressed in calories for the forage. These classifications are similar to those used by Anderson (2). NRC and USDA-SGPRS data were used in determining the energy density of the forages. Forages containing an energy density greater than 2.35 mcal/kg ME are classified as Pasture DM 2.6. Forages which contain between 2.01 and 2.35 mcal/kg ME are classifed as Pasture DM 2.2. Forages containing less than 2.0 mcal/kg ME are classified as Pasture DM 1.8. These classifications are based upon the quality of the forage when it is consumed to assure that livestock requirements are met.

The digestible protein (DP) content of the forages on a monthly basis was also derived. This was done using USDA-SGPRS data, NRC publications, and rules of thumb as discussed by Wagner (38). DP is included due to influence it has on forage intake at different seasons of the year (Figure 1). It is possible for forages to contain sufficient energy to support production levels which are not physically possible because of the effect of DP deficiencies in the diet.

## Hay Production

Haying activities are included in the model to allow the ranch operation the option of either producing or buying the hay required by the livestock activities. The activities included, with the exception of alfalfa, are structured to supply hay of the required quality while also providing for some grazing subsequent to hay harvest.

The hay produced is classified as either Hay 2.2 or Hay 1.8. Hay 2.2 contains a minimum of six percent DP and an energy density greater than 2.01 mcal/kg ME. Hay 1.8 contains a minimum of two percent DP and an energy density of no less than 1.7 mcal/kg ME.

Hay and silage are harvested on a custom basis within the model. The hay is hauled by the ranch using a truck and bale elevator. Custom costs for cutting and baling and the labor requirements for hauling are reflected in the costs of the hay activities. The hay is not produced for sale, but for use by the livestock activities. Custom costs for silage harvest include all necessary operations.

Net returns, capital and labor requirements, and total annual pasture DM, hay and silage production for each of the forage activities contained in the model are shown in Tables XI and XII.

TABLE XI

FORAGE ACTIVITY RETURNS, PRODUCTION, AND CAPITAL AND LABOR REQUIREMENTS--PERENNIAL FORAGES

| | Unit | Native Pasture | | | Lovegrass | | Alfalfa |
|---|---|---|---|---|---|---|---|
| | | Continuous Grazing | Deferred Grazing | Rotation Grazing | Rotation Grazing | Hay 1.8 + Grazing | Hay 2.2 |
| **Net Return** | | | | | | | |
| Obj. 1 | dol. | -1.67 | -1.67 | -1.67 | -14.33 | -28.47 | -78.35 |
| Obj. 2 | dol. | -2.69 | -2.69 | -2.69 | -18.97 | -36.83 | -89.82 |
| **Production** | | | | | | | |
| Total DM | cwt. | 10.05 | 10.05 | 10.05 | 50.00 | 50.00 | 55.50 |
| Pasture DM 2.6 | cwt. | 2.30 | --- | 2.05 | --- | --- | --- |
| Pasture DM 2.2 | cwt. | 1.10 | .35 | 2.45 | 33.20 | 16.70 | --- |
| Pasture DM 1.8 | cwt. | 1.80 | 4.90 | --- | 9.30 | 9.30 | --- |
| Hay 2.2 | tons | --- | --- | --- | --- | --- | 2.5 |
| Hay 1.8 | tons | --- | --- | --- | --- | .75 | --- |
| Silage | tons | --- | --- | --- | --- | --- | --- |
| **Capital Inputs** | | | | | | | |
| Annual Operating | dol. | .41 | .41 | .41 | 8.37 | 9.72 | 28.57 |
| Machinery Investment | dol. | 8.79 | 8.79 | 8.79 | 39.18 | 58.59 | --- |
| Pasture Improvement | dol. | --- | --- | --- | 23.60 | 23.60 | --- |
| Ownership Cost | dol. | 1.02 | 1.02 | 1.02 | 4.64 | 8.36 | 11.47 |
| **Labor** | | | | | | | |
| April-May | hrs. | .02 | .02 | .02 | --- | --- | .04 |
| June-July | hrs. | --- | --- | --- | .11 | .84 | .78 |
| August-September | hrs. | .02 | .02 | .02 | --- | --- | .73 |
| October-November | hrs. | --- | --- | --- | --- | --- | --- |
| December-March | hrs. | --- | --- | --- | .15 | .15 | --- |

TABLE XII

FORAGE ACTIVITY RETURNS, PRODUCTION, AND CAPITAL AND LABOR REQUIREMENTS--CROP FORAGES

| | Unit | Wheat Graze-Out | Wheat-Sorghum Sudan Graze-Out | Sorghum Sudan Graze-Out | Sorghum Sudan Hay + Grazing | Sorghum Silage |
|---|---|---|---|---|---|---|
| Net Returns | | | | | | |
| Obj. 1 | dol. | -13.95 | -14.17 | -11.36 | -38.86 | -52.25 |
| Obj. 2 | dol. | -21.20 | -22.61 | -18.50 | -49.72 | -59.79 |
| Production | | | | | | |
| Total DM | cwt. | 30.50 | 32.50 | 60.00 | 60.00 | 60.00 |
| Pasture DM 2.6 | cwt. | 23.90 | 24.50 | 21.00 | --- | --- |
| Pasture DM 2.2 | cwt. | --- | --- | 21.00 | 12.80 | --- |
| Pasture DM 1.8 | cwt. | --- | --- | --- | --- | --- |
| Hay 2.2 | tons | --- | --- | --- | 1.75 | --- |
| Hay 1.8 | tons | --- | --- | --- | --- | --- |
| Silage | tons | --- | --- | --- | --- | 8.00 |
| Capital Inputs | | | | | | |
| Annual Operating | dol. | 15.03 | 15.03 | 18.68 | 14.97 | 31.38 |
| Machinery Investment | dol. | 55.84 | 62.25 | 55.11 | 74.52 | 57.36 |
| Pasture Improvement | dol. | --- | --- | --- | --- | --- |
| Ownership Cost | dol. | 7.25 | 7.44 | 7.14 | 10.86 | 7.54 |
| Labor | | | | | | |
| April-May | hrs. | --- | --- | .60 | .60 | .42 |
| June-July | hrs. | .18 | .29 | --- | .78 | --- |
| August-September | hrs. | .45 | --- | --- | --- | --- |
| October-November | hrs. | --- | .38 | --- | --- | --- |
| December-March | hrs. | --- | .11 | --- | --- | .16 |

## Livestock Activities

As previously discussed, feed is the single largest input in the production of livestock. Any given livestock activity or mix of activities is dependent on the quality and quantity of forage available to the livestock during the grazing season. Such factors influence the season of calving, calf weaning weights, steer gains, and ultimately the combination of possible livestock activities. Differences in management goals and practices can result in a variety of possible cow-calf and stocker steer activities. The cow-calf and stocker activities included in the model, and the codes used to identify them, are shown in Table XIII.

The assumptions used as a basis for constructing the cow-calf activities are presented in Tavle XIV. A cow-calf unit consists of one 1,000 pound cow, four percent of a 1,600 pound bull, and 12 percent of a replacement heifer. The cow-calf unit produces .44 units of a steer calf, .32 units of a heifer calf, .12 units of a replacement heifer, .1 units of a cull cow and .01 units of an aged bull. An 88 percent calving rate and a two percent per year death loss in the cow herd are assumed.

Due to the wide range of possible stocker activities, several alternative activities are included in the model. The stocker steer activities are based on three separate purchase activities: the October purchase of 400 pound and 485 pound steers for year-long grazing and the May purchase of 500 pound steers for summer grazing. The steers are assembled, worked, and run in smaller pastures with some supplemental feed until they adjust to the new surroundings. When steer calves are

TABLE XIII

LIST AND CODES OF LIVESTOCK ACTIVITIES AND STEER GAIN PATTERNS

| Cow-Calf Activities Detail | Activity Code |
|---|---|
| Spring Cow-Calf--March Calving | |
| 400 Pound Calf-Sell Sept. 30<br>205 Day Weaning | SCC 400 |
| 460 Pound Calf-Sell May 1<br>205 Day Weaning | SCC 460 |
| Fall Cow-Calf--September Calving | |
| 500 Pound Calf-Sell May 1<br>240 Day Weaning | FCC 500 |
| 675 Pound Calf-Sell June 1<br>270 Day Weaning | FCC 675 |

| Initial Weight (Pounds) | Steer Activities Gain Pattern (Pounds/Day) | Ending Weight (Pounds) | Activity Code |
|---|---|---|---|
| | Fall Stockers--October 15-September 15 | | |
| 400 | 1 Oct.-Nov.<br>.5 Dec.-Mar.<br>2.0 Apr.-July<br>1.7 Aug-Sept. | 840 | FSTRS840 |
| 400 | .6 Oct.-Mar.<br>1.9 Apr.-Sept. | 854 | FSTRS854 |
| 400 | .7 Oct.-Mar.<br>2.0 Apr.-July<br>1.5 Aug-Sept. | 863 | FSTRS863 |
| 400<br>Limit Grazing on Wheat | .9 Oct.-Mar.<br>1.8 Apr.-May 15 | 894 | FSTRS894 |
| 400<br>Wheat Pasture Oct. 1-May 15 | 1.25 Oct.-Mar.<br>1.7 Apr.-May 15 | 701 | FSTRS701 |
| 485 | .6 Oct.-Mar.<br>1.9 Apr.-Sept. | 940 | FSTRS940 |
| 485 | .7 Oct.-Mar.<br>2.0 Apr.-July<br>1.5 Aug.-Sept. | 949 | FSTRS949 |

TABLE XIII (Continued)

| Initial Weight (Pounds) | Gain Pattern (Pounds/Day) | Ending Weight (Pounds) | Activity Code |
|---|---|---|---|
| 485 | .6 Oct.-Mar.<br>2.2 Apr.-July<br>1.7 Aug.-Sept. | 963 | FSTRS963 |
| 485 | 1.0 Oct.-Nov.<br>.5 Dec.-Mar.<br>2.0 Apr.-May<br>1.7 Aug.-Sept. | 955 | FSTRS955 |
| 485 | .7 Oct.-Nov.<br>.3 Dec.-Mar.<br>2.5 Apr.-May<br>2.0 June-July<br>1.6 Aug.-Sept. | 936 | FSTRS936 |
| | Summer Stockers--May 1-October 1 | | |
| 500 | 2.5 May<br>1.8 June-Sept. | 798 | SSTRS798 |
| 500 | 2.5 May<br>2.0 June-July<br>1.7 Aug.-Sept. | 805 | SSTRS805 |
| 500 | 2.5 May<br>2.0 June-July<br>1.9 Aug.-Sept. | 815 | SSTRS815 |
| 500 | 2.0 May-July<br>1.7 Aug.-Sept. | 787 | SSTRS787 |
| 500 | 1.7 May-Sept. | 760 | SSTRS760 |
| 500 | 2.0 May-July<br>1.5 Aug.-Sept. | 755 | SSTRS755 |
| 500 | 1.25 May-Sept. | 690 | SSTRS690 |

TABLE XIV

ASSUMPTIONS FOR THE COW-CALF UNIT

| Item | Unit | Amount |
|---|---|---|
| Cow Weight at Calving | lb. | 1100 |
| Average Bull Weight | lb. | 1600 |
| Cows/Bull | hd. | 25 |
| Replacement Heifers/Cow | hd. | .12 |
| Calving Percent | % | 88 |
| Replacement Heifer Average Daily Gain | lb. | .75 |
| Steers | hd. | .44 |
| Heifers | hd. | .32 |
| Cull Cow | hd. | .10 |
| Bull Sold | hd. | .01 |
| Death Loss (Cows) | hd. | .02 |
| <u>Calf Average Daily Gain</u> | | |
| SCC-400 | lb. | 2.00 |
| SCC-460 | lb. | 2.20 |
| FCC-500 | lb. | 2.08 |
| FCC-675 | lb. | 2.50 |

held back from the cow-calf activities for grazing as stockers, the costs and feed requirements associated with weaning are included in the transfer to the stocker activity. A two percent death loss is assumed for stockers grazed from October 15 through September 15, and a one percent death loss is assumed for summer stockers grazed from May 1 to October 1.

## Labor

The labor requirements for the livestock activities were based upon the labor required for similar activities as previously constructed in the OSU Enterprise Budgets. Cow-calf labor requirements were adjusted to reflect the amount of supplemental feeding, calf care, the calving system, and the labor required for forage management necessary for the activity. For example, those activities utilizing limit grazing require more labor for livestock herding.

## Livestock Production

The average daily gains for the various steer activities are presented in Table XIII. These patterns of weight gain were derived from actual steer gains recorded at the USDA-SGPRS. Each of these gain patterns can be achieved by proper management.

The forage requirements by month for the cow-calf and stocker steer activities are presented in Table XV. These figures represent the minimum nutritional requirements for the levels of production assumed in the activity. The diet has been balanced for energy and DP requirements and necessary supplemental feeding has been included.

# TABLE XV

## LIVESTOCK FORAGE REQUIREMENTS BY MONTH MEASURED IN HUNDREDWEIGHTS[1]

| Activity Code | | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCC 400 | TOTAL DRY MATTER | 5.53 | 5.05 | 7.73 | 7.48 | 8.52 | 8.85 | 9.45 | 9.80 | 9.78 | 4.74 | 4.64 | 5.23 |
| | Pasture DM 2.2 | — | — | — | — | 8.52 | 8.85 | 9.45 | 9.80 | 9.78 | — | — | — |
| | Pasture DM 1.8 | 4.62 | 4.17 | 6.82 | 6.98 | — | — | — | — | — | 4.74 | 4.14 | 4.32 |
| | 41% Prot. Sup. | .31 | .28 | .31 | .30 | — | — | — | — | — | — | .30 | .31 |
| | Hay 1.8 | .03 | .03 | .03 | .01 | — | — | — | — | — | — | .01 | .03 |
| | Pasture DP | .21 | .19 | .28 | .26 | .44 | .45 | .49 | .51 | .52 | .20 | .20 | .21 |
| SCC 460 | TOTAL DRY MATTER | 5.87 | 5.36 | 7.73 | 7.48 | 8.52 | 8.85 | 9.57 | 9.98 | 10.02 | 4.96 | 4.70 | 5.25 |
| | Pasture DM 2.2 | — | — | — | — | 8.52 | 8.85 | 9.57 | 9.98 | 10.02 | — | — | — |
| | Pasture DM 1.8 | 4.56 | 4.48 | 6.92 | 6.98 | — | — | — | — | — | 4.96 | 4.20 | 4.34 |
| | 41% Prot. Sup. | .31 | .28 | .31 | .30 | — | — | — | — | — | — | .30 | .31 |
| | Hay 1.8 | .03 | .03 | .03 | .01 | — | — | — | — | — | — | .01 | .03 |
| | Pasture DP | .21 | .19 | .28 | .26 | .44 | .46 | .50 | .53 | .54 | .20 | .20 | .21 |
| FCC 500 | TOTAL DRY MATTER | 9.56 | 8.76 | 10.47 | 10.56 | 5.43 | 5.88 | 6.11 | 6.14 | 7.07 | 7.73 | 7.48 | 9.56 |
| | Pasture DM 2.6 | 1.56 | 1.49 | 2.22 | — | — | — | — | — | — | — | 1.47 | 1.56 |
| | Pasture DM 2.2 | — | — | — | 10.56 | — | — | — | — | — | — | — | — |
| | Pasture DM 1.8 | 4.70 | 4.47 | 6.65 | — | 5.43 | 5.88 | 6.11 | 6.14 | 7.07 | 7.83 | 4.41 | 4.70 |
| | 41% Prot. Sup. | — | — | — | — | — | — | — | — | — | .40 | — | — |
| | Hay 2.2 | .16 | .14 | .08 | — | — | — | — | — | — | — | .08 | .16 |
| | Pasture DP | .51 | .49 | .57 | .57 | .21 | .20 | .21 | .22 | .27 | .27 | .44 | .48 |
| FCC 675 | TOTAL DRY MATTER | 10.30 | 9.57 | 11.13 | 11.43 | 12.24 | 6.01 | 6.21 | 6.21 | 7.07 | 7.73 | 8.60 | 9.42 |
| | Pasture DM 2.6 | 2.05 | 1.89 | 2.43 | — | — | — | — | — | — | — | 2.00 | 2.12 |
| | Pasture DM 2.2 | — | — | — | 11.43 | 12.24 | — | — | — | 3.07 | 3.33 | — | — |
| | Pasture DM 1.8 | 6.15 | 5.68 | 7.30 | — | — | 6.01 | 6.21 | 6.21 | 4.00 | 4.00 | 6.00 | 6.30 |
| | 41% Prot. Sup. | — | — | — | — | — | — | — | — | — | .40 | — | — |
| | Hay 2.2 | .10 | .10 | .07 | — | — | — | — | — | — | — | .03 | .05 |
| | Pasture DP | .56 | .54 | .64 | .65 | .71 | .21 | .22 | .23 | .27 | .27 | .46 | .52 |

TABLE XV (Continued)

| Activity Code | | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stockers- FSTRS840 | TOTAL DRY MATTER | 3.42 | 3.09 | 3.42 | 4.10 | 4.24 | 4.99 | 5.47 | 5.41 | 3.65 | 2.05 | 4.04 | 3.42 |
| | Pasture DM 2.6 | — | — | — | 2.00 | 4.24 | 3.37 | 2.80 | 1.72 | 1.80 | — | — | — |
| | Pasture DM 2.2 | — | — | — | — | — | 1.62 | 2.67 | 3.69 | 1.85 | 1.00 | — | — |
| | Pasture DM 1.8 | 2.42 | 2.33 | 2.82 | 2.10 | — | — | — | — | — | 1.05 | 3.45 | 2.42 |
| | 41% Prot. Sup. | .40 | .36 | .40 | — | — | — | — | — | — | — | .39 | .40 |
| | Hay 1.8 | .03 | .02 | .01 | — | — | — | — | — | — | — | .01 | .03 |
| | Pasture DP | .20 | .18 | .20 | .40 | .44 | .46 | .51 | .49 | .25 | .11 | .23 | .19 |
| FSTRS854 | TOTAL DRY MATTER | 3.26 | 2.94 | 3.26 | 4.11 | 4.90 | 5.37 | 5.55 | 5.46 | 2.46 | 1.68 | 3.15 | 3.26 |
| | Pasture DM 2.6 | — | — | — | 2.11 | — | — | — | — | — | — | — | — |
| | Pasture DM 2.2 | — | — | — | 2.00 | 4.90 | 5.37 | 5.55 | 5.46 | 2.46 | 1.00 | — | — |
| | Pasture DM 1.8 | 2.26 | 2.14 | 2.62 | — | — | — | — | — | — | .68 | 2.65 | 2.29 |
| | 41% Prot. Sup. | .40 | .40 | .44 | — | — | — | — | — | — | — | .30 | .37 |
| | Hay 1.8 | .03 | .02 | .01 | — | — | — | — | — | — | — | .01 | .03 |
| | Pasture DP | .20 | .19 | .21 | .37 | .42 | .43 | .48 | .51 | .26 | .09 | .18 | .19 |
| FSTRS863 | TOTAL DRY MATTER | 3.43 | 3.21 | 3.36 | 4.10 | 4.85 | 5.29 | 5.46 | 5.47 | 2.65 | 1.76 | 3.31 | 3.42 |
| | Pasture DM 2.6 | — | — | .89 | 4.10 | 3.00 | 1.29 | 2.76 | — | — | — | — | — |
| | Pasture DM 2.2 | — | — | — | — | 1.85 | 4.00 | 2.70 | 5.47 | 2.65 | 1.00 | — | — |
| | Pasture DM 1.8 | 2.45 | 2.46 | 2.47 | — | — | — | — | — | — | .76 | 2.78 | 2.46 |
| | 41% Prot. Sup. | .38 | .35 | — | — | — | — | — | — | — | — | .33 | .36 |
| | Hay 1.8 | .03 | .02 | — | — | — | — | — | — | — | — | .01 | .03 |
| | Pasture DP | .22 | .20 | .23 | .40 | .45 | .46 | .51 | .45 | .23 | .10 | .19 | .21 |
| FSTRS894 | TOTAL DRY MATTER | 3.41 | 3.08 | 3.57 | 4.11 | 5.27 | 5.37 | 5.46 | 5.46 | 2.85 | 1.76 | 3.30 | 3.41 |
| | Pasture DM 2.6 | .91 | 1.00 | 1.50 | 2.51 | — | — | — | 3.00 | 1.30 | — | .85 | .86 |
| | Pasture DM 2.2 | — | — | — | 1.60 | 5.27 | 5.37 | 5.46 | 2.46 | 1.45 | 1.76 | — | — |
| | Pasture DM 1.8 | 1.90 | 1.68 | 1.87 | — | — | — | — | — | — | — | 2.25 | 1.95 |
| | Hay 1.8 | .03 | .02 | .01 | — | — | — | — | — | — | — | .01 | .03 |
| | Pasture DP | .25 | .23 | .27 | .39 | .43 | .44 | .49 | .51 | .26 | .11 | .22 | .24 |

## TABLE XV (Continued)

| Activity Code | | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FSTRS703 | TOTAL DRY MATTER | 4.14 | 3.98 | 4.18 | 4.31 | 2.35 | — | — | — | — | 3.87 | 3.72 | 4.14 |
| | Pasture DM 2.6 | 3.54 | 3.58 | 4.18 | 4.31 | 2.35 | — | — | — | — | 3.87 | 3.52 | 3.54 |
| | Hay 1.8 | .03 | .02 | — | — | — | — | — | — | — | — | .01 | .03 |
| | Pasture DP | .43 | .39 | .40 | .41 | .22 | — | — | — | — | .25 | .42 | .43 |
| FSTRS940 | TOTAL DRY MATTER | 3.41 | 3.08 | 3.41 | 4.74 | 5.55 | 5.37 | 5.46 | 5.80 | 2.85 | 1.68 | 3.21 | 3.38 |
| | Pasture DM 2.6 | — | — | — | — | — | — | 5.46 | 5.80 | 2.85 | — | — | — |
| | Pasture DM 2.2 | — | — | — | 4.74 | 5.55 | 5.37 | — | — | — | 1.00 | — | — |
| | Pasture DM 1.8 | 2.42 | 2.32 | 2.79 | — | — | — | — | — | — | .68 | 2.66 | 2.40 |
| | 41% Prot. Sup. | .39 | .36 | .42 | — | — | — | — | — | — | — | .35 | .38 |
| | Hay 1.8 | .03 | .02 | .01 | — | — | — | — | — | — | — | .01 | .03 |
| | Pasture DP | .23 | .21 | .24 | .42 | .46 | .48 | .52 | .55 | .28 | .11 | .21 | .22 |
| FSTRS949 | TOTAL DRY MATTER | 3.97 | 3.60 | 4.03 | 5.36 | 5.54 | 5.29 | 5.47 | 5.61 | 2.71 | 2.01 | 3.77 | 3.97 |
| | Pasture DM 2.6 | — | — | — | 3.00 | 3.00 | 5.29 | 5.47 | — | — | — | — | — |
| | Pasture DM 2.2 | — | — | — | — | 2.54 | — | — | 5.61 | 2.71 | 1.01 | — | — |
| | Pasture DM 1.8 | 2.94 | 2.80 | 3.38 | 2.36 | — | — | — | — | — | 1.00 | 3.19 | 2.96 |
| | 41% Prot. Sup. | .43 | .40 | .45 | — | — | — | — | — | — | — | .38 | .41 |
| | Hay 1.8 | .03 | .02 | .01 | — | — | — | — | — | — | — | .01 | .03 |
| | Pasture DP | .25 | .23 | .36 | .45 | .49 | .51 | .56 | .49 | .27 | .11 | .22 | .24 |
| FSTRS963 | TOTAL DRY MATTER | 3.41 | 3.08 | 3.41 | 4.77 | 5.55 | 5.37 | 5.92 | 5.89 | 3.00 | 1.68 | 3.21 | 3.38 |
| | Pasture DM 2.6 | — | — | — | 4.77 | 5.55 | 5.37 | 5.92 | 3.00 | — | — | — | — |
| | Pasture DM 2.2 | — | — | — | — | — | — | — | 2.89 | 3.00 | 1.00 | — | — |
| | Pasture DM 1.8 | 2.42 | 2.32 | 2.79 | — | — | — | — | — | — | .68 | 2.66 | 2.40 |
| | 41% Prot. Sup. | .39 | .36 | .42 | — | — | — | — | — | — | — | .35 | .38 |
| | Hay 1.8 | .03 | .02 | .01 | — | — | — | — | — | — | — | .01 | .03 |
| | Pasture DP | .23 | .21 | .24 | .46 | .52 | .54 | .59 | .53 | .27 | .11 | .21 | .22 |

TABLE XV (Continued)

| Activity Code | | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FSTRS955 | TOTAL DRY MATTER | 3.41 | 3.08 | 3.42 | 5.30 | 5.46 | 5.29 | 5.47 | 5.60 | 2.71 | 2.05 | 3.90 | 3.42 |
| | Pasture DM 2.6 | — | — | — | 2.30 | 2.70 | 5.29 | 5.47 | 3.00 | 1.71 | — | — | — |
| | Pasture DM 2.2 | — | — | — | — | 2.76 | — | — | 2.60 | 1.00 | 1.05 | — | — |
| | Pasture DM 1.8 | 2.42 | 2.32 | 2.81 | 3.00 | — | — | — | — | — | 1.00 | 3.23 | 2.44 |
| | 41% Prot. Sup. | .39 | .36 | .41 | — | — | — | — | — | — | — | .47 | .38 |
| | Hay 1.8 | .03 | .02 | .01 | — | — | — | — | — | — | — | .01 | .03 |
| | Pasture DP | .22 | .20 | .23 | .44 | .49 | .50 | .55 | .52 | .26 | .13 | .26 | .22 |
| FSTFS955 | TOTAL DRY MATTER | 3.41 | 3.08 | 3.42 | 5.30 | 5.46 | 5.29 | 5.47 | 5.60 | 2.71 | 2.05 | 3.90 | 3.42 |
| | Pasture DM 2.6 | — | — | — | 2.30 | 2.70 | 5.29 | 5.47 | 3.00 | 1.71 | — | — | — |
| | Pasture DM 2.2 | — | — | — | — | 2.76 | — | — | 2.60 | 1.00 | 1.05 | — | — |
| | Pasture DM 1.8 | 2.42 | 2.32 | 2.81 | 3.00 | — | — | — | — | — | 1.00 | 3.23 | 2.44 |
| | 41% Prot. Sup. | .39 | .36 | .41 | — | — | — | — | — | — | — | .47 | .38 |
| | Hay 1.8 | .03 | .02 | .01 | — | — | — | — | — | — | — | .01 | .03 |
| | Pasture DP | .22 | .20 | .23 | .44 | .49 | .50 | .55 | .52 | .26 | .13 | .26 | .22 |
| FSTRS936 | TOTAL DRY MATTER | 3.60 | 3.25 | 3.59 | 5.04 | 5.21 | 5.28 | 5.46 | 5.70 | 2.76 | 1.68 | 3.78 | 3.59 |
| | Pasture DM 2.6 | — | — | — | — | 5.21 | 5.28 | 5.46 | — | — | — | — | — |
| | Pasture DM 2.2 | — | — | — | 5.04 | — | — | — | 5.70 | 2.76 | — | — | — |
| | Pasture DM 1.8 | 3.16 | 2.86 | 3.16 | — | — | — | — | — | — | 1.68 | 3.36 | 3.16 |
| | 41% Prot. Sup. | .44 | .39 | .43 | — | — | — | — | — | — | — | .42 | .43 |
| | Pasture DP | .19 | .17 | .19 | .49 | .55 | .50 | .54 | .50 | .13 | .12 | .22 | .18 |
| Summer Stockers | | | | | | | | | | | | | |
| SSTRS798 | TOTAL DRY MATTER | — | — | — | — | 4.25 | 4.74 | 5.55 | 5.52 | 5.54 | — | — | — |
| | Pasture DM 2.6 | — | — | — | — | 4.25 | — | — | — | — | — | — | — |
| | Pasture DM 2.2 | — | — | — | — | — | 4.74 | 5.55 | 5.52 | 5.54 | — | — | — |
| | Pasture DP | — | — | — | — | .47 | .40 | .44 | .47 | .48 | — | — | — |
| SSTRS805 | TOTAL DRY MATTER | — | — | — | — | 4.24 | 4.83 | 5.54 | 5.47 | 5.29 | — | — | — |
| | Pasture DM 2.6 | — | — | — | — | 4.24 | — | — | — | — | — | — | — |
| | Pasture DM 2.2 | — | — | — | — | — | 4.83 | 5.54 | 5.47 | 5.29 | — | — | — |
| | Pasture DP | — | — | — | — | .47 | .43 | .47 | .46 | .46 | — | — | — |

TABLE XV (Continued)

| Activity code | | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SSTRS815 | TOTAL DRY MATTER | – | – | – | – | 4.25 | 4.74 | 5.55 | 5.49 | 5.28 | – | – | – |
| | Pasture DM 2.6 | – | – | – | – | 4.25 | .74 | – | 2.00 | 5.28 | – | – | – |
| | Pasture DM 2.2 | – | – | – | – | – | 4.00 | 5.55 | 3.49 | – | – | – | – |
| | Pasture DP | – | – | – | – | .47 | .43 | .47 | .49 | .50 | – | – | – |
| SSTRS787 | TOTAL DRY MATTER | – | – | – | – | 4.25 | 4.74 | 5.55 | 5.55 | 5.28 | – | – | – |
| | Pasture DM 2.6 | – | – | – | – | 4.25 | .74 | – | – | – | – | – | – |
| | Pasture DM 2.2 | – | – | – | – | – | 4.00 | 5.55 | 5.55 | 5.28 | – | – | – |
| | Pasture DP | – | – | – | – | .47 | .43 | .47 | .45 | .46 | – | – | – |
| SSTRS760 | TOTAL DRY MATTER | – | – | – | – | 4.10 | 4.23 | 4.78 | 5.19 | 5.29 | – | – | – |
| | Pasture DM 2.6 | – | | – | – | – | – | – | – | – | – | – | – |
| | Pasture DM 2.2 | – | – | – | – | 4.10 | 4.23 | 4.78 | 5.19 | 5.29 | – | – | – |
| | Pasture DP | – | – | – | – | .36 | .37 | .41 | .44 | .44 | – | – | – |
| SSTRS755 | TOTAL DRY MATTER | – | – | – | – | 4.24 | 4.76 | 5.54 | 5.47 | 5.29 | – | – | – |
| | Pasture DM 2.6 | – | – | – | – | 4.24 | – | – | – | – | – | – | – |
| | Pasture DM 2.2 | – | – | – | – | – | 4.76 | 5.54 | 5.47 | 5.29 | – | – | – |
| | Pasture DP | – | – | – | – | .40 | .42 | .47 | .42 | .42 | – | – | – |
| SSTRS690 | TOTAL DRY MATTER | – | – | – | – | 3.11 | 3.17 | 3.73 | 3.91 | 3.96 | – | – | – |
| | Pasture DM 2.6 | – | – | – | – | – | | – | – | – | – | – | – |
| | Pasture DM 2.2 | – | – | – | – | 3.11 | 3.17 | 3.73 | 3.91 | 3.96 | – | – | – |
| | Pasture DP | – | – | – | – | .30 | .31 | .33 | .35 | .35 | – | – | – |

[1]These requirements represent a balanced ration in terms of dry matter, energy, and digestible protein for each of the livestock activities.

Livestock forage requirements and necessary supplemental feed were derived using the balanced ration technique. To estimate these, the energy density and DP required for the specified production levels were determined. The livestock activities were constructed using similar feeding methods to meet supplemental energy and DP requirements for varying patterns of livestock weight gain. The major criterion of ration construction in the model was energy density. DP was used as a check to ensure that all of the nutritional needs of the livestock were met. Protein supplement was included where its use is required, i.e., to meet the protein requirements of the livestock activities when the forage quality available contains insufficient digestible protein to obtain the gains assumed. The cow-calf activities also required two pounds of salt and mineral per month, while the steer activities required one pound per month. The balanced rations necessary to obtain the production specified for each livestock activity are included in Table XV. Costs, feed, labor and capital requirements, and the production of the cow-calf and stocker activities included in the model are presented in Table XVI.

## Model Summary

A submatrix composition of the 3200 acre ranch linear programming model is presented in Table XVII. Each individual submatrix permits the model to complete specific functions. For example, the D matrices allow the model to account for the pasture and crop forage produced and to allocate this forage to the most profitable livestock activity. Each letter in a submatrix represents a set of coefficients for the rows and columns indicated. Negative letters represent production, and positive

## TABLE XVI

## COSTS, PRODUCTION, FORAGE INPUT, CAPITAL AND LABOR REQUIREMENTS FOR THE LIVESTOCK ACTIVITIES

| | | Spring Cow-Calf | | Fall Cow-Calf | | Fall Stocker Steers 400 Pound Initial Weight | | | | | Fall Stocker Steers 485 Pound Initial Weight | | | | | Summer Stocker Steers | | | 500 Pound Initial Weight | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Item | Unit | SCC 400 | SCC 460 | FCC 500 | FCC 675 | FSTRS840 | FSTRS854 | FSTRS863 | FSTRS894 | FSTRS701 | FSTRS940 | FSTRS949 | FSTRS963 | FSTRS955 | FSTRS936 | SSTRS798 | SSTRS805 | SSTRS815 | SSTRS787 | SSTRS760 | SSTRS775 | SSTRS690 |
| **Net Return** | | | | | | | | | | | | | | | | | | | | | | |
| Obj. 1 | dol. | -27.80 | -27.80 | -32.83 | -32.70 | -19.37 | -19.37 | -19.20 | -19.37 | -19.38 | -19.37 | -19.37 | -19.37 | -19.37 | -18.06 | -13.54 | -13.54 | -13.54 | -13.54 | -13.54 | -13.54 | -13.54 |
| Obj. 2 | dol. | -32.91 | -32.91 | -39.81 | -39.61 | -23.71 | -23.71 | -23.48 | -23.71 | -20.99 | -23.71 | -23.71 | -23.71 | -23.71 | -22.07 | -16.42 | -16.42 | -16.42 | -16.42 | -16.42 | -16.42 | -16.42 |
| **Production** | | | | | | | | | | | | | | | | | | | | | | |
| Steer Calf | cwt. | 1.85 | 2.09 | 2.29 | 3.04 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Heifer Calf | cwt. | 1.28 | 1.42 | 1.60 | 2.21 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Cull Cow | cwt. | .95 | .95 | .95 | .95 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Steer | cwt. | — | — | — | — | 8.23 | 8.37 | 8.46 | 8.76 | 6.94 | 9.21 | 9.30 | 9.44 | 9.36 | 9.17 | 7.79 | 7.52 | 7.67 | 6.83 | 7.90 | 7.97 | 8.07 |
| **Capital Inputs** | | | | | | | | | | | | | | | | | | | | | | |
| Annual Operating | dol. | 16.86 | 16.86 | 6.17 | 8.25 | 188.49 | 194.26 | 185.43 | 194.26 | 117.37 | 226.54 | 225.01 | 225.32 | 224.46 | 224.73 | 96.08 | 96.08 | 96.08 | 96.08 | 96.08 | 96.08 | 96.08 |
| Livestock Investment | dol. | 416.60 | 416.60 | 416.60 | 416.60 | 3.60 | 3.60 | 3.60 | 3.60 | 3.60 | 3.60 | 3.60 | 3.60 | 3.60 | 3.60 | 3.60 | 3.60 | 3.60 | 3.60 | 3.60 | 3.60 | 3.60 |
| Machinery Investment | dol. | 19.00 | 19.00 | 28.76 | 28.40 | 15.16 | 15.16 | 14.80 | 15.16 | 11.27 | 15.16 | 15.16 | 15.16 | 15.16 | 13.39 | 7.37 | 7.37 | 7.37 | 7.37 | 7.37 | 7.37 | 7.37 |
| Equipment Investment | dol. | 4.91 | 4.91 | 4.91 | 4.91 | 4.412 | 4.412 | 4.412 | 4.412 | 4.612 | 4.41 | 4.41 | 4.41 | 4.41 | 4.41 | 4.41 | 4.41 | 4.41 | 4.41 | 4.41 | 4.41 | 4.41 |
| Total Ownership Cost | dol. | 5.11 | 5.11 | 6.98 | 6.91 | 4.34 | 4.34 | 4.28 | 4.34 | 3.61 | 4.34 | 4.34 | 4.34 | 4.34 | 4.01 | 2.88 | 2.88 | 2.88 | 2.88 | 2.88 | 2.88 | 2.88 |
| **Labor** | | | | | | | | | | | | | | | | | | | | | | |
| April-May | hrs. | 1.74 | 1.74 | 1.62 | 1.52 | .44 | .44 | .44 | .44 | .57 | .44 | .44 | .44 | .44 | .44 | .45 | .45 | .45 | .45 | .45 | .45 | .45 |
| June-July | hrs. | 1.34 | 1.34 | 1.08 | 1.34 | .44 | .44 | .44 | .44 | — | .44 | .44 | .44 | .44 | .44 | .58 | .58 | .58 | .58 | .58 | .58 | .58 |
| August-September | hrs. | 1.18 | 1.18 | 2.67 | 2.73 | .67 | .67 | .67 | .67 | — | .67 | .67 | .67 | .74 | .56 | .74 | .74 | .74 | .74 | .74 | .74 | .74 |
| October-November | hrs. | 1.67 | 1.67 | 2.42 | 2.04 | .89 | .89 | .89 | .84 | .84 | .79 | .79 | .79 | .73 | .63 | .01 | .01 | .01 | .01 | .01 | .01 | .01 |
| December-March | hrs. | 5.81 | 5.81 | 5.94 | 5.24 | 1.69 | 1.69 | 1.57 | 1.57 | 1.57 | 1.69 | 1.69 | 1.69 | 1.69 | 1.36 | — | — | — | — | — | — | — |
| **Forage Input** | | | | | | | | | | | | | | | | | | | | | | |
| Total DM | cwt. | 86.80 | 88.29 | 94.75 | 105.92 | 47.30 | 45.40 | 48.94 | 47.05 | 30.69 | 47.94 | 51.33 | 48.67 | 54.58 | 48.94 | 25.60 | 25.37 | 25.31 | 25.37 | 23.59 | 25.30 | 17.88 |
| Pasture DM 2.6 | cwt. | — | — | 8.30 | 10.49 | 15.93 | 2.11 | 15.95 | 11.93 | 28.89 | 14.11 | 16.76 | 24.61 | 20.47 | 15.95 | 4.25 | 4.24 | 12.27 | 4.99 | — | 4.24 | — |
| Pasture DM 2.2 | cwt. | 46.40 | 46.94 | 10.56 | 30.07 | 10.83 | 26.74 | 13.50 | 35.30 | — | 16.66 | 11.87 | 6.89 | 7.41 | 13.50 | 21.35 | 21.13 | 13.04 | 20.38 | 23.59 | 21.06 | 17.88 |
| Pasture DM 1.8 | cwt. | 31.47 | 36.84 | 63.39 | 57.86 | 16.59 | 12.64 | 17.38 | 9.65 | — | 13.27 | 18.63 | 13.27 | 17.22 | 17.38 | — | — | — | — | — | — | — |
| 41% Protein Supplement | cwt. | 1.81 | 1.81 | .40 | .40 | 1.95 | 1.91 | 1.42 | — | — | 1.90 | 2.07 | 1.90 | 2.03 | 2.11 | — | — | — | — | — | — | — |
| Hay 2.2 | ton | — | — | .62 | .35 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Hay 1.8 | ton | .14 | .14 | — | — | .10 | .10 | .09 | .10 | .09 | .10 | .10 | .10 | .10 | — | — | — | — | — | — | — | — |

## TABLE XVII

## MODEL SUBMATRICES

| | Forage Production | Beef Production | Borrow Capital | Hired Labor | Buy | Transfer | Sell | RHS1 |
|---|---|---|---|---|---|---|---|---|
| Net Revenue | -NR[1] | -NR | -NR | -NR | -NR | | NR[2] | |
| Land | A[3] | | | | | | | H[4] |
| Labor | -B[5] | -B[5] | | B[5] | | | | B[6] |
| Capital | C[7] | C[7] | -C | C | | | | |
| Forage | -D[8] | D[8] | | | | ±D[8] | | |
| Variable Inputs | -E[9] | ±E[9] | | | -E[9] | ±E | | |
| Sale | | -F[10] | | | | | F[10] | |
| Accounting | G[11] | G[11] | | | | | | |

[1]These submatrices includes net return to land, operator labor, risk, management, fixed machinery, fixed equipment, and fixed livestock capital, and net return to land, operator labor, management, and risk before the production is sold.

[2]This submatrix shows net return to the farm from the sale of one unit of product.

[3]These submatrices shows the land requirements for each activity.

[4]This submatrix shows the amount of each land type.

[5]These submatrices contain the coefficients of operator labor required for each activity.

[6]These submatrices show the hours of operator labor assigned to each time period.

[7]These submatrices include the capital requirements of the activities, and the coefficients for borrowing capital.

[8]These submatrices contain forage production by pasture and forage required by livestock activity.

[9]These submatrices allow purchase of variable inputs for pasture or livestock utilization.

[10]These submatrices enable the model to sell the livestock produced.

[11]These submatrices provide an accounting of machine use, pasture forage production, and forage utilization.

letters represent utilization. The model is explained in total by the following discussion of the various submatrices.

## Objectives

The net revenue submatrix contains the two rows which define the two alternative objective functions maximized in the model, OBJ1 and OBJ2. OBJ1 represents net returns to land, operator labor, management, fixed machinery and equipment, and risk. OBJ2 represents net returns to land, operator labor, management, and risk. Negative signs on the net returns shown in the columns indicate the net revenue (cost) of the activities before the production is sold. The positive sign on net revenue in the sell column indicates the price of one unit of product to be sold.

## Constraints and Accounting Rows

The remaining rows in the model limit the utilization of the available and produced resources, and provide information for accounting purposes.

### Land Constraint

Land can be allocated within the model as either native pastureland or cropland. In the base model 240 acres is allocated to cropland and 2960 acres to native pastureland.

### Labor Constraint

Labor is allocated to the activities in the model by means of the labor rows. Two types of labor, operator and hired, are available for use in each of the five time periods designated. The base model constrains available operator labor to 450 hours in April-May, June-July, August-September, and October-November. There are 900 hours of operator labor available in December-March. The operator labor available in each time period will be allocated to the activities first. Any additional labor required can be hired at $3.50 per hour. There are no restrictions placed on the amount of labor hired or used.

Capital Constraint

The capital requirements of the model are divided into five categories: operating capital, livestock capital, machinery capital, equipment capital, and pasture establishment capital. Interest is charged for all capital required in both of the objective functions. In this way the payment of the opportunity cost of capital required by the model is guaranteed. The implicit assumption here is that machinery and equipment are variable inputs, when in the short run they are not. Alternatives to this assumption are discussed in the earlier presentation of machinery and equipment costs.

Operating capital includes the cost of the variable inputs used on the ranch. Livestock capital requirements are derived from the average investment per unit of livestock. The capital requirements for machinery and equipment capital consist of the average capital investment in these resources per hour or per acre of use. Pasture establishment capital includes the capital costs for converting cropland to lovegrass or alfalfa. This implies that the establishment of such pasture or hayland is a long-term investment, requiring that the capital involved in these activities be paid a return.

## Forage Constraint

The forage rows are made up of 14 pasture DM rows, seven hay rows, and one silage row. The pasture DM rows are divided into the respective forage quality groups for each of the five time periods. The hay rows contain two hay production rows which represent the hay quality groups, and five rows which allocate the appropriate quality hay to the three time periods in which the livestock activities require hay. The silage row can be used to substitute silage for Pasture DM 2.2 during any particular time period necessary.

The pasture DM rows restrict forage consumption by the livestock activities to the amount of forage actually produced by the pasture activities and the quality required by the livestock activities in each time period. The two hay production rows restrict the amount of hay fed to no more than the total of the hay produced and bought.

## Variable Inputs

The variable input rows permit specific inputs to vary in level of use as the price of the input is changed. These rows also restrict input use to the amount of the input purchased. They also allow the model to allocate the inputs to the most profitable activity. The inputs allocated through these rows are purchased by the Buy Activities.

## Sell Rows

The sell rows restrict the sale of products by the individual activities to the amount actually produced by the activity. Calves and steers of varying sizes, cull cows, and aged bulls are included in these rows.

Accounting Rows

Seventy-seven rows are used to account for the resources produced and to monitor their utilization by the model. Since these rows are strictly for accounting purposes, they are not restricted in any way.

The accounting rows are used to measure total pasture forage yields by quality, pasture production of DP, and the total pasture forage, hay, DP, and protein supplement consumed by the cow-calf and stocker activities in each time period. These rows also account for the total hours of use of the pickups, tractor, and hay hauling equipment. They also total cow-calf, fall steer, and summer steer numbers.

## Columns

The activities contained in the model take the form of column vectors. The eight types of columns included are: 1) Pasture Production, 2) Livestock Production, 3) Borrow Capital, 4) Hire Labor, 5) Buy, 6) Transfer, 7) Sell, and 8) the Right Hand Side (RHS). These activities utilize restricted resources, produce resources to be used by other activities, use resources produced by other activities, or any combination of the above. A discussion of the activities contained in the columns follows.

Pasture Production

The model contains 11 forage production activities (Tables XI and XII). Three of these activities are different grazing schemes of native range. They are continuous grazing, deferred grazing, and summer grazing. Three activities involve the use of introduced forage grasses.

The two activities involving lovegrass are rotation grazing and the production of Hay 1.8 plus grazing. Alfalfa is used to produce Hay 2.2. The five remaining activities utilize wheat, hybrid sorghum-sudan, sudan and sorghum. These activities are wheat for graze-out, double cropped wheat and hybrid sorghum-sudan for graze-out, hybrid sorghum-sudan for graze-out, sudan for production of Hay 2.2 plus grazing, and sorghum for silage (Tables XI and XII).

Livestock Production

The livestock production activities contained in the model consist of two spring-calving cow-calf activities, two fall-calving cow-calf activities, five fall stocker steer activities beginning with 400 pound steer calves, five fall stocker steer activities beginning with 485 pound steer calves, and seven summer stocker steer activities beginning with 500 pound stocker steers (Table XIII).

Within each of these groups, different rations are used to meet the animals nutritional requirements. Difference between activities are reflected in weight gains, forage intakes, and the final weight of the animals produced. These differences influence the livestock nutritional requirements and thus the rations used in any given activity. All livestock activities use the concept of a balanced ration to fulfill their particular nutritional requirements.

The base assumptions and data on the livestock activities contained in the model have been previously discussed and are presented in Tables XV and XVI. The products sold are those contained in the various sell rows.

## Borrow Capital

There is a capital borrowing activity for each type of capital required by the production activities. The interest rate used in the analysis for borrowing all types of capital is 9.5%.

## Hired Labor

If all of the operator labor designated for a given period is utilized, the model uses these activities to hire additional labor for the time period. There are five activities for hired labor which coincide with each of the five time periods in the analysis.

## Buy Activities

The buy activities are used to purchase certain variable inputs which are then utilized by other activities. In this way examination of the effects of a price change on the level of use of any particular input is facilitated. The buy activities include the purchase of Hay 2.2, Hay 1.8, 41% Protein Supplement, nitrogen, and 400, 485, and 500 pound stocker steers.

## Transfer Activities

The transfer columns permit resources to move from one activity to another, or from one time period to another. Hay that is produced or bought is compiled in the production row and then transferred to the utilization row for the time period in which it is required. Forty-one Percent Supplement acquired by the buy protein column is similarly transferred to the time periods when it is needed. Steer calves produced by the cow-calf activities can be transferred to the appropriate stocker activities. When additional costs or returns are associated with the transfer of the resource, they are accounted for in the net revenue row.

The forage transfer activities included in the model and their functions are listed in Table XVIII. There are two basic functions performed by these forage transfer activities. Some activities allow forage from a higher quality grouping to substitute for lower quality forage in the same time period. An example of this is TAS22-18 where Pasture DM 2.2 is allowed to substitute for Pasture DM 1.8 in August-September. Other activities allow forage to move from one time period to another. DP is transferred with the forage. The transfer may also involve a loss in forage quality (AS22-018) with a corresponding loss in DP content. Some transfer activities (T018-DM) indicate no changes in forage quality as forage is stockpiled.

These activities permit forage to be efficiently utilized in periods other than those in which it is produced.

## Sell Activities

The function of the sell activities is to market the livestock produced by the ranch operation modeled. The sell prices can be altered to examine the effects of price relationships on ranch organization.

## Right Hand Side (RHS)

The right hand sides restrict the use of certain resources within the model. When rows are limited, and a coefficient is not inserted in the RHS, the value of the row cannot exceed zero. For purchased or produced resources this restricts utilization from being greater than the amount purchased and produced.

TABLE XVIII

FORAGE TRANSFER ACTIVITIES

| Activity Code | Function |
|---|---|
| TA26-22 | Allow A-MPS 2.6 to be substituted for A-MPS 2.2 |
| TJ26-22 | Allow J-JPS 2.6 to be substituted for J-JPS 2.2 |
| TJ22-18 | Allow J-JPS 2.2 to be substituted for J-JPS 1.8 |
| TAS26-22 | Allow A-SPS 2.6 to be substituted for A-SPS 2.2 |
| TAS22-18 | Allow A-SPS 2.2 to be substituted for A-SPS 1.8 |
| TAS18-ON | Allow A-SPS 1.8 to be utilized in October-November |
| TO22-18 | Allow O-NPS 2.2 to be substituted for O-NPS1.8 |
| TO18-DM | Allow O-NPS 1.8 to be utilized in December-March |
| TJ22-AS | Allow J-JPS 2.2 to be utilized in August-September |
| TAM22-JJ | Allow A-MPS 2.2 to be utilized in June-July |
| TAM1.8-DM[1] | Allow A-MPS 1.8 to be utilized in December-March |
| TAS22018 | Allow A-SPS 2.2 to be utilized as O-NPS 2.2 and O-NPS 1.8 |
| TON26D26 | Allow O-NPS 2.6 to be utilized as D-MPS 2.6 |

[1]This activity allows Pasture DM 1.8 to be grazed in December-March instead of April, as provided for by the forage activities.

In this model, the RHS is used to restrict the number of acres of cropland and pastureland to a specified level. In the base model this is 240 acres cropland and 2960 acres pastureland. The RHS also restricts operator labor in each time period on the basis of 225 hours available per month.

Cropland and pastureland are the only absolutely restricted resources contained in the model. Such absolute restrictions can be altered by changing the restriction to examine different land resource mixes.

## August-September DP Limitation

Preliminary testing of the analytical model indicated problems in the solutions. Livestock numbers were very high. Examination revealed that all forage was being consumed, but that August-September DP was extremely deficient. Thus, the activity levels in the solution were not reasonable.

From several possibilities, the decision was made to limit August-September DP so that the amount consumed could not exceed the amount provided by the model. This approach requires the model to balance the ration for energy and DP. With this revision, the model supplied the protein required by the livestock activities in most instances. However, in certain situations the model does not supply sufficient supplemental protein. This is indicated when excess forage is produced in August-September and there is no excess DP in the same period. In such cases, the supplemental protein required to balance the steer rations in August-September can be calculated from the amount of excess forage produced.

For example, assume that 20,000 pounds of excess forage are produced in August-September while all DP in this period is consumed. August-September forage of quality DM 2.2 or DM 1.8 contains approximately 5% DP. Multiplying 20,000 pounds times .05 gives an answer of 1000 pounds of DP necessary to meet livestock requirements. Forty-one Percent Protein Supplement contains 35.3% DP. Thus, the amount of 41% Protein Supplement required for 1000 pounds of DP is equal to 1000 ÷ .353 = 2833 pounds of 41% Protein Supplement. At 10¢ per pound, $283.30 would need to be spent on supplement to obtain the livestock numbers and gains indicated, reducing returns by the same amount.

When the solution is forced to meet nutritional needs in this manner, the solution obtained may not be optimal. This can be rechecked by forcing this additional supplement into the solution through the model. In situations examined, this did not change the solution materially other than reducing returns.

This DP limitation was necessary in the August-September time period only. It was done to achieve feasible results, and resulted in late summer protein supplementation of steers to maintain high rates of gain. This is a valid practice, as presented by Shoop and McIlvain (31).

# CHAPTER III

# THE BASE MODEL AND APPLICATIONS

This chapter presents the base solution obtained from the model specified in the previous chapter. The solution is examined to determine the adequacy of the results obtained, and whether or not they realistically depict a possible ranch organization. Selected organizational limitations are imposed on the model and the effects of these limitations are evaluated. The model is also used to examine the effects of livestock price changes on the optimal ranch organization and on net returns to the operation.

Many ranchers have the opportunity to change the amount of cropland in their operations. The model is used to observe the effect of different relative amounts of cropland on the ranch organization. Particular attention is focused on net returns, the optimal mix of livestock and pasture activities in each situation, and the intensity of operation as the land resource mix is varied.

## The Base Solution

Net returns, pasture and livestock activities, and labor and capital requirements for the base solution are presented in Table XIX. Each of these major components is discussed in detail in this section. Then, changes in resource restrictions and prices are considered in following sections.

# TABLE XIX

## NET RETURNS AND ORGANIZATIONS FOR A 3200 ACRE RANCH UNDER VARIED ORGANIZATIONAL LIMITATIONS

| Item | Unit | Base Solution[1] | Summer Stockers ≤ 400[2] | Summer Stockers = 0[3] | Fall Stockers ≤ 250[4] | Fall Stockers = 0[5] |
|---|---|---|---|---|---|---|
| OBJ1 | dol. | 69,223 | 62,000.00 | 50,481 | 35,797 | 19,065 |
| OBJ2 | dol. | 62,215 | 55,167.00 | 43,791 | 29,162 | 12,873 |
| Hired Labor* | | | | | | |
| April-May | hrs. | 47 | -55 | -162 | -129 | -68 |
| June-July | hrs. | 26 | -62 | -183 | -153 | -121 |
| August-September | hrs. | 222 | 122 | -18 | 94 | 222 |
| October-November | hrs. | -364 | -186 | 24 | -20 | -49 |
| December-March | hrs. | -740 | -419 | -60 | -16 | 133 |
| Capital Requirements | | | | | | |
| Total Capital | dol. | 145,300 | 151,000 | 152,700 | 141,150 | 135,600 |
| Operating Capital | dol. | 92,090 | 97,760 | 101,150 | 53,670 | 6,870 |
| Livestock Capital | dol. | 2,940 | 2,490 | 1,860 | 39,300 | 81,810 |
| Machinery Capital | dol. | 44,620 | 44,550 | 45,170 | 46,630 | 45,290 |
| Equipment Capital | dol. | 3,600 | 3,050 | 2,290 | 1,550 | 970 |
| Pasture Establishment Capital | dol. | 2,040 | 3,150 | 3,190 | -- | 660 |
| Pasture | | | | | | |
| NATR-CG | acres | -- | 929 | 1,438 | 2,388 | 697 |
| NATR-DG | acres | -- | -- | -- | -- | -- |
| NATR-SG | acres | 2,960 | 2,031 | 1,522 | 572 | 2,263 |
| LOVLG-RG | acres | 86 | 134 | 135 | -- | 28 |
| WHT-GO | acres | 35 | 47 | 57 | 146 | 171 |
| WHTSD-GO | acres | -- | 13 | 48 | 75 | -- |
| SOSUD-GO | acres | 119 | 46 | -- | -- | -- |
| SOSUD-HY | acres | -- | -- | -- | 19 | 41 |
| Livestock | | | | | | |
| FCC-675 | hd. | -- | -- | -- | 92 | 192 |
| FSTRS-863 | hd. | -- | 186 | 405 | 72 | -- |
| FSTRS-894 | hd. | 94 | 105 | 114 | 178 | -- |
| SSTRS-805 | hd. | 665 | 400 | -- | -- | -- |
| SSTRS-815 | hd. | 58 | -- | -- | -- | -- |

*Negative sign denotes excess operator labor.

[1]The base solution is derived by maximizing returns to OBJ1 with no limitations other than those imposed by the model.

[2]Summer stockers are limited to 400 head to reflect a possible diversification of the organization.

[3]Summer stockers are removed from the organization due to risk associated with the activity.

[4]Summer stockers are excluded and fall stockers are limited to 250 head so that cow-calf activities are included to represent an organization commonly observed.

[5]All stocker activities are removed to observe the returns to a cow-calf organization.

Net Returns

Maximizing OBJ1 yielded a net return to land, operator labor, management, fixed machinery and equipment and risk of $69,223. Maximizing OBJ2 yielded a net return to land, operator labor, management and risk of $62,215. Maximizing the alternative objective functions resulted in an identical optimal mix of activities. Net returns can be further examined as additional interest costs, machinery and equipment ownership costs, and family living costs are considered.

In 1977, the average annual income of farm workers was $12,700 (35). The average annual income of workers in service industries was $13,460, and the average annual income of blue collar workers was $16,700. The Kansas Farm Management Summary and Analysis Report for 1976 reported that total family living costs for a family of 4.7 members with the oldest child in high school was $11,900. Adjusting this figure for inflation yields a figure near $13,600. For the analysis, $13,750 was chosen to represent family living expenses and opportunity costs of operator labor. Subtracting these expenses from the net returns indicated by OBJ1 yields a net return to land, machinery and equipment, management, and risk of $55,473.

The ownership costs associated with the machinery and equipment owned by the ranch must be paid by the firm. Total annual ownership costs for machinery and equipment are $11,670. Total interest costs associated with machinery and equipment must also be paid. The model pays the interest on the machinery and equipment actually used in the solution. In the base solution, interest is paid on $48,120 (Table XIX) of machinery and equipment capital at a rate of 9.5% for a total of $4,579 interest costs. From Tables I and III, total interest costs for machinery and equipment are $6,749. The difference between actual interest costs ($6,749) and those paid by the individual activities ($4,579) is equal to $2,170, which must be subtracted from net returns. Subtracting these ownership and additional interest costs yields a net return to land, management, and risk of $41,633 (Table XX) for the base solution. The optimal organization in this solution is thus capable of generating sufficient income to support the operator and pay the costs incurred in operation. Whether the returns to land, management, and risk are adequate to compensate for land costs, management ability, and the risks involved will be dependent on whether the land is owned by the operation and on the manager's individual preferences.

## Pasture and Livestock Activities

The 2960 acres of native rangelands are used entirely for summer grazing (NATR-SG). The 240 acres of cropland contain 86 acres of lovegrass for grazing (LOVEG-RG), 35 acres of wheat for graze-out (WHT-GO), and 119 acres of hybrid sorghum-sudan for graze-out (SOSUD-GO).

The pasture activities reflect the nutritional needs of the livestock activities. The base solution contains 723 summer stocker steers; 665 sold at a weight of 805 pounds (SSTRS805) and 58 sold at a weight of 815 pounds (SSTRS815). Ninety-four fall stocker steers are in the solution, all of which are sold at a weight of 894 pounds (SSTRS894). This activity is based on the grazing of wheat to supply winter protein needs.

## Forage Utilization

The production and use of forage by quality group and time period

TABLE XX

NET RETURNS TO LAND, MANAGEMENT AND RISK FOR ALTERNATIVE ORGANIZATIONS OF A 3200 ACRE NORTHWEST OKLAHOMA RANCH

| | Base Solution | Summer Stockers ≤ 400 | Summer Stockers = 0 | Fall Stockers ≤ 250 | Fall Stockers = 0 |
|---|---|---|---|---|---|
| OBJ1: | $69,223 | $62,000 | $50,481 | $35,797 | $19,065 |
| - Total Family Living | 13,750 | 13,750 | 13,750 | 13,750 | 13,750 |
| Net Return to Land, Machinery and Equipment, Management and Risk | $55,473 | $48,250 | $36,731 | $22,047 | $ 5,315 |
| - Machinery and Equipment Ownership Costs | 11,670 | 11,670 | 11,670 | 11,670 | 11,670 |
| - Additional Interest | 2,170 | 2,227 | 2,240 | 2,170 | 2,365 |
| Net Returns to Land, Management and Risk | $41,633 | $34,353 | $22,921 | $ 8,207 | $-8,720 |

for the base solution are presented in Table XXI. This table allows an examination of the possible forage utilization in terms of which livestock activity grazes what pasture activity in a given time period. For example, in April-May the FSTRS894 require 230 cwt. Pasture DM 2.6 and 640 cwt. of Pasture DM 2.2. They could obtain this by grazing the WHT-GO and LOVEG-RG activities.

The forage utilization indicates very little excess forage (130 cwt. in December-March) and very little forage transfer between time periods. This indicates that the steer activities tend to consume the forage as it is produced.

## Labor and Capital Requirements

The optimal organization for the base solution requires 295 hours of hired labor; 47 hours in April-May, 26 hours in June-July, and 222 hours in August-September. There are 1104 hours of unused operator labor; 364 in October-November and 740 hours in December-March.

The total annual capital requirements for the operation are $145,300. Capital for operating expenditures makes up the bulk of this at $92,092.

## Model Monitors

Two areas in the model are important monitors of the validity of the solution and the adequacy of the net returns as measured by the objective functions. These areas are the hours of selected machine use, and the amount of excess forage produced within the solution. August-September protein supplement is monitored to examine the profitability of providing supplemental protein in this time period. These monitors are contained in Table XXII.

## TABLE XXI

## PASTURE CALENDAR: FORAGE PRODUCTION AND UTILIZATION--BASE SOLUTION[1]

| | Pasture DM Production | | | Transfer | Source | Pasture DM Utilization | | |
|---|---|---|---|---|---|---|---|---|
| | Total (cwt. DM) | Activity (cwt. DM) | | (cwt. DM) | | Total (cwt. DM) | Activity (cwt. DM) | |
| **April-May** | | | | | | | | |
| 2.6 | 3800 | NATR-SG | 2960 | | | 3800 | FSTRS894 | 230 |
| | | WMT-GO | 340 | | | | SSTRS805 | 2820 |
| | | | | | | | SSTRS815 | 250 |
| 2.2 | 690 | LOVEG-RG | 690 | -50[a] | | 640 | FSTRS894 | 640 |
| **June-July** | | | | | | | | |
| | | NATR-SG | 3110 | | | | | |
| 2.6 | 4770 | SOSUD-GO | 1660 | -4730 | | 40 | SSTRS815 | 40 |
| 2.2 | 3680 | NATR-SG | 2220 | 4780 | | 8460 | FSTRS894 | 1020 |
| | | LOVEG-RG | 1460 | | A-MPS2.2 | | SSTRS805 | 6890 |
| | | | | | J-JPS2.6 | | SSTRS815 | 550 |
| **August-September** | | | | | | | | |
| 2.6 | 830 | SOSUD-GO | 830 | | | 830 | FSTRS894 | 410 |
| | | | | | | | SSTRS815 | 420 |
| 2.2 | 8240 | NATR-SG | 5020 | -490 | | 7750 | FSTRS894 | 380 |
| | | LOVEG-RG | 720 | | | | SSTRS805 | 7170 |
| | | SOSUD-GO | 2500 | | | | SSTRS815 | 200 |
| **October-November** | | | | | | | | |
| 2.6 | 80 | WMT-GO | 80 | | | 80 | FSTRS894 | 80 |
| 2.2 | | | | 170 | A-SPS2.2 | 170 | FSTRS894 | 170 |
| 1.8 | | | | 210 | A-SPS2.2 | 210 | FSTRS894 | 210 |
| **December-March** | | | | | | | | |
| 2.6 | 410 | WMT-GO | 410 | | | 400 | FSTRS894 | 400 |
| 1.8 | 800 | LOVEG-RG | 800 | 110 | A-SPS2.2 | 790 | FSTRS894 | 790 |

[a] Negative sign denotes forage transferred out of the appropriate group.

[1] The figures presented have been rounded to the nearest 1000 lbs. since more precise management of forage is not realistic in a ranch situation.

TABLE XXII

EXCESS FORAGE PRODUCTION, ADDITIONAL PROTEIN REQUIREMENTS, AND SELECTED MACHINE USE FOR A 3200 ACRE RANCH UNDER VARIOUS ORGANIZATIONAL LIMITATIONS

| | Solution | SSTEER $\leq$ 400 | SSTEER = 0 | FSTEER $\leq$ 250 | FSTEER = 0 |
|---|---|---|---|---|---|
| Excess Forage (cwt. of DM) | | | | | |
| D-MPS 2.6 | 850 | - | - | 33,900 | 34,800 |
| D-MPS 1.8 | 12,300 | - | - | - | - |
| August-September 41% Protein Supplement (cwt.) | 237 | 128 | - | - | - |
| Machine Use (hrs.) | | | | | |
| Pickup | 894 | 974 | 1,033 | 875 | 786 |
| Tractor | 94 | 81 | 86 | 135 | 113 |

The hours of selected machine use are monitored to examine the base assumptions of the model concerning machine use. These assumptions affect the charge for ownership costs by the model. In the base solution the pickups are used a total of 894 hours. This amount is reasonably consistent with the 1000 hours of annual use assumed in the Machine Complement. The tractor is used 94 hours, compared to an assumed annual use of 600 hours. The total machinery capital required by the model is $44,625 compared to the $79,000 invested in the machinery. When these machines are used at lower levels than those assumed, ownership costs and interest on the machinery investment are underpaid by the activities in the solution. Thus, the returns measured by OBJ2 which consider ownership costs as variable can be questioned. In both OBJ1 and OBJ2 the costs not paid by the activities must be accounted for in examining returns to the operation (Table XX).

The base solution produced 13,150 pounds of excess forage. Of this amount, 12,300 pounds occurs in December-March as Pasture DM 1.8. Since this is low quality winter forage produced in an organization emphasizing summer steers, it can be concluded that there exists no economical way of utilizing this forage. Eight hundred fifty pounds of the excess is produced in December-March as Pasture DM 2.6. Though the livestock activities do not require this forage, a good manager would be expected to graze this high-quality forage in place of lower-quality forages. In this way, all excess would realistically be Pasture DM 1.8. This excess would be produced by LOVEG-RG, and amounts to approximately 10 pounds per acre. Management practices assumed include spring burning of lovegrass residue (32), so that this cost is paid for by the activity.

The model supplies 23,700 pounds of 41% protein supplement to the summer stocker activities to meet protein requirements. The model chose the activities requiring protein supplementation as the most profitable, which is indicative of the profitability of late summer feeding of protein supplement to maintain summer weight gains.

## Sensitivity Analysis

An examination of the shadow prices of the various activities indicates the relative stability of the organization obtained in the solution. Shadow prices indicate the amount of change in costs and prices necessary to cause a change in the level of the activity shown in the solution. The shadow prices for the pasture and livestock activities are shown in Table XXIII.

The shadow prices in the base solution indicate that the derived organization is relatively stable. For example, the minimum increase in costs, or decrease in returns, or combination thereof necessary to decrease the acreage of NATR-SG is $4.40. Though the interrelationship of activities cannot always be traced within this type of analysis, the relative stability of the organization can be examined by comparing shadow prices to activity costs.

## Marginal Value Products of Inputs (MVP)

The importance of any given input in the production process can be examined by observing the MVP of a unit of that input. The MVP indicates the change in the value of the objective function (net returns) that would result from the addition of one more unit of that input. The MVP's of the land resources and high-quality forages are presented in Table XXIV.

## TABLE XXIII

## FORAGE AND LIVESTOCK ACTIVITY SHADOW PRICES FOR VARIED ORGANIZATIONS

| Activity | Activity Cost in the Model | Solution | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Base | | SSTEERS ≤ 400 | | SSTEERS = 0 | | FSTEERS ≤ 250 | | FSTEERS = 0 | |
| | | ↑Unit | Cost[a]↓ | ↑Unit | Cost↓ | ↑Unit | Cost↓ | ↑Unit | Cost↓ | ↑Unit | Cost↓ |
| NATR-CG | 1.67 | | | 3.36 | .81 | .09 | .29 | .43 | .30 | .70 | .62 |
| NATR-SG | 1.67 | | 4.40 | .81 | 3.36 | .29 | .09 | .30 | .43 | .62 | .70 |
| LOVEG-RG | 14.33 | 10.00 | 3.21 | 18.75 | 11.84 | 2.21 | 2.81 | | | 29.28 | 11.71 |
| WHT-GO | 13.95 | 63.61 | 6.27 | 16.87 | 32.00 | 8.76 | 5.85 | 13.61 | 22.63 | 20.62 | 28.86 |
| WHTSD-GO | 14.17 | | | 16.68 | 21.38 | 4.13 | 3.55 | 17.21 | 11.70 | | |
| SOSUD-GO | 11.36 | 2.78 | 15.15 | 15.57 | 17.20 | | | | | | |
| SOSUD-HY | 19.35 | | | | | | | 12.64 | 7.49 | 69.33 | 14.66 |
| FCC-675 | 32.70 | | | 106.87* | | 131.11* | | 39.14 | 26.53 | 80.79 | 31.86 |
| FSTRS863 | 19.20 | | | 16.73 | 7.14 | 2.29 | 1.43 | 7.53 | 7.21 | | |
| FSTRS894 | 19.37 | 24.11 | 2.32 | 8.88 | 16.31 | 1.73 | 1.49 | 7.21 | 7.53 | | |
| SSTRS805 | 13.54 | 2.85 | 2.17 | | 3.91 | | | | | | |
| SSTRS815 | 13.54 | 2.35 | 2.86 | | | | | | | | |
| FSTRS710 | 17.38 | 81.30* | | 19.31* | | 13.21* | | 73.20* | | | |
| SCC400 | 27.80 | * | | * | | 118.79* | | 56.81* | | | |

*Activity in base solution at the zero level.

[1]Unit costs are the amount of change required in costs and prices to cause a change in the level of the activity. An activity level increase would require a decrease in costs or an increase in returns or a combination thereof on the amount presented. An activity level decrease would result from a cost increase or returns decrease at the amount specified. For example, the activity cost of NATR-CG is $1.67. In the solution for SSTEERS ≤ 400, an increase in costs of $3.36, making the activity cost equal to $5.03 would change the level at which NATR-CG appears in the solution.

TABLE XXIV

THE MVP OF LAND AND HIGH-QUALITY FORAGE

| | Base Solution | SSTEER ≤ 400 | SSTEER = 0 | FSTEER ≤ 250 | FSTEER = 0 |
|---|---|---|---|---|---|
| Cropland | $86.46 | $80.30 | $81.65 | $34.53 | $19.36 |
| Native Pastureland | 14.70 | 10.40 | 9.88 | 3.37 | 3.20 |
| Pasture 2.6[1] | | | | | |
| O-NPS 2.6 | 21.33 | 4.39 | 3.48 | 14.02 | 7.80 |
| A-MPS 2.6 | 6.71 | 4.70 | 5.98 | 3.06 | 2.98 |
| A-SOS 2.6 | .50 | 1.71 | 2.14 | 3.16 | .81 |
| D-MPS 2.6 | -- | 4.39 | 3.48 | -- | -- |
| J-JPS 2.6 | 3.79 | 2.29 | 1.79 | .84 | .81 |

[1]Because cropland is valuable as a course of high quality forage, the MVP of the Pasture 2.6 groups is a further examination of the high MVP of cropland.

In the base solution, the MVP figures indicate that an additional acre of cropland in the organization would increase net returns by $84.46. An additional acre of native pastureland would increase returns $14.70.

The value (MVP) of additional units of high-quality forage in certain time periods is quite large. For example, an additional cwt. of Pasture DM 2.6 in October-November would increase net returns by $21.33. An additional cwt. of April-May Pasture DM 2.6 would increase returns $6.71. Lower quality forages are worth comparatively less, with one cwt. of Pasture DM 2.2 in August-September increasing returns by only $.10. Cropland and high-quality forage are quite interrelated, since cropland is capable of producing those forages with the highest MVP.

Evaluation

The base solution indicates an organization which may be subject to certain problems in reality. The large number of stockers may be unrealistic due to possible problems in obtaining the steers of the weight required when necessary at the given price.

Summer stockers require late summer high-quality forage to maintain weight gains. The hybrid sorghum-sudan supplying this forage can vary widely in production while presenting management problems and risks due to these variations. Its capacity to fail or to virtually grow past the animals as growing conditions vary raises the prospect of not supplying sufficient high-quality forage to maintain weight gains, or of supplying more than can be effectively utilized. There are also risks involved in "putting all the eggs in one basket", which this organization does.

From the standpoint of whether or not the organization derived could produce sufficient forage to support the number of steers indicated, the base solution is both feasible and realistic.

## Organizational Limitations

There are some potential problems, as discussed, in the base solution. Several possible managerial alternatives are possible in the organization of the ranch. The model was used to examine some of these alternatives through a series of limitations on the level of livestock activities. The effects of these limitations in comparison to the base solution and each other are presented in Tables XIX, XX, XXII, XXIII, and XXIV.

### Summer Stockers ≤ 400

The first alternative modeled involved limiting the number of summer stocker steers to no more than 400. This reflects a possible desire to diversify, taking a less risky position. The number 400 was chosen as approximately one-half of the total number of steers in the base solution. This limitation resulted in a decrease in net returns as measured by OBJ1 from $69,223 to $62,000, and a decrease in net returns to land, management and risk from $41,633 to $34,353 (Table XX).

The organization for this solution contains 291 fall stocker steers. FSTRS894 increases from 94 to 105 steers. FSTRS863 enters the solution at a level of 186 head. The organization retains 400 summer stocker steers, all in the SSTRS805 activity.

The limitation of summer steer activities, and the resultant increase in the level of fall steer activities necessitates a shift in pasture activities to provide for forage required. Crop activities shift to supply high-quality forage in the late summer and winter months. Some native range is now utilized on a year-round basis. Most pronounced is the decrease in LOVEG-RG and the decrease in SOSUD-GO.

The pasture calendar for this solution is presented in Table XXV. No excess forage is produced, and most forage is utilized in the period produced, though some is transferred between quality groups.

In this organization, hired labor requirements are reduced to 122 hours, all in August-September. Unused operator labor occurred in each of the remaining time periods, totalling 722 hours. More of the available operator labor is used in this organization. Total capital requirements increased, mostly due to increased amounts of operating capital required as higher numbers of fall steers affect the average capital used for operating expenses. These fall steer activities require capital over a longer time period. This organization is similar in machine use to the base solution. August-September protein supplementation is again a profitable practice.

<u>Summer Stockers = 0</u>

The second alternative modeled removed all summer stocker steers from the organization. There are a variety of reasons for such an action. The operator may simply prefer other organizations. The high degree of risk associated with holding summer steers for a short period of high gains may be sufficient for the manager to exclude summer steers. The availability of stockers for summer grazing is also questionable.

## TABLE XXV

## PASTURE CALENDAR: FORAGE PRODUCTION AND UTILIZATION SSTEERS $\leq$ 400[1]

| | Pasture DM Production | | | Transfer | Source | Pasture DM Utilization | | |
|---|---|---|---|---|---|---|---|---|
| | Total (cwt. DM) | Activity (cwt. DM) | | (cwt. DM) | | Total (cwt. DM) | Activity (cwt. DM) | |
| April-May | | | | | | | | |
| 2.6 | 3290 | NATR-CG | 740 | | | 3290 | FSTRS863 | 1380 |
| | | NATR-SG | 2000 | | | | FSTRS894 | 260 |
| | | WHT-GO | 440 | | | | SSTRS805 | 1700 |
| | | WHTSD-GO | 140 | | | | | |
| 2.2 | 1070 | LOVEG-RG | 1070 | | | 1070 | FSTRS863 | 350 |
| | | | | | | | FSTRS894 | 720 |
| 1.8 | 230 | NATR-CG | 230 | -230* | | | | |
| June-July | | | | | | | | |
| 2.6 | 4200 | NATR-CG | 1410 | -3450 | | 750 | FSTRS863 | 750 |
| | | NATR-SG | 2145 | | | | | |
| | | SOSUD-GO | 650 | | | | | |
| 2.2 | 3780 | NATR-SG | 1520 | 2760 | J-JPS2.6 | 6540 | FSTRS863 | 1240 |
| | | LOVEG-RG | 2260 | | | | FSTRS894 | 1160 |
| | | | | | | | SSTRS805 | 4150 |
| August-September | | | | | | | | |
| 2.6 | 460 | WHTSD-GO | 140 | | | 460 | FSTRS894 | 460 |
| | | SOSUD-GO | 320 | | | | | |
| 2.2 | 6460 | NATR-CG | 930 | -220 | | 6240 | FSTRS863 | 1520 |
| | | NATR-SG | 3460 | | | | FSTRS894 | 410 |
| | | LOVEG-RG | 1110 | | | | FSTRS805 | 4310 |
| | | SOSUD-GO | 960 | | | | | |
| October-November | | | | | | | | |
| 2.6 | 110 | WHT-GO | 110 | -20 | | 90 | FSTRS894 | 90 |
| 2.2 | 90 | NATR-CG | 90 | 280 | J-JPS2.6 | 370 | FSTRS863 | 190 |
| | | | | | | | FSTRS894 | 180 |
| 1.8 | 370 | NATR-CG | 370 | 530 | J-JPS2.6 | 900 | FSTRS863 | 660 |
| | | | | | A-SPS2.2 | | FSTRS894 | 240 |
| December-March | | | | | | | | |
| 2.6 | 600 | WHT-GO | 560 | 20 | O-NPS2.6 | 620 | FSTRS863 | 170 |
| | | WHTSD-GO | 40 | | | | FSTRS894 | 450 |
| 1.8 | 2400 | NATR-CG | 1160 | 380 | A-SPS2.2 | 2730 | FFSTRS863 | 1950 |
| | | LOVEG-RG | 1240 | | A-MPS1.8 | | FSTRS894 | 780 |

*Negative signs denote forage transferred out of the appropriate group.

[1]The figures presented have been rounded to the nearest 1000 lbs. since more precise management of forage is not realistic in a ranch situation.

When summer stocker activities are removed, returns as measured by OBJ1 fall to $50,481. Subtracting other costs yields a net return to land, management and risk of $22,921 (Table XX).

The removal of summer steer activities causes a pronounced shift in pasture activities. Native range use is almost equally divided between NATR-CG and NATR-SG. The SOSUD-GO activity disappears, with the land being used for WHT-GO and SOSUD-GO. These activities provide the high-quality winter and early spring forage needed by the livestock. The two steer activities, FSTRS863 and FSTRS894 are both increased, with the major change in numbers being the increase of FSTRS863 to 405 head.

The pasture calendar for this organization is given in Table XXVI. There is some stockpiling of forage for later use, as indicated by the transfer activities. No excess forage is produced, and steers are not fed protein supplement in August-September.

This organization requires only 24 hours of hired labor in October-November. Unused operator labor has fallen to 428 hours total, mostly in April-July. Capital requirements increase slightly, again because of higher amounts of operating capital required by fall steers. Machine use levels change only slightly.

Fall Stockers ≤ 250

The next organizational alternative modeled was diversified to include cow-calf activities with the fall stocker activities. Fall stockers were limited to approximately half the number contained in the previous organization. This organization reflects a combination of activities frequently observed in the production area.

## TABLE XXVI

## PASTURE CALENDAR: FORAGE PRODUCTION AND UTILIZATION SSTEERS = 0

| | Pasture DM Production | | | Transfer | | Pasture DM Utilization | | |
|---|---|---|---|---|---|---|---|---|
| | Total (cwt. DM) | Activity (cwt. DM) | | (cwt. DM) | Source | Total (cwt. DM) | Activity (cwt. DM) | |
| April-May | | | | | | | | |
| 2.6 | 3710 | NATR-CG | 1140 | -550* | | 3160 | FSTRS863 | 2870 |
| | | NATR-SG | 1500 | | | | FSTRS894 | 290 |
| | | WHT-GO | 550 | | | | | |
| | | WHTSD-GO | 520 | | | | | |
| 2.2 | 1080 | LOVEG-RG | 1080 | 450 | A-MPS2.6 | 1530 | FSTRS863 | 750 |
| | | | | | | | FSTRS894 | 780 |
| 1.8 | 360 | NATR-CG | 360 | -360 | | | | |
| June-July | | | | | | | | |
| 2.6 | 3760 | NATR-CG | 2160 | -2120 | | 1640 | FSTRS863 | 1640 |
| | | NATR-SG | 1600 | | | | | |
| 2.2 | 3430 | NATR-SG | 1100 | 520 | A-MPS2.6<br>J-JPS2.6 | 3950 | FSTRS863 | 2710 |
| | | LOVEG-RG | 2330 | | | | FSTRS894 | 1240 |
| August-September | | | | | | | | |
| 2.6 | 500 | WHTSD-GO | 500 | | | 500 | FSTRS894 | 500 |
| 2.2 | 5130 | NATR-CG | 1430 | -1390 | | 3740 | FSTRS863 | 3290 |
| | | NATR-SG | 2580 | | | | FSTRS894 | 450 |
| | | LOVEG-RG | 1120 | | | | | |
| October-November | | | | | | | | |
| 2.6 | 130 | WHT-GO | 130 | -30 | | 100 | FSTRS894 | 100 |
| 2.2 | 140 | NATR-CG | 140 | 460 | J-JPS2.6 | 600 | FSTRS863 | 400 |
| | | | | | | | FSTRS894 | 200 |
| 1.8 | 580 | NATR-CG | 580 | 1110 | J-JPS2.6 | 1690 | FSTRS863 | 1430 |
| | | | | | A-SPS2.2 | | FSTRS894 | 260 |
| December-March | | | | | | | | |
| 2.6 | 810 | WHT-GO | 670 | 30 | O-NPS2.6 | 840 | FSTRS863 | 360 |
| | | WHTSD-GO | 140 | | | | FSTRS894 | 480 |
| 1.8 | 3060 | NATR-CG | 1800 | 1880 | A-SPS2.2 | 4940 | FSTRS863 | 3980 |
| | | LOVEG-RG | 1260 | | A-MPS1.8 | | FSTRS894 | 960 |

*Negative sign denotes forage transferred out of the appropriate group.

[1]The figures presented have been rounded to the nearest 1000 lbs. since more precise management of forage is not realistic in a ranch situation.

In this organization, net returns are reduced to $35,797 as measured by OBJ1. Net returns to land, management and risk fall to $8,207 (Table XX). This represents a marked decrease in returns compared to returns with steer organizations.

The cow-calf activity entering the organization is FCC-675. This is a very management intensive activity, requiring fall-calving and the use of wheat pasture to creep calves and supply the protein requirements of the cows. FSTRS863 and FSTRS894 remain in the solution, with the emphasis on FSTRS894. The entire organization thus requires a high level of livestock management.

Forage production activities have shifted to NATR-CG for the native rangelands, and LOVEG-RG and WHT-GO for cropland. Sudan for hay (SOSUD-HY) enters the solution to provide the hay required by the cows. The increase in NATR-CG helps meet the more consistent monthly forage demands of this organization. The pasture calendar for this organization is presented in Table XXVII. The management intensity of the organization is reflected by the increase in forage transfers. Many of these indicate quality substitutes within time periods. For example, of the 4500 cwt. of Pasture DM 2.6 produced in April-May, only 960 cwt. is consumed as Pasture DM 2.6. The remaining 3540 cwt. is consumed by activities requiring only Pasture DM 2.2. Also, approximately 340 cwt. of excess Pasture DM 2.6 is produced in December-March. Management could stockpile this, or graze it in place of Pasture DM 1.8 in this time period.

The cow-calf activities cause a shift in labor requirements. Ninety-four hours of hired labor are required in August-September, while unused operator labor decreases to 319 total hours. Total capital requirements decrease and shift from operating capital to livestock

TABLE XXVII

PASTURE CALENDAR: FORAGE PRODUCTION AND UTILIZATION FSTEERS ≤ 250

| | Pasture DM Production | | | Transfer | | Pasture DM Utilization | | |
|---|---|---|---|---|---|---|---|---|
| | Total (cwt. DM) | Activity (cwt. DM)[1] | | (cwt. DM) | Source | Total (cwt. DM) | Activity (cwt. DM) | |
| **April-May** | | | | | | | | |
| 2.6 | 4500 | NATR-CG | 1910 | -3540* | | 960 | FSTRS863 | 510 |
| | | NATR-SG | 470 | | | | FSTRS894 | 450 |
| | | WHT-GO | 1300 | | | | | |
| | | WHTSD-GO | 820 | | | | | |
| 2.2 | | | | 3540 | A-MPS2.6 | 3540 | FCC675 | 2190 |
| | | | | | | | FSTRS863 | 130 |
| | | | | | | | FSTRS894 | 1220 |
| 1.8 | 600 | NATR-CG | 600 | -600 | | | | |
| **June-July** | | | | | | | | |
| 2.6 | 4240 | NATR-CG | 3610 | -3950 | | 290 | FSTRS863 | 290 |
| | | NATR-SG | 630 | | | | | |
| 2.2 | 430 | NATR-SG | 430 | 1980 | J-JPS2.2 | 2410 | FSTRS863 | 480 |
| | | | | | | | FSTRS894 | 1930 |
| 1.8 | | | | 1130 | J-JPS2.6 | 1130 | FCC675 | 1130 |
| **August-September** | | | | | | | | |
| 2.6 | 780 | WHTSD-GO | 780 | | | 780 | FSTRS894 | 780 |
| 2.2 | 3700 | NATR-CG | 2460 | -2140 | | 1560 | FCC675 | 280 |
| | | NATR-SG | 1000 | | | | FSTRS863 | 590 |
| | | SOSUD-HY | 240 | | | | FSTRS894 | 690 |
| 1.8 | | | | 940 | J-JPS2.6 | 940 | FCC675 | 940 |
| | | | | | A-SPS2.2 | | | |
| **October-November** | | | | | | | | |
| 2.6 | 340 | WHT-GO | 340 | | | 340 | FCC675 | 190 |
| | | | | | | | FSTRS894 | 150 |
| 2.2 | 240 | NATR-CG | 240 | 450 | A-SPS2.2 | 690 | FCC675 | 310 |
| | | | | | | | FSTRS863 | 70 |
| | | | | | | | FSTRS894 | 310 |
| 1.8 | 960 | NATR-CG | 960 | 620 | A-SPS2.2 | 1580 | FCC675 | 920 |
| | | | | | | | FSTRS863 | 260 |
| | | | | | | | FSTRS894 | 400 |
| **December-March** | | | | | | | | |
| 2.6 | 1940 | WHT-GO | 1720 | | | 1600 | FCC675 | 780 |
| | | WHTSD-GO | 220 | | | | FSTRS863 | 60 |
| | | | | | | | FSTRS894 | 760 |
| 1.8 | 2980 | NATR-CG | 2980 | 1570 | A-SPS2.2 | 4550 | FCC675 | 2340 |
| | | | | | A-MPS1.8 | | FSTRS863 | 710 |
| | | | | | | | FSTRS894 | 1500 |

*Negative sign denotes forage transferred out of the appropriate group.

[1]The figures presented have been rounded to the nearest 1000 lbs. since more precise management of forage is not realistic in a ranch situation.

capital, representative of the investment in the cow herd. The major change in machine use is the increase in tractor use. However, it is still much less than assumed in the machinery complement (Table I).

Fall Stockers = 0

This alternative was modeled to compare a strict cow-calf operation to the organizations containing various stocker activites. The net returns to this organization are much lower, only $19,605. The net returns to land, management, and risk are -$8,720 (Table XX).

WHT-GO is the major use of cropland, with SOSUD-HY also increasing to meet the needs of the cow-calf organization (FCC-675).

The pasture calendar for this organization is presented in Table XXVIII. The transfer of high quality forage to lower quality groups indicates an inefficient use of this forage. Again, an excess of Pasture DM 2.6 is produced in December-March.

Hired labor requirements increase to 355 total hours, while unused operator labor is at a low of 238 hours. Total capital requirements have been decrease to $135,600.

Summary

A comparison of net returns shows that the most profitable organizations are based on the stocker steer activities. Summer stockers are the most profitable, but other factors may limit their inclusion in most organizations. Cow-calf activities can be combined profitably with stockers, but a strictly cow-calf operation does not generate sufficient returns to pay for the activity costs budgeted. The profitability of the stocker activities coincides with practices observed in Northwest Oklahoma, where such organizations dominate.

# TABLE XXVIII

## PASTURE CALENDAR: FORAGE PRODUCTION AND UTILIZATION FSTEERS = 0

| | Pasture DM Production | | | Transfer | | Pasture DM Utilization | | |
|---|---|---|---|---|---|---|---|---|
| | Total (cwt. DM) | Activity (cwt. DM) | | (cwt. DM) | Source | Total (cwt. DM) | Activity (cwt. DM) | |
| April-May | | | | | | | | |
| 2.6 | 4430 | NATR-CG | 500 | -4430* | | | | |
| | | NATR-SG | 2260 | | | | | |
| | | WHT-GO | 1670 | | | | | |
| 2.2 | 220 | LOVEG-RG | 220 | 4430 | A-MPS2.6 | 4650 | FCC675 | 4650 |
| 1.8 | 170 | NATR-CG | 170 | -170 | | | | |
| June-July | | | | | | | | |
| 2.6 | 3440 | NATR-CG | 1050 | -3440 | | | | |
| | | NATR-SG | 2390 | | | | | |
| 2.2 | 2180 | NATR-SG | 1700 | -2180 | | | | |
| | | LOVEG-RG | 480 | | | | | |
| 1.8 | | | | 2400 | J-JPS2.6 | 2400 | FCC675 | 2400 |
| August-September | | | | | | | | |
| 2.2 | 5330 | NATR-CG | 700 | -4750 | | 600 | FCC675 | 600 |
| | | NATR-SG | 3870 | | | | | |
| | | LOVEG-RG | 240 | | | | | |
| | | SOSUD-HY | 540 | | | | | |
| 1.8 | | | | 2000 | A-SPS2.2 | 2000 | FCC675 | 2000 |
| October-November | | | | | | | | |
| 2.6 | 390 | WGT-GO | 390 | | | 390 | FCC675 | 390 |
| 2.2 | 70 | NATR-CG | 70 | 580 | J-JPS2.6 | 65 | FCC675 | 650 |
| 1.8 | 280 | NATR-CG | 280 | 1690 | J-JPS | 1970 | FCC675 | 1970 |
| December-March | | | | | | | | |
| 2.6 | 2020 | WHT-GO | 2020 | | | 1670 | FCC675 | 1670 |
| 1.8 | 1130 | NATR-CG | 870 | 3870 | A-SPS2.2 | 5000 | FCC675 | 5000 |
| | | LOVEG-RG | 260 | | A-MPS1.8 | | | |

*Negative sign denotes forage transferred out of the appropriate group.

[1]The figures presented have been rounded to the nearest 1000 lbs. since more precise management of forage is not realistic in a ranch situation.

The pasture activities shift as varying limitations are placed on the organization. Such shifts are based on the changing forage requirements of the altered organization. The higher gaining steer activities are those present in the organizations, indicating that high total weight gains are necessary for the steer activities to be most profitable. Supplemental protein is required in the late summer months to produce these high gains in summer stocker activities.

The pasture calendars indicate that steers require and consume high quality forage as it is produced, while cow-calf activities can allow an organization to stockpile and use lower-quality forage. If a disastrous forage production period is encountered, it can have a severe affect on the steer organizations.

Operator labor is more fully utilized as longer-term livestock activities enter the solution. Conversely, returns to land, management, and risk decrease at the same time. The level of management and risk associated with each solution may vary in reality, but is not specifically examined in this study.

Machine use indicates that the base assumptions concerning the use of tractor and implements will not be met. Subtracting the ownership costs from OBJ1 (Table XX) will more accurately reflect actual returns than the use of OBJ2. However, maximizing the different objective functions yields the same organization.

In each solution, shadow prices indicate relatively stable organizations. Native rangeland use is the most sensitive to price changes, revealing the need for management capable of altering the pattern of use within different solutions (Table XXIII).

The MVP figures suggest that high-quality forage is most profitably used by steers, and that the value of cropland is tied to its capability of producing these forages. When organizations contain cows, the MVP of Pasture DM 2.2 and cropland drastically decreases (Table XXIV).

## The Effects of Changes in Livestock Prices

The ranch operator is confronted with varying prices and price relationships. How to change or adjust as these relationships vary is a matter of concern. The model was used to examine the effect of these changes in livestock prices on the optimal ranch organization.

The three price vectors presented in Table VII were used to represent changing price conditions. The effects of changes in the base livestock prices to prices representing current price relationships and 1975 price relationships are shown in contrast to the base solution in Table XXIX.

### Current Prices

Changing livestock prices to represent current price relationships increased the net returns as measured by OBJ1 from \$69,223 to \$81,281. Net returns to land, management and risk increased from \$41,633 to \$53,712 (Table XXX).

Summer stockers continued to dominate the solution, but the overall mix of activities shifted somewhat. SSTRS805 decreased from 665 to 564 head, SSTRS815 increased from 58 to 136 head, and SSTRS760 entered the solution with 29 head. The fall stocker activity in the solution, FSTRS854, replaced FSTRS894.

## TABLE XXIX

## THE EFFECTS OF CHANGES IN LIVESTOCK PRICES ON OPTIMAL RANCH ORGANIZATIONS

| Item | Unit | Current Price Vector | Base Price Vector | 1975 Price Vector |
|---|---|---|---|---|
| OBJ1 | dol. | 81,281 | 69,223 | 60,065 |
| Hired Labor | | | | |
| April-May | hrs. | 51 | 47 | -166 |
| June-July | hrs. | 39 | 26 | -205 |
| August-September | hrs. | 222 | 222 | -57 |
| October-November | hrs. | -337 | -364 | -69 |
| December-March | hrs. | -696 | -740 | -212 |
| Capital Requirements | dol. | 149,661 | 145,296 | 148,050 |
| Operating Capital | dol. | 95,634 | 92,092 | 97,862 |
| Livestock Capital | dol. | 3,018 | 2,938 | 1,635 |
| Machinery Capital | dol. | 44,674 | 44,625 | 46,550 |
| Equipment Capital | dol. | 3,753 | 3,601 | 2,003 |
| Pasture Establishment Capital | dol. | 2,582 | 2,040 | - |
| Pasture | | | | |
| NATR-CG | acres | - | - | 2,006 |
| NATR-DG | acres | - | - | - |
| NATR-DG | acres | 2,960 | 2,960 | 954 |
| LOVEG-RG | acres | 109 | 186 | - |
| WHT-GO | acres | - | 35 | 106 |
| WHTSD-GO | acres | 22 | - | 92 |
| SOSUD-GO | acres | 109 | 119 | 42 |
| Livestock | | | | |
| FSTRS854 | hd. | 110 | - | - |
| FSTRS894 | hd. | - | 94 | 286 |
| FSTRS936 | hd. | - | - | 186 |
| SSTRS805 | hd. | 564 | 665 | - |
| SSTRS815 | hd. | 136 | 58 | - |
| SSTRS760 | hd. | 29 | - | - |
| Machine Use | | | | |
| Pickup | hrs. | 931 | 894 | 882 |
| Tractor | hrs. | 90 | 94 | 139 |
| Excess Forage | | | | |
| D-MPS 2.6 | lbs. | 6,500 | 850 | 30,100 |
| D-MPS 1.8 | lbs. | - | 12,300 | - |
| MVP | | | | |
| Cropland | dol. | 106.73 | 86.46 | 125.33 |
| Native | dol. | 17.13 | 14.70 | 10.13 |
| A-MPS 2.6 | dol. | 8.49 | 6.71 | 4.54 |
| O-NPS 2.6 | dol. | 21.18 | 21.33 | 46.47 |
| A-SPS 2.6 | dol. | 1.61 | .50 | 7.42 |

TABLE XXX

NET RETURNS TO LAND, MANAGEMENT AND RISK UNDER DIFFERENT PRICE RELATIONSHIPS

| | Current Prices | Base Prices | 1975 Prices |
|---|---|---|---|
| Net Returns to Land, Operator Labor, Fixed Machinery and Equipment, Management and Risk | $81,281 | $69,223 | $60,065 |
| - Family Living Expenses | 13,750 | 13,750 | 13,750 |
| Net Returns to Land, Fixed Machinery and Equipment, Management and Risk | $67,731 | $55,473 | $46,315 |
| - Machinery and Equipment Ownership Costs | 11,670 | 11,670 | 11,670 |
| - Additional Interest | 2,148 | 2,170 | 2,136 |
| Net Returns to Land, Management and Risk | $53,713 | $41,633 | $32,509 |

With the removal of FSTRS894, WHT-GO disappears from the solution, LOVEG-RG increases from 86 to 107 acres, and WHTSD-GO enters the solution. These shifts in the forage production are caused by price changes which affect the relative profitability of livestock activities. The forage activities change as the forage requirements for the changed mix of livestock activities differs.

Hired labor requirements increase by 17 hours, and unused operator labor declines from 1104 to 1033 hours. Capital requirements increase slightly due to increased livestock numbers showing increased operating capital needs.

Some excess forage is produced as Pasture DM 2.6 in December-March, but it is reasonable to assume that this will be grazed in place of Pasture DM 1.8.

<u>1975 Prices</u>

The 1975 price relationship was chosen because it represents an extreme situation. The price relationship represented by these prices allows evaluation of the ranch organization in response to an adverse price situation. Using the 1975 prices in the model decreased net returns as measured by OBJ1 to $60,065, and yielded a net return to land, management, and risk of $32,509 (Table XXX).

This price change causes a drastic organizational change. Summer steers are not in the solution at all. FSTRS894 increases from 94 to 286 head, and 168 head of FSTRS939 enter the solution.

The forage activities shift to supply the altered requirements. NATR-SG falls to 954 acres, and 2006 acres of NATR-CG is now in the organization. LOVEG-RG is not in the solution with cropland being used for WHT-GO and WHTSD-GO as SOSUD-GO falls from 119 to 42 acres. These forage activities provide high-quality winter and late summer forages, necessary for the higher weight gains of the steer activities in the solution.

No hired labor is required by this solution. Unused operator labor decreases to 709 hours. However, the pattern of utilization is altered substantially due to the absence of summer steers. Capital requirements increase slightly as the livestock activities shift toward fall stockers.

There are 30,100 pounds of excess Pasture DM 2.6 produced in December-March. This would be utilized as previously discussed. The major change in machine use is the increase in tractor hours as all cropland is used for the production of annual forage crops.

## Summary

Stocker steers are the most profitable activity in each price situation. However, changing prices affected the mix of stocker activities which were most profitable. This can be seen by the fact that no stocker steer activity appears in all three situations, and only three of the activities appear in two situations. As illustrated by the 1975 situation, a price change may drastically alter the optimal organization.

The MVP of cropland remains high (Table XXIX), but particularly so in the 1975 situation when the high quality forage it produces is so vital to the heavy steer activities in October-November and August-September.

## Price Adjustments

The examination of these price changes suggested certain price adjustments could be justified in order that these prices reflect reality more accurately.

On an overall basis there may be problems in obtaining sufficient numbers of 500 pound stocker steers in late April or early May. The price paid for summer stockers was adjusted to reflect this problem. In the base price set, the price paid for 500 pound stocker steers was increased from $47.28 to $52.06 per hundredweight. The current price purchase price for these steers was increased from $61.08 to $66.00 per hundredweight. It is felt that these changes provide a more accurate picture of both ranch organization and profitability.

The 1975 price set seemed to produce inordinately high returns given the price situation. The reported price of 800-1000 pound steers tended to reflect prices for grain fed animals. The heavy steers produced on grass would not have realistically sold for as much as grain-fed animals. For this reason, the sale price of 800-1000 pound steers was reduced from $43.31 to $38.00. This change has no effect on ranch organization, but it is felt that it more accurately reflects the profitability of the organization in this situation.

These price changes are used in all succeeding uses of the model to examine ranch organization.

## The Effects of Changes in the Land Resource

McIlvain (27) has extensively documented the effects of the use of lovegrass and forage crops in combination with native rangelands on steer gains and stocking rates. This involves cropping some land in order to take advantage of these effects. The effects of adding cropland to native rangeland for complementary use may alter the base organization and the mix of activities. The model was used to examine the effects of varying amounts of cropland in the land resource on ranch organization, the mix of livestock and forage activities, and returns.

Three mixes of cropland and native rangeland were examined. They were:

| Mix | Cropland (acres) | Native Rangeland (acres) |
|---|---|---|
| I | 0 | 3200 |
| II | 240 | 2960 |
| III | 480 | 2720 |

Each of these resource mixes was examined under the base price set and varying organizational limitations. The three organizational limitations used were: 1) no limitations on livestock activities, 2) summer stocker activities excluded from the solution, and 3) all stocker activities excluded from the solution.

Returns, livestock and pasture activities, and labor and capital requirements for each situation are presented in Tables XXXI and XXXII. The results within each land resource mix are examined for the effects of organizational limitations. The different mixes will also be compared on the basis of returns, organization, and intensity of operation.

3200 Acres Native Rangeland

The returns to a ranch organization using only native rangeland are much less than when cropland is a part of the land resource unit

TABLE XXXI

NET RETURNS TO LAND, MANAGEMENT AND RISK FOR VARYING LAND RESOURCE MIXES UNDER DIFFERENT ORGANIZATIONAL LIMITATIONS FOR A 3200 ACRE RANCH IN NORTHWEST OKLAHOMA

| | Base[1] | | | Summer Stockers = 0[2] | | | All Stockers = 0[3] | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3200 Native | 240 Crop 2960 Native | 480 Crop 2720 Native | 3200 Native | 240 Crop 2960 Native | 480 Crop 2720 Native | 3200 Native | 240 Crop 2960 Native | 480 Crop 2720 Native |
| Net Returns to Land, Operator Labor, Fixed Machinery and Equipment, Management and Risk | $ 34,030 | $ 52,598 | $ 68,892 | $ 27,689 | $ 50,481 | $ 66,229 | $ 5,249 | $ 19,065 | $ 22,333 |
| - Family Living Expense | 13,750 | 13,750 | 13,750 | 13,750 | 13,750 | 13,750 | 13,750 | 13,750 | 13,750 |
| Net Returns to Land, Fixed Machinery and Equipment, Management and Risk | $ 20,280 | $ 38,848 | $ 55,142 | $ 13,939 | $ 36,731 | $ 52,479 | $-8,501 | $ -5,315 | $ 8,585 |
| - Machinery and Equipment Ownership Cost | 6,644[4] | 11,670 | 11,670 | 6,644[4] | 11,670 | 11,670 | 6,644[4] | 11,670 | 11,670 |
| - Additional Interest | -[5] | 2,217 | 1,026 | -[5] | 2,240 | 1,024 | -[5] | 2,365 | 1,279 |
| Net Returns to Land, Management and Risk | $ 13,636 | $ 24,961 | $ 42,446 | $ 7,295 | $ 22,821 | $ 39,785 | $-15,145 | $ -8,720 | $ -4,364 |

[1]The base solution for each land resource mix is derived by maximizing returns to OBJ1 with no limitations other than those imposed by the model.

[2]Summer stockers are removed from the solution due to risks associated with the activity.

[3]All stockers are excluded to evaluate a strictly cow-calf organization.

[4]The $6,644 Machinery and Equipment Ownership costs for the 3200 acres of native rangeland is caused by the removal of the tractor and farm implements from the Machinery Complement.

[5]No additional interest is charged because the model pays all interest costs.

TABLE XXXII

THE EFFECTS OF CHANGES IN THE LAND RESOURCE MIX ON RANCH RESOURCE REQUIREMENTS AND ORGANIZATION FOR A 3200 ACRE RANCH IN NORTHWEST OKLAHOMA

| | | Base[1] | | | Summer Stockers = 0[1] | | | Fall Stockers = 0[1] | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Item | Unit | 3200 Native | 240 Crop 2960 Native | 480 Crop 2720 Native | 3200 Native | 240 Crop 2960 Native | 480 Crop 2720 Native | 3200 Native | 240 Crop 2960 Native | 480 Crop 2720 Native |
| OBJ1 | dol. | 34,030 | 52,598 | 68,892 | 27,689 | 50,481 | 66,229 | 5,249 | 19,065 | 22,335 |
| Hired Labor | | | | | | | | | | |
| April-May | hrs. | -131 | -21 | 19 | -237 | -162 | -90 | -52 | -68 | 48 |
| June-July | hrs. | -121 | -34 | 31 | -301 | -183 | -65 | -193 | -121 | 18 |
| August-September | hrs. | 34 | 158 | 234 | -158 | -18 | 114 | -160 | 222 | 446 |
| October-November | hrs. | 444 | -248 | - | -148 | 24 | 196 | -129 | -49 | 110 |
| December-March | hrs. | -900 | -524 | -83 | -326 | -60 | 244 | 215 | 133 | 541 |
| Capital Requirements | | 93,154 | 149,348 | 203,239 | 102,448 | 153,727 | 207,787 | 117,574 | 135,596 | 115,616 |
| Operating Capital | dol. | 56,309 | 96,112 | 133,718 | 67,294 | 101,196 | 138,558 | 4,918 | 6,868 | 11,300 |
| Livestock Capital | dol. | 2,043 | 2,644 | 3,028 | 1,223 | 1,868 | 2,501 | 79,955 | 81,815 | 112,271 |
| Machinery Capital | dol. | 32,298 | 44,462 | 56,529 | 33,262 | 45,175 | 57,203 | 31,758 | 45,287 | 56,259 |
| Equipment Capital | dol. | 2,504 | 3,240 | 3,711 | 1,669 | 2,290 | 3,065 | 943 | 965 | 1,324 |
| Pasture Establishment Capital | dol. | - | 2,890 | 6,253 | - | 3,198 | 6,460 | - | 661 | 4,462 |
| Pasture | | | | | | | | | | |
| NATR-CG | acres | | 572 | 1,223 | 464 | 1,438 | 2,443 | 2,843 | 697 | 501 |
| NATR-DG | acres | - | - | - | - | - | - | 357 | - | - |
| NATR-SG | acres | 3,200 | 2,388 | 1,497 | 2,736 | 1,522 | 277 | - | 2,263 | 2,219 |
| LOVEG-RG | acres | - | 122 | 265 | - | 135 | 274 | - | 28 | 189 |
| WHT-CO | acres | - | 48 | 91 | - | 57 | 98 | - | 171 | 234 |
| WHTSD-GO | acres | - | - | 56 | - | 48 | 108 | - | - | - |
| SOSUD-GO | acres | - | 70 | 67 | - | - | - | - | - | - |
| SOSUD-HY | acres | - | - | - | - | - | - | - | 41 | 57 |
| Livestock | | | | | | | | | | |
| FSTRS854 | hd. | - | - | - | 340 | - | - | - | - | - |
| FSTRS863 | hd. | - | 117 | 250 | - | 405 | 437 | - | - | - |
| FSTRS894 | hd. | - | 111 | 241 | - | 114 | 260 | - | - | - |
| SSTRS865 | hd. | 537 | 506 | 350 | - | - | - | - | - | - |
| SCC-460 | hd. | - | - | - | - | - | - | 192 | - | - |
| FCC-675 | hd. | - | - | - | - | - | - | - | 196 | 269 |

[1]See footnotes 1-3 on Table XXXI.

(Table XXXI). When native rangelands are the only source of forage, the livestock organization is very specialized. SSTRS805 is the only summer stocker activity in the base solution. When summer stockers are excluded, only FSTRS854 is present. Further, when all stockers are excluded, only SCC-400 enters the solution.

Excess forage is produced by the model in the last two organizational limitations (Table XXXIII). When summer stockers are excluded, excess forage is produced in August-September, indicating the type of DP deficiency in the model as earlier discussed. In this case, the 55,500 pounds of excess forage indicate that an additional 7860 pounds of 41% Protein Supplement are required to meet protein needs. This further decreases returns. The excess forage produced in December-March simply has no economical use.

Labor requirements decrease when no cropland is involved. Only 34 hours of additional labor are required in the base solution, and 215 hours in the situation where all stocker activities are excluded. Unused operator labor is 1596 hours, 1170 hours, and 534 hours in the three situations.

Capital requirements are reduced since the tractor and farm implements are not necessary (Machinery Capital) and the relatively smaller livestock numbers reduce operating capital requirements. The $6644 for machinery and equipment ownership cost (Table XXXI) is due to the fact that tractor and farm implements are not included in the machinery complement when all of the land is native rangeland.

Stocker activities continue to be the most profitable. The model indicates that a strictly cow-calf operation on native range would be disastrous to returns.

TABLE XXXIII

EXCESS FORAGE PRODUCTION, MACHINE USE, AND MVP OF LAND AS THE LAND RESOURCE MIX CHANGES FOR A 3200 ACRE RANCH IN NORTHWEST OKLAHOMA

| | Base[1] | | | Summer Stockers = 0[1] | | | Fall Stockers = 0[1] | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3200 Native | 240 Crop 2960 Native | 480 Crop 2720 Native | 3200 Native | 240 Crop 2960 Native | 480 Crop 2720 Native | 3200 Native | 240 Crop 2960 Native | 480 Crop 2720 Native |
| **Excess Forage (lbs. DM)** | | | | | | | | | |
| D-MPS 2.6 | - | - | - | - | - | - | - | 34,800 | 47,700 |
| D-MPS 1.8 | - | - | - | - | - | - | 87,000 | - | - |
| A-SPS 2.2 | - | - | - | 55,500 | - | - | - | - | - |
| **Machine Use (hrs.)** | | | | | | | | | |
| Pickup | 566 | 950 | 1,314 | 705 | 1,033 | 1,376 | 454 | 786 | 1,065 |
| Tractor | - | 83 | 168 | - | 86 | 173 | - | 113 | 183 |
| **MVP** | | | | | | | | | |
| Cropland | | $ 81.95 | $ 75.94 | | $ 81.65 | $ 72.05 | | $ 19.36 | $ 12.38 |
| Native Pastureland | $ 10.12 | 10.57 | 9.94 | $ 8.69 | 9.88 | 9.21 | $ .61 | 3.20 | 2.39 |
| Pasture DM 2.6[2] | | | | | | | | | |
| A-MPS 2.6 | 2.76 | 4.27 | 4.51 | 5.19 | 5.98 | 5.38 | .53 | 2.96 | 2.60 |
| J-JPS 2.6 | 2.76 | 2.46 | 2.23 | 1.65 | 1.79 | 1.84 | .53 | .81 | .71 |
| A-SPS 2.6 | 1.16 | 1.08 | 1.68 | 3.56 | 2.14 | 3.52 | 1.19 | 1.47 | .71 |
| D-NPS 2.6 | 19.89 | 4.81 | 4.27 | 19.30 | 3.48 | 3.34 | - | 7.80 | 6.66 |
| D-MPS 2.6 | 19.89 | 4.81 | 4.27 | 19.30 | 3.48 | 3.34 | 14.49 | - | - |

[1]See footnotes 1-3 on Table XXXI.

[2]The MVP of Pasture DM 2.6 is a key factor in the MVP of cropland, which produces this high-quality forage.

240 Acres Cropland

This land resource mix is identical to that in the base solution. These situations have been previously discussed in detail. The only difference from the previous situations is the altered purchase price of 500 pound summer stockers. The effect on returns can be seen from Tables XX and XXXI. Net returns to land, management, and risk have fallen from $41,633 to $24,961.

The changes in organization can be seen from Tables XIX and XXXII. Summer stocker numbers have been reduced, and FSTRS863 is now present in the base solution. Forage activities have shifted to meet changing needs, with SOSUD-GO falling from 119 to 70 acres. Hired labor requirements have been reduced to 158 hours, and unused operator labor to 827 hours. Capital requirements have changed only slightly. When the organizational limitations are imposed with the changed price, no differences in solution occur.

480 Acres Cropland

The net returns to this land resource mix are consistently higher in all situations than for ranches with less cropland (Table XXXI).

Livestock numbers in this organization are consistently higher. There is a pronounced change in the base solution. Summer stockers are decreased and larger numbers of FSTRS894 and FSTRS863 are present (Table XXXII). When summer stockers are excluded from the solution, FSTRS863 shows a marked increase. Most of the cropland acres are used as LOVEG-RG, WHT-GO, and WHTSD-GO. There is some SOSUD-GO in the bawe solution. Native range use varies widely as the organization changes, similar to other resource situations.

Additional labor is required in each solution, ranging from 284 hours in the base solution to 1153 hours in the cow-calf situation. Increased capital requirements reflect increased livestock numbers and machinery needs.

Excess Pasture DM 2.6 is produced in December-March in the cow-calf situation. Such forage would be grazed in place of Pasture DM 1.8.

<u>Summary</u>

The net returns to land, management, and risk increased as the amount of cropland in the organization was increased (Table XXXI). The increase is much greater on a per acre basis as cropland is first added to the resource. The MVP of cropland also indicates that as cropland acreage increase, the increase in returns is less on a per acre basis (Table XXXIII).

High-quality forage has a consistently high MVP for stocker organizations, particularly in the fall and winter months. This is especially so when there is no cropland in the land resource of the ranch.

The inclusion of cropland in the land resource thus results in an increase in net returns, and an increase in the intensity of ranch operation. As cropland is added, management expertise must increase since more choices are possible, and the labor, capital, and livestock per acre of the ranch unit are higher.

The livestock activities change as cropland is added. The number of animals in the solution increases as the relative amounts of cropland change. The most profitable livestock activities are the higher gaining activities made possible by the high quality forage produced by cropland. However, in no case is a cow-calf operation the most profitable, as reflected by net returns to land, management and risk (Table XXXI).

Labor and capital requirements of the organization increase as cropland is added. This indicates that the intensity of the operation as measured by labor and capital per acre is increasing.

The MVP figures of cropland and forage are useful for decision making (Table XXXIII). When cropland is added to native pastureland the MVP of native pastureland increases. Thus, the addition of cropland allows native pastureland to be more efficiently used by the organization.

# CHAPTER IV

## AN ANALYSIS OF ALTERNATIVE ORGANIZATIONS UNDER SELECTED PRICE AND FORAGE YIELD CONDITIONS

The previous chapter examined the effects of various organizational limitations, changes in livestock prices, and changes in the land resource on the level of returns to the ranch and the most profitable mix of livestock and pasture activities. This approach allowed livestock and pasture activities to vary as situations change.

Many ranchers operate under an established set of organizational limitations in the short run. Some of these limitations are the result of managerial preference, such as a decision to have a certain number of cows. Other decisions, once made, do not allow for short run changes. For example, spring calving cows cannot easily be shifted to fall calving. Once lovegrass is established, it is for a long term. Land cannot be easily shifted in and out of such perennial forages.

These limitations will affect the responsiveness of the ranch unit to changes in prices or weather conditions, and the returns it receives in these circumstances. In this chapter, three possible organizational strategies are developed. Then, using the model, these organizations are examined to determine the effects of price and weather variations on the mix of activities which can be varied from year to year and the associated net returns.

## The Alternative Organizations

Several possible organizations were discussed and developed to model possible managerial decisions and limitations. Three organizations were chosen for examination.

### Organization I

The first organization is based upon the relative profitability of the stocker steer activities previously discussed. The base strategy of this organization is to allow no more than 200 summer stocker steers in the organization. This limitation on the summer stocker activities is related to possible problems encountered in obtaining the cattle, and to reducing the risk associated with a very specialized plan. Such a strategy also provides for use of operator labor throughout the year and represents a manager with a preference for running only stocker cattle.

### Organization II

The second organization is based on a managers decision to maintain a degree of diversification in the operation. In this case, the diversification is achieved by limiting the various types of livestock activities to pre-planned levels. This plan establishes a base cow herd of 100 head in the organization. It also specifies that at least 150 fall stockers be present, and that no more than 100 summer stockers will be included in the organization. This plan is representative of a diversified organization on the basis of pre-established levels of livestock activities.

Organization III

The third organization developed is also based on the idea of diversification. Diversification is achieved by imposing pre-established levels of the various pasture activities. Summer grazing of native rangeland (NATR-SG) is limited to no more than 1000 acres, while sorghum-sudan for grazeout is limited to no more than 40 acres. Imposing limits on these activities effectively constrains the possible numbers of summer stockers, while limiting the possible managerial difficulties associated with intensive summer forage use. Livestock diversification is achieved by requiring a base cow herd of 100 head in the organization. The managerial approach here is tied to managing forage production, and matching livestock activities to the various forage activities.

Organizational Fixities

Each of these base organizational strategies was examined by imposing the strategy limitations on the L. P. model and obtaining a base solution. Then, the pasture and livestock activities in the base solution which cannot be varied in the short-run were fixed in the organization. This resulted in specifying the acreage of lovegrass and number of cows at the levels in the respective base solutions. These activities were not permitted to vary as weather conditions and prices changed. Some slight modifications were made when necessary to ensure feasible solutions in all possible situations.

The stocker and crop activities which can be changed from year to year were allowed to vary as prices or pasture conditions changed. As a result, solutions described in the following sections represent a manager making all of the profitable adjustments possible with respect to livestock numbers and forage activities. Perfect knowledge of events for the year by the manager is assumed. The manager will correctly anticipate forage conditions and livestock prices and will alter livestock numbers and the mix of livestock and forage activities so as to maximize returns. For example, he will correctly anticipate a dry year, and buy less livestock. These adjustments are constrained in each case by the limits imposed by the organizational plan.

The specific limitations imposed on the different organizations are outlined in Table XXXIV. These base organizational strategies were then examined by introducing price and weather variation.

## Sources of Variation

The two major variations to which a ranch operation is subject are livestock prices and weather conditions. Any combination of the two can have potentially drastic effects on the operation. Changes in livestock prices are introduced using the three alternative livestock prices sets previously estimated and presented in Table VII. By substituting alternative prices for the base prices in the model, the response of the organization to these changes is observed. The prices paid for 500 pound summer stockers in the base price and current price sets, and the sale price of 800-1000 pound steers in the 1975 price set were modified as discussed in Chapter III.

Forage production can vary tremendously as weather conditions vary from season to season and year to year. Variations in weather conditions were introduced to the model by altering the forage production coefficients as originally included in the model. Two sets of alternative

TABLE XXXIV

ORGANIZATIONAL RESTRICTIONS USED IN THE FLEXIBILITY ANALYSIS

| Activity | Upper Limit | Lower Limit |
|---|---|---|
| Organization I[1] | | |
| LOVEG-RG | 160 acres | 160 acres |
| SSTEER#[2] | 200 head | -- |
| Organization II[3] | | |
| LOVEG-RG | 180 acres | 180 acres |
| SCC-460 | 50 head | 50 head |
| FCC-500 | 50 head | 50 head |
| SSTEER# | 100 head | -- |
| FSTEER#[4] | -- | 150 head |
| Organization III[5] | | |
| LOVEG-RG | 120 acres | 120 acres |
| NATR-SG | 1000 acres | -- |
| SOSUD-GO | 40 acres | -- |
| FCC-500 | 100 head | 100 head |

[1]Organization I represents a stocker steer operation with summer stockers limited to reduced risk.

[2]SSTEER# is the code for the nubmer of summer stocker steers in the model.

[3]Organization II represents a diversified cow-calf and stocker steer operation where diversification is achieved by limiting livestock numbers.

[4]FSTEER# is the code for the number of fall stocker steers in the model.

[5]Organization III represents a diversified cow-calf and stocker steer operation where diversification is achieved by limiting the acreage of forage activities.

forage production coefficients were derived to represent Low Forage Yields and High Forage Yields. The changes in forage yields were based upon recorded research data for the forage activities involved from the USDA-SGPRS of Woodward and other sources (26) (34) (35). The two alternative sets of forage yield coefficients are presented in Table XXXV. These alternative yields and the base or normal yields were used to provide three weather events for use in the flexibility analysis.

The alternative yields represent weather conditions which result in generally low, normal (average), or generally high forage yields for the entire grazing year. No alternative yields were estimated to represent situations where adverse or favorable weather conditions occurred in succession, such as favorable winter and spring moisture conditions followed by a dry summer.

## Response to Variation

The three organizations were analyzed with all combinations of forage yields and livestock prices. This resulted in model solutions for each of the three organizations in nine possible situations. The net returns to land, operator labor, fixed machinery and equipment, management and risk for each situation are presented in Table XXXVI. Family living expenses, ownership costs of machinery and equipment, and interest costs not paid by the model were subtracted to derive net returns to land, management and risk. The optimal solution for each situation within each organization are discussed in the following sections.

TABLE XXXV

ESTIMATED FORAGE ACTIVITY YIELDS FOR LOW AND HIGH FORAGE YIELD YEARS

| | | NATR-CG | NATR-DG | NATR-SG | LOVEG-RG | LOVEG-HY | ALF-HAY | WHT-GO | WHTSD-GO | SOSUD-GO | SOSUD-HY | SOSUD-SIL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Low Forage Yields by Period | | | | | | | | | | |
| A-MPS 2.6 | cwt. | .50 | - | .75 | - | - | - | - | 3.00 | - | - | - |
| A-MPS 2.2 | cwt. | - | - | - | 6.80 | - | - | 6.50 | 4.00 | - | - | - |
| A-MPS 1.8 | cwt. | .20 | 1.00 | - | - | - | - | - | - | - | - | - |
| J-JPS 2.6 | cwt. | .50 | - | .50 | - | - | - | - | - | 10.00 | - | - |
| J-JPS 2.2 | cwt. | .75 | - | 1.25 | 12.75 | 5.50 | - | - | - | - | - | - |
| A-SPS 2.6 | cwt. | - | - | - | - | - | - | - | 7.00 | - | - | - |
| A-SPS 2.2 | cwt. | .25 | - | .50 | - | - | - | - | - | 18.00 | 8.60 | - |
| A-SPS 1.8 | cwt. | .30 | - | .50 | - | - | - | - | - | - | - | - |
| O-NPS 2.6 | cwt. | - | - | - | - | - | - | 1.50 | - | - | - | - |
| O-NPS 2.2 | cwt. | - | - | - | - | - | - | - | - | - | - | - |
| O-NPS 1.8 | cwt. | .30 | .85 | - | - | - | - | - | - | - | - | - |
| D-MPS 2.6 | cwt. | - | - | - | - | - | - | 8.00 | 2.60 | - | - | - |
| D-MPS 1.8 | cwt. | .70 | 1.65 | - | 5.95 | 5.95 | - | - | - | - | - | - |
| Hay 2.2 | tons | - | - | - | - | - | 1.75 | - | - | - | 1.25 | - |
| Hay 1.8 | tons | - | - | - | - | .70 | - | - | - | - | - | - |
| Silage | tons | - | - | - | - | - | - | - | - | - | - | 1.60 |
| A-MDP | cwt. | .08 | .03 | .10 | .68 | - | - | 1.43 | 1.54 | - | - | - |
| J-JDP | cwt. | .10 | - | .17 | 1.30 | .55 | - | - | - | 1.00 | - | - |
| A-SDP | cwt. | .04 | - | .07 | - | - | - | - | .70 | 1.10 | .47 | - |
| O-NDP | cwt. | .01 | .04 | - | - | - | - | .33 | - | - | - | - |
| D-MDP | cwt. | .03 | .04 | - | .44 | .44 | - | 1.76 | .57 | - | - | - |
| | | High Forage Yields by Period | | | | | | | | | | |
| A-MPS 2.6 | cwt. | 1.00 | - | 1.50 | - | - | - | 15.00 | 8.00 | - | - | - |
| A-MPS 2.2 | cwt. | - | - | - | 9.00 | - | - | - | - | - | - | - |
| A-MPS 1.8 | cwt. | .50 | 1.25 | - | - | - | - | - | - | - | - | - |
| J-JPS 2.6 | cwt. | 2.25 | - | 1.00 | - | - | - | - | - | 18.00 | - | - |
| J-JPS 2.2 | cwt. | - | - | 1.50 | 18.50 | 9.50 | - | - | - | - | - | - |
| A-SPS 2.6 | cwt. | .50 | - | - | - | - | - | - | 15.00 | 18.00 | - | - |
| A-SPS 2.2 | cwt. | 1.00 | - | 2.50 | 16.00 | 16.00 | - | - | - | 20.00 | 17.00 | - |
| A-SPS 1.8 | cwt. | - | - | - | - | - | - | - | - | - | - | - |
| O-NPS 2.6 | cwt. | - | - | - | - | - | - | 4.00 | - | - | - | - |
| O-NPS 2.2 | cwt. | .15 | .50 | - | - | - | - | - | - | - | - | - |
| O-NPS 1.8 | cwt. | .60 | 1.75 | - | - | - | - | - | - | - | - | - |
| D-MPS 2.6 | cwt. | - | - | - | - | - | - | 13.00 | 10.00 | - | - | - |
| D-MPS 1.8 | cwt. | 2.00 | 4.50 | - | 16.50 | 16.50 | - | - | - | - | - | - |
| Hay 2.2 | tons | - | - | - | - | - | 3.50 | - | - | - | - | 2.25 |
| Hay 1.8 | tons | - | - | - | - | .90 | - | - | - | - | - | - |
| Silage | tons | - | - | - | - | - | - | - | - | - | - | 3.20 |
| A-MDP | cwt. | .13 | .03 | .15 | .90 | - | - | 3.30 | 1.76 | - | - | - |
| J-JDP | cwt. | .18 | - | .25 | 1.85 | .95 | - | - | - | 1.80 | - | - |
| A-SDP | cwt. | .10 | - | .18 | 1.60 | 1.60 | - | - | 1.50 | 2.90 | .94 | - |
| O-NDP | cwt. | .03 | .09 | - | - | - | - | .88 | - | - | - | - |
| D-MDP | cwt. | .05 | .09 | - | 1.22 | 1.22 | - | 2.86 | 2.20 | - | - | - |

## TABLE XXXVI

## NET RETURNS TO ALTERNATIVE ORGANIZATIONS FOR SELECTED LIVESTOCK PRICE AND FORAGE YIELD CONDITIONS[1]

| | Organization I | | | Organization II | | | Organization III | | |
|---|---|---|---|---|---|---|---|---|---|
| | Current Prices | Base Prices | 1975 Prices | Current Prices | Base Prices | 1975 Prices | Current Prices | Base Prices | 1975 Prices |
| **Low Forage Yields:** | | | | | | | | | |
| Net Returns to Land, Operator Labor, Fixed Machinery and Equipment, Management and Risk | $ 48,739 | $ 29,838 | $ 22,745 | $ 32,189 | $ 17,158 | $ 7,035 | $ 35,004 | $ 18,404 | $ 7,680 |
| - $13,750 Family Living Expense | 34,989 | 16,088 | 8,995 | 18,439 | 5,408 | -6,715 | 23,254 | 6,654 | -6,070 |
| - $11,670 Ownership Costs and Additional Interest | -2,542 | -2,566 | -2,622 | -2,674 | -2,674 | -2,720 | -2,547 | -2,544 | -2,601 |
| Net Return to Land, Management and Risk | $ 20,777 | $ 1,852 | $ -5,297 | $ 4,095 | $ -8,936 | $-21,105 | $ 9,037 | $ -7,560 | $-20,341 |
| **Normal Forage Yields:** | | | | | | | | | |
| Net Returns to Land, Operator Labor, Fixed Machinery and Equipment, Management and Risk | $ 77,107 | $ 51,908 | $ 49,284 | $ 62,988 | $ 39,048 | $ 29,953 | $ 66,230 | $ 40,761 | $ 30,964 |
| - $13,750 Family Living Expense | 63,357 | 38,158 | 35,534 | 49,238 | 25,298 | 16,203 | 52,480 | 27,011 | 17,214 |
| - $11,670 Ownership Costs and Additional Interest | -2,188 | -2,251 | -2,443 | -2,320 | -2,326 | -2,435 | -2,199 | -2,215 | -2,286 |
| Net Return to Land, Management and Risk | $ 49,499 | $ 24,237 | $ 21,421 | $ 35,248 | $ 11,302 | $ 2,098 | $ 38,611 | $ 12,126 | $ 3,258 |
| **High Forage Yields:** | | | | | | | | | |
| Net Returns to Land, Operator Labor, Fixed Machinery and Equipment, Management and Risk | $113,469 | $ 78,435 | $ 79,247 | $ 98,341 | $ 64,088 | $ 58,791 | $102,335 | $ 66,842 | $ 65,468 |
| - $13,750 Family Living Expense | 99,719 | 64,695 | 65,497 | 84,591 | 50,338 | 45,041 | 88,585 | 53,092 | 51,718 |
| - $11,670 Ownership Costs and Additional Interest | -1,858 | -1,879 | -2,131 | -1,917 | -1,921 | -2,079 | -1,814 | -1,804 | -1,917 |
| Net Return to Land, Management and Risk | $ 86,191 | $ 51,136 | $ 51,696 | $ 71,004 | $ 36,747 | $ 31,292 | $ 75,101 | $ 39,618 | $ 53,131 |

[1]The respective organizational limitations, alternative forage yields and prices are presented in Tables XXXIV, XXXV, and XXXVII.

Organization I

Net returns to land, management and risk for Organization I range from -$5,297 in a low forage yield--1975 prices situation to $86,191 in a high forage yield--current prices situation. Returns are negative in only one instance. As forage yields increase, net returns also increase.

The pasture and livestock activities for Organization I in each situation are shown in Table XXXVII. The 160 acres of lovegrass are fixed in the organization. The cropland is basically used for WHT-GO and WHTSD-GO by this organization. The use of native rangeland varies widely, but the greatest variations are observed as forage conditions change. Price changes alter use very little.

There are only two situations in which the maximum number of summer steers are not present. Each of these situations involves the 1975 price set. The optimal mix of fall stocker activities varies as forage yields and prices change. For example, FSTRS863 is present in seven of the nine situations, but in numbers ranging from 58 to 328 head. FSTRS854 is present in six of the nine situations, but in numbers ranging from 15 to 563 head. FSTRS936 appear only in 1975 price situations, and FSTRS701 only when there are high forage yields. The overall tendency is for price changes to affect the mix of activities, and for forage yields to affect the level of the activities.

Forage utilization by this organization can be observed in the pasture calendar for the base solution in Table XXXVIII. This calendar is representative of forage use patterns for the organization, and is an example of how the model can be used to examine grazing patterns. For steer organizations, the forage tends to be consumed in the period

TABLE XXXVII

PASTURE AND LIVESTOCK ACTIVITIES IN VARIOUS PRICE AND FORAGE YIELD SITUATIONS: ORGANIZATION I[1]

| | | Low Forage Yields | | | Normal Forage Yields | | | High Forage Yields | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Unit | Current Prices | Base Prices | 1975 Prices | Current Prices | Base Prices | 1975 Prices | Current Prices | Base Prices | 1975 Prices |
| **Pasture** | | | | | | | | | | |
| NATR-CG | acres | | | 2239 | 1504 | 1542 | 1586 | 917 | 1070 | 1140 |
| NATR-DG | acres | | | | | | | | | |
| NATR-SG | acres | 2960 | 2960 | 721 | 1456 | 1418 | 1374 | 2043 | 1890 | 1820 |
| LOVEG-RG | acres | 160 | 160 | 160 | 160 | 160 | 160 | 160 | 160 | 160 |
| WHT-GO | acres | 15 | 38 | 38 | 5 | 44 | 37 | 80 | 80 | 52 |
| WHTSD-GO | acres | | 36 | 42 | 75 | 36 | 43 | | | 28 |
| SOSUD-GO | acres | 65 | 6 | | | | | | | |
| SOSUD-HY | | | | | | | | | | |
| **Livestock** | | | | | | | | | | |
| FSTRS701 | head | | | | | | | 29 | 15 | |
| FSTRS854 | head | 107 | | 139 | 97 | 15 | | | | |
| FSTRS863 | head | 161 | 188 | | 328 | 313 | | 563 | 498 | |
| FSTRS894 | head | | 56 | 70 | | 87 | 101 | 58 | 126 | 227 |
| FSTRS936 | head | | | 138 | | | 356 | | | 408 |
| SSTRS805 | head | 200 | 200 | 200 | 91 | 200 | | 172 | 200 | |
| SSTRS815 | head | | | | 109 | | | 28 | | |

[1]The restrictions placed on Organization I are presented in Table XXXIV.

## TABLE XXXVIII

## PASTURE CALENDAR FOR THE BASE SOLUTION: ORGANIZATION I[1]

| | Pasture DM Production | | | Transfer | Source | Pasture DM Utilization | | |
|---|---|---|---|---|---|---|---|---|
| | Total (cwt. DM) | Activity (cwt. DM) | | (cwt. DM) | | Total (cwt. DM) | Activity (cwt. DM) | |
| April-May | | | | | | | | |
| 2.6 | 3320 | NATR-CG | 1150 | | | 3320 | FSTRS854 | 30 |
| | | NATR-SG | 1340 | | | | FSTRS863 | 2220 |
| | | WHT-GO | 430 | | | | FSTRS894 | 220 |
| | | WHTSD-GO | 400 | | | | SSTRS805 | 850 |
| 2.2 | 1280 | LOVEG-RG | 1280 | | | 1280 | FSTRS854 | 100 |
| | | | | | | | FSTRS863 | 580 |
| | | | | | | | FSTRS894 | 600 |
| 1.8 | 390 | NATR-CG | 390 | -390* | | | | |
| June-July | | | | | | | | |
| 2.6 | 3800 | NATR-CG | 2310 | -2530 | | 1270 | FSTRS863 | 1270 |
| | | NATR-SG | 1490 | | | | | |
| 2.2 | 3760 | NATR-SG | 1060 | 1520 | J-JPS2.6 | 5280 | FSTRS854 | 160 |
| | | LOVEG-RG | 2700 | | | | FSTRS863 | 2100 |
| | | | | | | | FSTRS894 | 940 |
| | | | | | | | SSTRS805 | 2080 |
| August-September | | | | | | | | |
| 2.6 | 380 | WHTSD-GO | 380 | | | 380 | FSTRS894 | 380 |
| 2.2 | 5330 | NATR-CG | 1560 | -170 | | 5160 | FSTRS854 | 120 |
| | | NATR-SG | 2420 | | | | FSTRS863 | 2540 |
| | | LOVEG-RG | 1330 | | | | FSTRS894 | 340 |
| | | | | | | | SSTRS805 | 2160 |
| October-November | | | | | | | | |
| 2.6 | 100 | WHT-GO | 100 | -30 | | 70 | FSTRS894 | 70 |
| 2.2 | 150 | NATR-CG | 150 | 330 | J-JPS2.6 | 480 | FSTRS854 | 20 |
| | | | | | | | FSTRS863 | 310 |
| | | | | | | | FSTRS894 | 150 |
| 1.8 | 600 | NATR-CG | 600 | 760 | J-JPS2.6 | 1360 | FSTRS854 | 50 |
| | | | | | A-SPS2.2 | | FSTRS863 | 1110 |
| | | | | | | | FSTRS894 | 200 |
| December-March | | | | | | | | |
| 2.6 | 620 | WHT-GO | 520 | 30 | O-MPS2.6 | 650 | FSTRS894 | 650 |
| | | WHTSD-GO | 100 | | | | | |
| 1.8 | 3420 | NATR-CG | 1930 | -450 | A-SPS2.2 | 3870 | FSTRS854 | 150 |
| | | LOVEG-RG | 1490 | | A-MPS1.8 | | FSTRS863 | 3080 |
| | | | | | | | FSTRS894 | 640 |

*Negative sign denotes forage transferred out of the appropriate group.

[1] The figures presented have been rounded to the nearest 1000 lbs. since more precise management of forage is not realistic in a ranch situation.

TABLE XXXIX

LABOR REQUIREMENTS BY PERIOD FOR ALTERNATIVE ORGANIZATIONS IN VARIOUS PRICE AND FORAGE YIELD SITUATIONS

| | Organization I | | | Organization II | | | Organization III | | |
|---|---|---|---|---|---|---|---|---|---|
| | Current Prices | Base Prices | 1975 Prices | Current Prices | Base Prices | 1975 Prices | Current Prices | Base Prices | 1975 Prices |
| <u>Low Forage Yields</u> | | | | | | | | | |
| April-May | -144* | -189 | -240 | -127 | -127 | -144 | -89 | -95 | -160 |
| June-July | -196 | -192 | -262 | -196 | -196 | -216 | -151 | -161 | -237 |
| August-September | -56 | -62 | -159 | -25 | -25 | -67 | 128 | 116 | 15 |
| October-November | -209 | -219 | -168 | -111 | -111 | -140 | -186 | -165 | -101 |
| December-March | -442 | -488 | -345 | -50 | -50 | -67 | -254 | -216 | -70 |
| <u>Normal Forage Yields</u> | | | | | | | | | |
| April-May | -114 | -118 | -190 | -38 | -39 | -75 | 18 | 8 | -76 |
| June-July | -106 | -115 | -212 | -100 | -101 | -149 | -50 | -64 | -145 |
| August-September | 44 | 55 | -107 | 109 | 111 | 14 | 255 | 252 | 127 |
| October-November | -41 | -69 | -124 | 43 | 38 | -21 | -55 | -43 | 8 |
| December-March | -188 | -218 | -228 | 213 | 210 | 180 | -24 | | 140 |
| <u>High Forage Yields</u> | | | | | | | | | |
| April-May | -11 | -20 | -111 | 62 | 50 | 20 | 131 | 78 | 18 |
| June-July | -29 | -29 | -136 | -4 | -3 | -53 | 70 | 15 | -55 |
| August-September | 209 | 208 | 13 | 262 | 264 | 155 | 436 | 386 | 276 |
| October-November | 126 | 110 | 8 | 239 | 234 | 113 | 85 | 192 | 165 |
| December-March | 144 | 120 | 38 | 567 | 561 | 460 | 222 | 424 | 459 |

*Negative sign denotes excess operator labor.

produced, with very little stockpiling for later use. Large amounts of excess forage tend to be produced in the extreme 1975 price situation (Table XLI). Where the model fails to provide adequate protein supplement in August-September, as in the high forage yield-base price situation, returns to the organization are adjusted to account for purchase of the necessary supplement as discussed in Chapter II.

Labor requirements for the organization vary most as forage yields change. No additional labor is required in low forage yield situations, with unused operator labor ranging from 1047 hours to 1174 hours. In high forage yield situations, from 59 to 429 hours of additional labor is required, with unused operator labor ranging from 40 to 247 hours. The labor requirements of the organization by time period are shown in Table XXXIX.

The capital requirements of the organization are presented in Table XL. They range from $118,370 to $201,274, with major differences observed as forage yields vary and only minor changes as prices vary.

## Organization II

The net returns to land, management, and risk for Organization II in each of the situations are presented in Table XXXVI. Net returns to land, management, and risk range from -$21,105 in a low forage yield--1975 price situation, to $71,004 in a high forage yield--current price situation. Losses occur in two situations, and returns of less than $10,000 in four of the nine situations.

The pasture and livestock activities for Organization II are presented in Table XLII. The pasture activities in the organization include a fixed 180 acres of LOVEG-RG. The remaining cropland acreage

TABLE XL

CAPITAL REQUIREMENTS FOR ALTERNATIVE ORGANIZATIONS FOR SELECTED PRICE AND FORAGE YIELD SITUATIONS

| | Organization I | | | Organization II | | | Organization III | | |
|---|---|---|---|---|---|---|---|---|---|
| | Current Prices | Base Prices | 1975 Prices | Current Prices | Base Prices | 1975 Prices | Current Prices | Base Prices | 1975 Prices |
| Low Forage Yields: Total Capital Required (dol.) | 123,125 | 118,370 | 123,211 | 128,271 | 128,271 | 129,535 | 123,706 | 124,565 | 128,013 |
| Operating Capital | 73,371 | 68,952 | 74,646 | 38,686 | 38,686 | 41,565 | 33,955 | 34,832 | 39,286 |
| Livestock Capital | 1,686 | 1,601 | 1,236 | 42,428 | 42,428 | 42,306 | 42,676 | 42,630 | 42,225 |
| Machinery Capital | 42,173 | 42,079 | 41,969 | 41,477 | 41,477 | 41,128 | 42,507 | 42,591 | 42,486 |
| Equipment Capital | 2,119 | 1,962 | 1,584 | 1,432 | 1,432 | 1,288 | 1,736 | 1,680 | 1,184 |
| Pasture Establishment Capital | 3,776 | 3,776 | 3,776 | 4,248 | 4,248 | 4,248 | 2,832 | 2,832 | 2,832 |
| Normal Forage Yields: Total Capital Required (dol.) | 156,913 | 154,501 | 154,179 | 167,872 | 167,441 | 171,965 | 160,853 | 161,460 | 167,801 |
| Operating Capital | 102,869 | 101,153 | 103,425 | 73,828 | 73,673 | 79,433 | 66,709 | 67,515 | 75,069 |
| Livestock Capital | 2,252 | 2,216 | 1,646 | 43,161 | 43,155 | 42,868 | 43,406 | 43,377 | 42,909 |
| Machinery Capital | 45,208 | 44,633 | 43,314 | 44,305 | 44,242 | 43,444 | 45,275 | 45,141 | 44,969 |
| Equipment Capital | 2,808 | 2,723 | 2,018 | 2,330 | 2,323 | 1,972 | 2,631 | 2,595 | 2,022 |
| Pasture Establishment Capital | 3,776 | 3,776 | 3,776 | 4,248 | 4,248 | 4,248 | 2,832 | 2,832 | 2,832 |
| High Forage Yields: Total Capital Required (dol.) | 201,274 | 199,651 | 194,316 | 215,742 | 215,587 | 220,322 | 205,548 | 211,392 | 216,195 |
| Operating Capital | 142,942 | 141,592 | 139,629 | 116,642 | 116,551 | 123,259 | 106,402 | 112,429 | 118,822 |
| Livestock Capital | 3,059 | 3,005 | 2,286 | 43,976 | 43,960 | 43,642 | 44,461 | 44,070 | 43,672 |
| Machinery Capital | 47,748 | 47,596 | 45,824 | 47,547 | 47,518 | 46,253 | 48,151 | 41,616 | 47,913 |
| Equipment Capital | 3,749 | 3,682 | 2,801 | 3,329 | 3,310 | 2,920 | 3,802 | 3,445 | 2,956 |
| Pasture Establishment Capital | 3,776 | 3,776 | 3,776 | 4,248 | 4,248 | 4,248 | 2,832 | 2,832 | 2,832 |

TABLE XLI

MACHINE USE AND EXCESS FORAGE PRODUCTION FOR ALTERNATIVE ORGANIZATIONS AND SELECTED PRICE AND FORAGE YIELD SITUATIONS

| | Organization I | | | Organization II | | | Organization III | | |
|---|---|---|---|---|---|---|---|---|---|
| | Current Prices | Base Prices | 1975 Prices | Current Prices | Base Prices | 1975 Prices | Current Prices | Base Prices | 1975 Prices |
| **Low Forage Yields:** | | | | | | | | | |
| <u>Excess Forage (lbs. DM)</u> | | | | | | | | | |
| A-SPS 2.2 | - | - | 29,000 | - | - | - | - | - | - |
| A-SPS 1.8 | - | - | 17,400 | - | - | - | 4,700 | - | - |
| D-MPS 2.6 | - | - | 12,700 | - | - | 6,800 | 8,200 | 6,000 | 13,600 |
| <u>Machine Use (hrs.)</u> | | | | | | | | | |
| Pickup | 739 | 691 | 671 | 682 | 682 | 627 | 706 | 718 | 691 |
| Tractor | 70 | 76 | 77 | 64 | 64 | 65 | 84 | 84 | 86 |
| **Normal Forage Yields:** | | | | | | | | | |
| <u>Excess Forage (lbs. DM)</u> | | | | | | | | | |
| J-JPS 2.2 | - | - | 180,400 | - | - | - | - | - | - |
| A-SPS 1.8 | - | 2,800 | - | - | - | - | - | - | - |
| D-MPS 2.6 | - | - | 13,700 | - | - | 8,350 | - | - | 16,700 |
| <u>Machine Use (hrs.)</u> | | | | | | | | | |
| Pickup | 1,040 | 1,021 | 835 | 1,037 | 1,035 | 915 | 1,041 | 1,049 | 995 |
| Tractor | 82 | 76 | 77 | 66 | 65 | 66 | 83 | 84 | 89 |
| **High Forage Yields:** | | | | | | | | | |
| <u>Excess Forage (lbs. DM)</u> | | | | | | | | | |
| J-JPS 2.2 | - | - | 324,600 | - | - | - | - | - | - |
| A-SPS 2.2 | - | 42,400 | - | - | - | - | 23,000 | 2,200 | - |
| A-SPS 1.8 | - | - | 23,500 | - | - | - | - | - | - |
| O-NPS 1.8 | - | - | - | - | - | 23,900 | - | - | - |
| D-MPS 2.6 | - | - | - | - | - | - | - | - | - |
| D-MPS 1.8 | - | - | - | - | - | - | 121,700 | - | - |
| <u>Machinery Use (hrs.)</u> | | | | | | | | | |
| Pickup | 1,451 | 1,451 | 1,172 | 1,468 | 1,465 | 1,289 | 1,435 | 1,501 | 1,400 |
| Tractor | 71 | 71 | 75 | 64 | 64 | 64 | 84 | 84 | 85 |

TABLE XLII

PASTURE AND LIVESTOCK ACTIVITIES IN VARIOUS PRICE AND FORAGE YIELD SITUATIONS: ORGANIZATION II[1]

| | | Low Forage Yields | | | Normal Forage Yields | | | High Forage Yields | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Unit | Current Prices | Base Prices | 1975 Prices | Current Prices | Base Prices | 1975 Prices | Current Prices | Base Prices | 1975 Prices |
| **Pasture** | | | | | | | | | | |
| NATR-CG | acres | | | 2949 | 2563 | 2538 | 2078 | 1428 | 1448 | 1201 |
| NATR-DG | acres | 1155 | 1155 | 11 | | | | | | |
| NATR-SG | acres | 1805 | 1805 | | 397 | 422 | 882 | 1532 | 1511 | 1759 |
| LOVEG-RG | acres | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 |
| WHT-GO | acres | 58 | 58 | 54 | 47 | 53 | 45 | 60 | 60 | 60 |
| WHTSD-GO | acres | | | 6 | 13 | 6 | 15 | | | |
| SOSUD-GO | acres | 2 | 2 | | | 1 | | | | |
| SOSUD-HY | acres | | | | | | | | | |
| **Livestock** | | | | | | | | | | |
| SCC460 | head | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| FCC500 | head | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| FSTRS701 | head | | | | | | | 7 | | |
| FSTRS854 | head | | | 10 | | | | | | |
| FSTRS863 | head | 150 | 150 | | 317 | 299 | | 537 | 509 | |
| FSTRS894 | head | | | 9 | | 16 | 36 | | 30 | 118 |
| FSTRS936 | head | | | 137 | | | 300 | | | 400 |
| FSTRS949 | head | | | | | | | | | 10 |
| SSTRS805 | head | 63 | 63 | 23 | 81 | 100 | | 2 | 18 | 23 |
| SSTRS815 | head | | | | 19 | | | 98 | 82 | |

[1]The restrictions placed on Organization II are presented in Table XXXIV.

is mainly utilized for WHT-GO, with some WHTSD-GO appearing in normal forage years. Changes in native rangeland usage are greatest between forage yield conditions within the forage yields assumed native rangeland use varies only slightly as prices change. The one exception is in the low forage yield--1975 price situation.

The 100 cows fixed in the organization are 50 head of FCC-500 and 50 head of SCC-460. Summer stocker steers appear in eight of the nine situations, ranging from 23 head to 100 head. In four of the eight they are at a level less than the 100 maximum allowed. In the low forage yield--1975 prices and high forage yield--1975 prices, the 23 SSTRS805 are held over from the FCC-500 activity.

The mix of fall stockers varies with both price and forage yield changes. Increasing forage yields tend to increase numbers of fall stockers. In the high forage yield situation, FSTRS854 replaced FSTRS863 in the base and current price organizations. The 1975 price set significantly alters the organization.

The pasture calendar for the base solution of Organization II is shown in Table XLIII. There is some stockpiling of forage from June-July (2270 cwt.) for use in other time periods with this organization. Steer activities still tend to consume the high quality forage as it is produced, although the FCC-500 activity requires some high-quality forage from November-March. Excess forage is produced by Organization II only in 1975 price situations (Table XLI). Amounts are relatively small, except in the high forage yield instance.

Additional labor is required by this organization in all except low forage yield situations. This ranges from 194 hours in the normal forage yield--1975 price instance to 1130 hours in the high forage

# TABLE XLIII

## PASTURE CALENDAR FOR THE BASE SOLUTION: ORGANIZATION II[1]

| | Pasture DM Production | | | Transfer | Source | Pasture DM Utilization | | |
|---|---|---|---|---|---|---|---|---|
| | Total (cwt. DM) | Activity (cwt. DM) | | (cwt. DM) | | Total (cwt. DM) | Activity (cwt. DM) | |
| April-May | | | | | | | | |
| 2.6 | 2960 | NATR-CG | 2030 | -380* | | 2580 | FSTRS863 | 2120 |
| | | NATR-SG | 420 | | | | FSTRS894 | 40 |
| | | WHT-GO | 440 | | | | FSTRS805 | 420 |
| | | WHTSD-GO | 70 | | | | | |
| 2.2 | 1440 | LOVEG-RG | 1440 | 180 | A-MPS2.6 | 1620 | FCC500 | 530 |
| | | | | | | | SCC460 | 430 |
| | | | | | | | FSTRS863 | 550 |
| | | | | | | | FSTRS894 | 110 |
| 1.8 | 630 | NATR-CG | 630 | | | 630 | FCC500 | 270 |
| | | | | | | | SCC460 | 360 |
| June-July | | | | | | | | |
| 2.6 | 4250 | NATR-CG | 3810 | -3040 | | 1210 | FSTRS863 | 1210 |
| | | NATR-SG | 440 | | | | | |
| 2.2 | 3160 | NATR-RG | 320 | 770 | A-MPS2.6 | 4130 | SCC460 | 920 |
| | | LOVEG-RG | 3040 | | J-JPS2.6 | | FSTRS863 | 2000 |
| | | | | | | | FSTRS894 | 170 |
| | | | | | | | SSTRS805 | 1040 |
| 1.8 | | | | 600 | J-JPS2.6 | 600 | FCC500 | 600 |
| August-September | | | | | | | | |
| 2.6 | 70 | WHTSD-GO | 60 | | | 70 | FSTRS894 | 70 |
| | | SOSUD-GO | 10 | | | | | |
| 2.2 | 4770 | NATR-CG | 2530 | -200 | | 4570 | SCC460 | 1000 |
| | | NATR-RG | 720 | | | | FSTRS863 | 2440 |
| | | LOVEG-RG | 1500 | | | | FSTRS894 | 60 |
| | | SOSUD-GO | 20 | | | | SSTRS805 | 1080 |
| 1.8 | | | | 660 | J-JPS2.6 | 660 | FCC500 | 660 |
| October-November | | | | | | | | |
| 2.6 | 120 | WHT-GO | 120 | -40 | | 80 | FCC500 | 70 |
| | | | | | | | FSTRS894 | 10 |
| 2.2 | 250 | NATR-CG | 250 | 60 | J-JPS2.6 | 310 | FSTRS863 | 300 |
| | | | | | | | FSTRS894 | 10 |
| 1.8 | 1020 | NATR-CG | 1020 | 1150 | J-JPS2.6 | 2170 | FCC500 | 610 |
| | | | | | | | SCC460 | 460 |
| | | | | | | | FSTRS863 | 1060 |
| | | | | | | | FSTRS894 | 90 |
| December-March | | | | | | | | |
| 2.6 | 650 | WHT-GO | 630 | 40 | J-JPS2.6 | 690 | FCC500 | 340 |
| | | WHTSD-GO | 20 | | | | FSTRS863 | 280 |
| | | | | | | | FSTRS894 | 70 |
| 1.8 | 4860 | NATR-CG | 3180 | 200 | A-SPS2.2 | 5060 | SCC460 | 1020 |
| | | LOVEG-RG | 1680 | | | | FCC500 | 1030 |
| | | | | | | | FSTRS863 | 2940 |
| | | | | | | | FSTRS | 70 |

*Negative sign denotes forage transferred out of the appropriate group.

[1]The figures presented have been rounded to the nearest 1000 lbs. since more precise management of forage is not realistic in a ranch situation.

yield--current price situation. Those situations requiring the most additional labor have the least amounts of unused operator labor. Unused operator labor varies from three to four hours in high forage yield situations to 634 hours in the low forage yield--1975 price situation. These requirements are shown in Table XXXIX.

Capital requirements are presented in Table XL. They range from $128,271 in low forage yield--base price situation to $220,322 in the high forage yield--1975 price situation. Differences are largely traceable to increasing livestock numbers as forage yields improve.

Organization III

The various net returns to Organization III in each situation are shown in Table XXXVI. Net returns to land, management, and risk range from -$20,341 in low forage yield--1975 price instance to $75,101 in the high forage yield--current price situation.

The pasture and livestock activities in the various situations for Organization III are presented in Table XLIV. This organization contains 120 acres of LOVEG-RG and 100 head of FCC-500 fixed in each situation. The cropland acreage remaining is used mostly as WGT-GO and SOSUD-GO. The 1975 price situation includes WHTSD-GO while SOSUD-GO disappears from the operation. Native rangeland utilization is relatively consistent, with large changes only in the 1975 price situation for low and normal forage yields.

Summer stocker activities are present in all solutions and occur at high levels with the exception of the 1975 price situations. The mix and level of the various fall stocker activities vary widely as forage yields and prices change. Such variations indicate that

TABLE XLIV

PASTURE AND LIVESTOCK ACTIVITIES IN VARIOUS PRICE AND FORAGE YIELD SITUATIONS: ORGANIZATION III[1]

| | Unit | Low Forage Yields | | | Normal Forage Yields | | | High Forage Yields | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Current Prices | Base Prices | 1975 Prices | Current Prices | Base Prices | 1975 Prices | Current Prices | Base Prices | 1975 Prices |
| **Pasture** | | | | | | | | | | |
| NATR-CG | acres | 1771 | 1636 | 2960 | 1960 | 2024 | 2854 | 1960 | 1960 | 2006 |
| NATR-DG | acres | 189 | 324 | | | | | | | |
| NATR-SG | acres | 1000 | 1000 | | 1000 | 936 | 106 | 1000 | 1000 | 954 |
| LOVEG-RG | acres | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 |
| WHT-GO | acres | 98 | 98 | 108 | 69 | 80 | 90 | 80 | 103 | 118 |
| WHTSD-GO | acres | | | 12 | | | 30 | | | 2 |
| SOSUD-GO | acres | 22 | 22 | | 40 | 40 | | 40 | 17 | |
| SOSUD-HY | acres | | | | 11 | | | | | |
| **Livestock** | | | | | | | | | | |
| SCC460 | head | | | | | | | | | |
| FCC500 | head | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| FSTRS701 | head | | | | | | | 13 | | |
| FSTRS863 | head | 22 | 46 | | 168 | 152 | | 312 | 331 | |
| FSTRS894 | head | | | 18 | | 32 | 71 | | 122 | 233 |
| FSTRS936 | head | | | 138 | | | 230 | | | 279 |
| SSTRS805 | head | 261 | 224 | 1 | 278 | 274 | | 192 | 113 | 46 |
| SSTRS815 | head | | | | 38 | 19 | 46 | 234 | 103 | |

[1]The restrictions placed on Organization III are presented in Table XXXIV.

exceptional management would be necessary to make the correct decisions in this organization as the situation varies.

The pasture calendar for the base solution of Organization III is shown in Table XLV. The transfers observed are much like those for Organization II, with forage being stockpiled for later use, and some higher quality forages being substituted for lower quality forages in the same time periods. This organization produces excess high-quality forage in various circumstances, but produces large amounts of excess Pasture DM 2.2 in August-September only in the high forage yield--current price situation (Table XLI). This is a specification problem with protein in the model and not of economic significance, apart from the expense of purchasing additional protein. Additional labor requirements (Table XXXIX) range from 15 hours to 1095 hours, while unused operator labor ranges from 680 hours to zero. Additional labor requirements are highest when unused operator labor is lowest.

Capital requirements (Table XL) range from $123,706 to $216,195. Changes within forage yield situations are slight compared to the differences observed as yields change. Most increased capital requirements are tied to high operating capital needs as livestock numbers increase.

## Comparisons of the Organizations

It is important in comparing organizations, to remember that the solution for each situation assumes the manager makes the correct decisions to attain the optimal mix of activities within the flexibility allowed in the organization. For example, this assumes that in a low forage yield situation, conditions are anticipated and the corrent number of steers are bought, and the grass is managed in the most profitable way.

# TABLE XLV

## PASTURE CALENDAR FOR THE BASE SOLUTION: ORGANIZATION III[1]

| Group | Pasture DM Production Total (cwt. DM) | Pasture DM Production Activity | (cwt. DM) | Transfer (cwt. DM) | Source | Pasture DM Utilization Total (cwt. DM) | Pasture DM Utilization Activity | (cwt. DM) |
|---|---|---|---|---|---|---|---|---|
| **April-May** | | | | | | | | |
| 2.6 | 1340 | NATR-CG | 1620 | -960* | | 2380 | FSTRS863 | 1070 |
| | | NATR-SG | 940 | | | | FSTRS894 | 80 |
| | | WHT-GO | 780 | | | | SSTRS805 | 1150 |
| | | | | | | | SSTRS815 | 80 |
| 2.2 | 960 | LOVEG-RG | 960 | 590 | A-MPS2.6 | 1550 | FCC500 | 1050 |
| | | | | | | | FSTRS863 | 270 |
| | | | | | | | FSTRS89% | 230 |
| 1.8 | 510 | NATR-CG | 510 | 30 | A-MPS2.6 | 540 | FCC500 | 540 |
| **June-July** | | | | | | | | |
| 2.6 | 4480 | NATR-CG | 3040 | -3840 | | 640 | FSTRS863 | 620 |
| | | NATR-SG | 980 | | | | SSTRS 20 | |
| | | SOSUD-GO | 560 | | | | | |
| 2.2 | 2730 | NATR-SG | 700 | 1620 | A-MPS2.6 | 4350 | FSTRS863 | 1010 |
| | | LOVEG-RG | 2030 | | J-JPS2.6 | | FSTRS894 | 340 |
| | | | | | | | SSTRS805 | 2830 |
| | | | | | | | SSTRS815 | 170 |
| 1.8 | | | | 1200 | J-JPS2.6 | 1200 | FCC500 | 1200 |
| **August-September** | | | | | | | | |
| 2.6 | 280 | SOSUD-GO | 280 | | | 280 | FSTRS894 | 140 |
| 2.2 | 5450 | NATR-CG | 2020 | -1090 | | 4320 | FSTRS863 | 1220 |
| | | NATR-SG | 1590 | | | | FSTRS894 | 130 |
| | | LOVEG-RG | 1000 | | | | SSTRS805 | 2940 |
| | | SOSUD-GO | 840 | | | | SSTRS815 | 70 |
| 1.8 | | | | 1310 | J-JPS2.6 | 1310 | FCC500 | 1310 |
| | | | | | A-SPS2.2 | | | |
| **October-November** | | | | | | | | |
| 2.6 | 200 | WHT-GO | 200 | -20 | | 180 | FCC500 | 150 |
| | | | | | | | FSTRS894 | 30 |
| 2.2 | 180 | NATR-CG | 180 | | | 180 | FSTRS863 | 150 |
| | | | | | | | FSTRS894 | 30 |
| 1.8 | 810 | NATR-CG | 810 | 1010 | J-JPS2.2 | 1820 | FCC500 | 1220 |
| | | | | | | | FSTRS863 | 530 |
| | | | | | | | FSTRS894 | 70 |
| **December-March** | | | | | | | | |
| 2.6 | 940 | WHT-GO | 940 | 20 | O-NPS2.2 | 960 | FCC500 | 680 |
| | | | | | | | FSTRS863 | 140 |
| | | | | | | | FSTRS894 | 140 |
| 1.8 | 3650 | NATR-CG | 2530 | 130 | A-SPS2.2 | 3780 | FCC500 | 2050 |
| | | LOVEG-RG | 1120 | | | | FSTRS863 | 1490 |
| | | | | | | | FSTRS894 | 240 |

*Negative sign denotes forage transferred out of the appropriate group.

[1]The figures presented have been rounded to the nearest 1000 lbs. since more precise management of forage is not realistic in a ranch situation.

## Returns

The net return figures for each organization in each situation are contained in Table XXXVI. In all situations Organization I yielded the highest returns, and Organization II the lowest. The combination of low forage yields and 1975 price relationships was particularly disasterous to the organizations (II and III) containing cows. Low forage yields resulted in much lower returns to all organizations, as did the combination of normal forage yields and 1975 prices for organizations I and II.

## Pasture and Livestock Activities

The activity mixes for the three organizations are presented in Tables XXXVII, XLII, XLIV.

Summer stockers remain sufficiently profitable to be present in most solutions within the limitations imposed by the particular organization. Only in the 1975 price situation were summer stockers not profitable. The two summer stocker activities present in the solutions, SSTRS805 and SSTRS815 differ only in the rate of gain for August-September (Table XIII). The use of one or the other is tied to the quality of forage available in August-September. As forage yields change, the mix of the summer and fall stocker activities is determined by which activity uses the August-September forage profitably. This interrelationship causes more variation in the mix of steer activities when cows are included in the organization. The exact nature of this relationship cannot be determined. The mixes of fall stocker activities for all organizations tend to contain the FSTRS863 and FSTRS894 activities. The FSTRS936 activity appears in the solution only when 1975 prices are used. The FSTRS854 activity is present almost exclusively in Organization I solutions. Though the mix and level of activities changes from solution to solution and organization to organization, increasing forage yields tends to increase livestock numbers without changing the mix of activities. Changes in price relationships tend to leave numbers relatively constant while changing the mix of the livestock activities.

Forage activities vary as the requirements of the livestock activities change. Changes in the use pattern of native rangeland occur largely in response to varying forage yields. Adverse prices (1975) may affect use in certain instances, such as with low forage yields in Organizations I, II, and III.

The lovegrass acreage provides large quantities of forage. The crop activities provide high-quality forage. Cropland acreage is usually occupied by WHT-GO and WHTSD-GO. SOSUD-GO, tied heavily to summer stocker activities, consistently enters the solution in only Organization III.

The cow-calf activities in an organization necessitate forage stockpiling due to the consistent levels of forage requirements by period which they impose on the operation. Steers dominate in profitability partially due to the fact that steer gains can be effectively matched to forage growth and nutritional characteristics in an efficient manner. Pasture calendars indicate that the steers in an organization consume high-quality forage as produced, while cows require lower-quality forages, which allows for stockpiling. Excess forage figures (Table XLI) indicate that both low and high forage yields present particular management problems. These problems are particularly significant in Organization I. In Organization I the emphasis on stocker steers can cause difficulty in matching steer numbers to varying forage yields, since steer gain patterns and numbers are so closely tied to forage yields. The steers can be managed for low average daily weight gains when forage quality is low and are capable of converting high-quality forage into beef at high rates of gain per day when such forage is being produced. This represents a more profitable conversion of forage to beef in these situations than the cow-calf requirements for lower quality forage at a consistent rate. Cows simply do not require large amounts of high quality forage, even for raising heavy calves. Cows do exert a stabilizing influence on forage management by requiring consistent amounts of forage. However, this type of influence is not shown to be profitable by the analysis. Cows cannot use the high-quality forage produced in any time period as profitably as the various stocker steer activities.

Pickup use is simply tied to livestock numbers. As numbers increase, so do pickup hours. Tractor use varies only slightly between situations. It is more closely tied to the acreage farmed (Table XLI). Neither of these is an important factor as regards organizational comparisons.

## Labor Requirements

The steer activities are much less labor intensive than the cow-calf activities. Thus, Organization I requires much less operator and additional labor than Organizations II and III. Since labor requirements are tied to livestock numbers, changes in forage yields or prices which affect livestock numbers the most also affect labor requirements the most.

Capital Requirements

Organization I requires less capital in each situation then Organizations II and III. It does use relatively large amounts of operating capital, while Organizations II and III use more livestock capital. Thus, the capital needs of Organization I tend to be short term.

Capital requirements increase as livestock numbers increase. Price changes affect capital needs only slightly compared to changes in forage production.

Summary

The all steer operation (Organization I) yields higher returns with less labor and capital requirements than the other organizations in this analysis.

Adding cows to an operation (Organizations II and III) levels out forage requirements between time periods, but yields lower returns with higher labor and capital requirements than Organization I.

As previously explained, the returns, requirements, and organizations represented in this analysis reflect a manager who has anticipated the situation correctly, and reacted properly to maximize returns. Stocker steer activities are consistently the most profitable means of using the forage in a ranch situation. The level of returns for Organizations II and III illustrate the effects on returns of including cows in the organization. It would be folly for any ranch operation in this production area to not include stockers in its operation.

The particular steer and cow-calf activities appearing in the various solutions are those which are managed to use high-quality forages to obtain high rates of gain. The most prominent steer activities, SSTRS805, SSTRS815, FSTRS863, FSTRS894, and FSTRS936 use high-quality forages as produced to maintain high rates of gain, resulting in high total weight gains. The two cow-calf activities considered are somewhat unrelated in the aspect of profitability. The SCC-460 activity produces heavy calves for sale, while the FCC-500 activity becomes profitable as it produces steers for the high-gain summer stocker activities. The profitability of producing steers for the summer stocker activities instead of buying them overcomes the adverse effects of the 1975 price situation and results in summer stockers being present in solutions where they do not generally occur.

The least profitable operation (Organization II) resulted when livestock numbers were fixed for all general activities. A manager who locks in his options in this way, limits his returns.

The major effect of price changes is a change in the optimal mix of activities. Price changes tend to shift the levels of the major steer activities in relationship to one another rather than adding different activities.

The major effects of low and high forage yields are to decrease and increase livestock numbers, respectively. The optimal mix of activities is affected very little by a change in the amount of forage produced. Differences in the level of management required by and the degree of risk involved in each of the alternative organizations have not been estimated.

## CHAPTER V

## SUMMARY AND CONCLUSIONS

Ranchers who utilize large amounts of native rangeland in their operation are concerned with how to adjust to changes in prices and weather conditions. They want to know how to organize their operations to allow them to react to such changes while maintaining returns, which livestock activities are the most profitable, and how to use available cropland to their advantage. What is the most profitable was to use native rangeland? What can be done to give a ranch organization the flexibility to respond to changing situations?

A linear programming model can be used to examine questions such as these. To be reliable, such a model must be constructed to accurately depict resource availability, costs, machinery and equipment needs, prices and technical coefficients. A reliable method must also be chosen to measure and coordinate forage production and the nutritional requirements of livestock in a ranch situation.

This study derived such a model and used it to examine questions asked by ranchers. The study sought to answer questions concerning the most profitable mix of livestock and pasture forage activities for a 3200 acre ranch in Northwest Oklahoma. The model was used to estimate the effects of changes in prices and weather conditions on ranch organization and the response of different organizational plans to these changes.

The objective function, OBJ1, maximized net returns to land, operator labor, management, fixed machinery and equipment and risk for the ranch organization. Data reflecting machinery and equipment ownership costs and family living expenses were used to examine the adequacy of net returns to land, management and risk. The Oklahoma State University Budget Generator was used to derive and estimate technical coefficients and machinery and equipment costs for a 3200 acre ranch in Northwest Oklahoma.

Forage production and livestock requirements were measured using an energy density concept. Pasture forage production and livestock forage requirements were estimated in pounds of dry matter for three forage quality levels on a monthly basis. These coefficients were incorporated into five time periods based on the changes in energy density of forage during the grazing season. These time periods were used in the L. P. model to allocate forage to the most profitable livestock activities.

Assumptions utilized in constructing the model included 1) a 3200 acre ranch with 240 acres of cropland and 2960 acres of native pastureland used as the base unit, 2) a 9.5% interest charge for operating, machinery, equipment livestock and pasture improvement capital utilized within the model, 3) 2750 hours of available operator labor, 4) additional labor can be hired as needed, and 5) the only product sold is in the form of beef cattle.

Buy activities were included in the model for selected inputs, and activities were included for selling the production. Prices can be varied to examine organization changes in response to price fluctuations. The base prices assumed in the model were derived from current price estimates published for use with the Budget Generator. Livestock prices were adjusted to reflect differences in age, weight, and sex. Accounting rows were constructed to account for forage production and utilization by the activities in the model.

## Base Solution

The optimal ranch organization was derived for the base unit by means of the L. P. model. The base organization used the 2,960 acres of native pastureland for summer grazing, and the 240 acres of cropland for 86 acres of lovegrass grazed rotationally, 35 acres of wheat for grazeout, and 119 acres of hybrid sorghum-sudan for grazeout. The livestock activities included 723 summer stocker steers, 665 head of SSTRS805, and 58 head of SSTRS815. These two steer activities differ in the rates of gain during August-September. Ninety-four head of FSTRS894 were included, using limit grazing of winter wheat pasture to meet winter protein needs.

The base organization derived allows the forage produced to be converted into high rates of daily gain by the steer activities. The operation is specialized in production of summer stocker steers. Problems exist with this type of plan in forage management and the risks associated with such specialization, as well as availability of the number of steers required in late April and early May.

## Model Applications

The effects of selected organizational limitations which reflect various managerial preferences on the optimal mix of livestock and pasture forage activities were analyzed. Limiting stocker steer activities and adding cows to the organization resulted in lower returns to land, management and risk, especially when stocker steer activities were excluded from the organization.

Changes in livestock prices altered the optimal mix of livestock and pasture forage activities. The adverse price relationship represented by 1975 livestock prices caused a substantial shift in the mix of activities. Heavy fall stocker steers replaced summer stocker steers as the most profitable livestock activity, and sorghum-sudan for graze-out did not appear in the solution. Cropland was used to produce high-quality forage in the winter months to support higher winter weight gains for the livestock activities.

As the amount of cropland in the land resource was varied, both livestock numbers and the optimal mix of activities varied (Table XXXXII). As cropland acreage was increased, the ranch contained more livestock, and required larger amounts of labor and capital on a per acre basis. Returns to land, management, and risk increased as cropland was added. Indeed, when cropland was first added to native rangeland, the value of an additional acre of rangeland (MVP) increased, indicating a complementary relationship between forage crops and native rangelands.

## Flexibility

The flexibility of organization was examined by comparing the solutions derived from nine livestock price and forage yield conditions for each of three organizational plans. The solutions indicate the mix of pasture forage and livestock activities which will maximize returns under the price and forage yield conditions examined.

The stocker activities are consistently the most profitable livestock activities in all organizations and all situations examined. The tendency is for the level of the livestock activities to change as forage conditions change, and for the mix of activities to change as prices change. Of the cow activities in Organizations II and III, the most profitable (FCC500) is the activity capable of producing steer calves for the profitable summer stocker activities.

Summer stocker activities are profitable, but create problems for a manager desiring to achieve organizational flexibility. The profitability of the steer activities is tied to high rates of gain. A low forage yield situation may force the manager to adjust summer steer numbers when weight gains have not been sufficient to be profitable. Conversely, a high forage yield situation may result in the manager geing unable to profitably use available forage.

The fall stocker steer activities allow flexibility in that steer numbers can be adjusted downward during the grazing season if necessary. Problems can result with fall stocker steers because they must be purchased well before forage yield conditions are known. For example, consider a manager with an operation containing 100 head of fall-calving cows producing 500 pound calves on May 1. If the operator buys 300 head of 400 pound steer calves in October, he would have to adjust numbers in the spring if a low forage yield situation developed. Instead of buying summer steers, fall steer numbers could be adjusted to 200 head by the operator, and only the summer steers kept from the cow-calf activity would be grazed if forage conditions warrant. If a high forage yield resulted, more summer steers could be purchased, or heifers from the cow-calf activity could also be kept to graze the forage.

The cow-calf activities provide organization flexibility in forage management by providing the option of keeping or selling the calves produced. A fall-calving activity provides the best flexibility by allowing the decision to be made when as estimate of the forage yield conditions can be made by the manager. However, the inclusion of cow-calf activities in the organization considerably lowers the net returns. The net returns can be drastically reduced to such an organization when there is a combination of adverse prices and low forage yields.

The profitability of the various stocker activities is closely associated with the steers' capacity to efficiently utilize high-energy, high-protein forages when they are produced by the pasture activities. The cow-calf activities do not require, and thus do not efficiently use, these high quality forages. The stocker activities can also be managed to match high forage intakes with high forage production, and vice-versa. Cow forage intakes are more consistent season to season, and cannot be varied as much as steer intakes without suffering undesirable consequences.

## Limitations and Implications for Further Study

The study assumes that in each situation examined the manager correctly anticipated conditions and acted to maximize returns within the limitations imposed. The probability of the manager making the correct decisions and dealing with the problems presented by changing the mix of activities can only be subjectively examined by the reader. The study does not attempt to estimate these probabilities and then compare organizational strategies.

The study assumes that additional labor and capital are available as required at the prices indicated. In reality this may not always be the case. Further study could examine the implications of using only operator labor and limited capital.

The model can be used to answer questions concerning livestock activity mixes for a variety of ranch situations not included in the study by altering or fixing various resources or activities. The right hand sides can be altered to model different ranch sizes or different mixes of cropland and native pastureland. Cash crop activities or alternative livestock activities can be easily added using the Oklahoma State University Extension Budgets. Activities can also be removed to account for operator preference. In this way, various ranch or farm-ranch situations could be studied. Extension personnel could use the model in this way.

The model as constructed does not allow for stocker rate changes during the pasture year. In reality, when stocking rates have been incorrectly estimated, or forage conditions change during the year, adjustments in numbers would be necessary, For example, suppose a rancher buys 400 fall stocker steers weighing 400 pounds in October. During the winter grazing season (October-March) these steers are managed to gain from .7 to .9 pounds per day. In April the rancher places them on spring pasture. Now, suppose rainfall is low in late April and May, causing forage conditions to deteriorate so that the stocker numbers or gains cannot be maintained. Some steers would have to be sold to adjust the stocking rate. This may result in the rancher selling 650-700 pound steers on or about the first of June, and perhaps at various dates throughout the summer if conditions do not improve.

The model does not account for this decision possibility. Likewise, if high rainfall increases forage production, the rancher could attempt to buy more cattle, but would he want or be able to? In such situations a base cow herd could add flexibility by producing calves which could be weaned in May and either sold or be kept according to forage conditions. This harvests the forage, but the returns would need to be budgeted out.

The most frequently appearing fall stocker activities (FSTRS863, FSTRS894, FSTRS936) could be restructued to allow the steers to be sold at an earlier date (May 15) at lighter weights. In this way the model could be allowed to adjust stocking rates at some point in time. The established profitability of the stocker steer activities could be further examined with regard to stocking rate decisions, steer availability, and the interrelationship of stocker steer and cow-calf activities in the ranch operation.

Only generally low, normal, and generally high forage yield alternatives for the entire grazing year were examined in this study. Using these base yields, a variety of forage yield situations could be modeled for a pasture year, such as normal yields with low yields in August-September. The effect of these situations on the mix of livestock activities could be examined. Further study could estimate the probabilities of various forage yield conditions, or the risk associated with a given organization, and examine returns on this basis. Expected values and probability distributions could also be estimated for alternative organizational strategies to deal with changing weather conditions. Differences in the level of management required for alternative organizations could be dealt with to further examine the adequacy of returns to land, management, and risk.

The analysis of organizational flexibility has only been touched by this study. Organizations could be compared using alternative approaches. For example, all livestock and pasture forage activities could be fixed within the model, and price and forage conditions varied to examine the effect of net returns to the organization. This study only fixed the activities which are not easily changed from year to year, i.e., lovegrass and specific cow-calf activities.

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APPENDIX

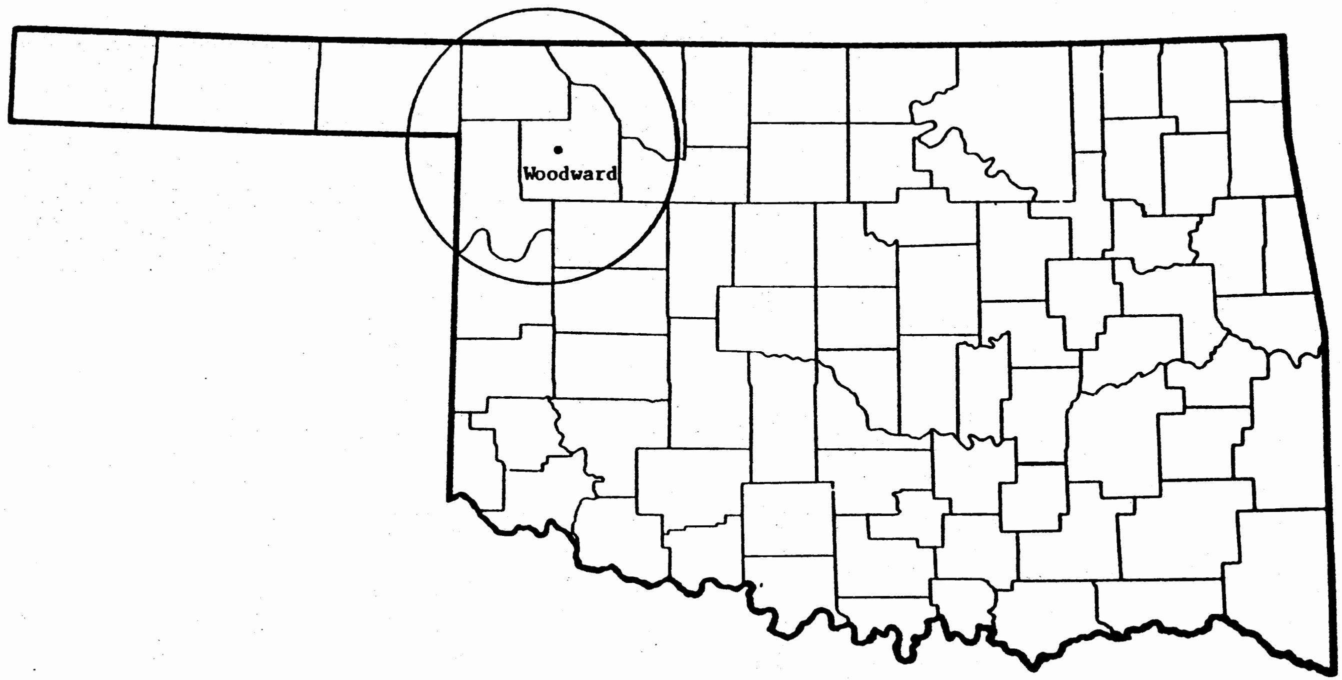


Figure 5. The Area of the Study: Northwest Oklahoma

## TABLE XLVI

## PROGRAM TO COMPUTE DIGESTIBLE OR METABOLIZABLE ENERGY AND DIGESTIBLE PROTEIN REQUIREMENTS FOR GROWING AND FINISHING BEEF CATTLE

```
C     THIS PROGRAM COMPUTES THE FOLLOWING REQUIREMENTS FOR GROWING AND FINISH-
C     ING BEEF CATTLE:
C
C     1. DIGESTIBLE OR METABOLIZABLE ENERGY
C     2. DIGESTIBLE PROTEIN
C
C
C--------------------------INPUT--------------------------------------------
C
C     AS MANY PROGRAMS CAN BE COMPUTED AS DESIRED,
C     WITH ONE PROGRAM PER CARD.
C     CC 01-10---INITIAL WEIGHT IN KILOGRAMS
C     CC 11-20---DESIRED AVERAGE DAILY GAIN IN KILOGRAMS
C     CC 21-22---BEGINNING MONTH
C     CC 23-24---ENDING MONTH FOR WHICH DATA APPLY
C                (NOTE: THE MONTHS REFERRED TO ABOVE MUST BE NUMBERED
C                ONE (1) THROUGH TWELVE (12), JAN= 1 - DEC= 12)
C     CC 25------ENTER 1 IF ME IS DESIRED RATHER THAN DE
C     CC30-59---IDENTIFICATION, USER'S OPTION
C
C
C
C--------------------------OUTPUT-------------------------------------------
C
C     1. INITIAL WEIGHT: ENDING WEIGHT: AVERAGE DAILY GAIN
C        (IN KILOGRAMS)
C     2. DIGESTIBLE ENERGY OR METABOLIZABLE ENERGY
C        (PER MONTH IN MEGACALORIES)
C     3. DIGESTIBLE PROTEIN
C        (PER MONTH IN KILOGRAMS)
C     4. AVERAGE WEIGHT
C        (PER MONTH IN KILOGRAMS)
C
      DIMENSION M(12),ND(12),MO(12),NDD(12),AMW(12)
      DIMENSION DE(12),DP(12),ME(12),PROG(5)
      DATA MO/'JAN','FEB','MAR','APR','MAY','JUN','JUL','AUG','SEP',
     X 'OCT','NOV','DEC'/
      DATA NDD/31,28,31,30,31,30,31,31,30,31,30,31/
      REAL IWT,ME
      WRITE(6,101)
  101 FORMAT('1')
      LL=0
   99 READ(5,100,END=999)IWT,ADG,IBM,IEM,IDENT,PROG
      LL=LL+1
  100 FORMAT(2F10.5,2I2,I1,T30,5A6)
      IF(IEM.LT.IBM) GO TO 105
      NM=IEM-IBM+1
      GO TO 106
  105 NM=12-IBM+IEM+1
  106 CONTINUE
      J=IBM
      L=0
      K=IBM
      DO 13 I=1,NM
      IF(J.GT.12) K=K+1
      ND(I)=NDD(K)
      M(I)=MO(K)
      J=J+1
      IF(J.GT.12) GO TO 107
      K=J
      GO TO 13
  107 IF(L.EQ.1) GO TO 13
      L=1
      K=0
   13 CONTINUE
      EW=IWT
      TW=0.
      DO 11 K=1,NM
      L=ND(K)
      DO 10 I=1,L
      EW=EW+ADG
      TW=TW+EW
   10 CONTINUE
      AMW(K)=TW/ND(K)
      TW=0.
      X=.137*(AMW(K)**.75)
      DE(K)= ND(K)*(X+(X*(ADG*1.28)))
      X=.112*(AMW(K)**.75)
      ME(K)= ND(K)*(X+(X*(ADG*1.32)))
      X=2.79*(AMW(K)**.75)
      DP(K)=ND(K)*(X+(X*(ADG*1.905)))
      DP(K)=(DP(K)/1000.0)*1.25
   11 CONTINUE
      WRITE(6,115)LL,PROG,IWT,EW,ADG,(M(I),I=1,NM)
  115 FORMAT(//,4X,' PROGRAM',I2,':', 'INITIAL WEIGHT      ',
     X 'ENDING WEIGHT',5X,'AVG DAILY GAIN',2X,5A6,//,
     X 14X,F14.2,5X,F13.2,5X,F14.2,//,6X,A3,11(7X,A3))
      IF(IDENT.EQ.1) GO TO 140
      WRITE(6,120)(DE(I),I=1,NM)
      GO TO 141
  140 WRITE(6,131)(ME(I),I=1,NM)
  141 WRITE(6,121)(DP(I),I=1,NM)
  121  FORMAT('0','DP',F9.2,11(F10.2))
  120 FORMAT(/,1X,'DE',F9.2,11(F10.2))
  131 FORMAT(/,1X,'ME',F9.2,11(F10.2))
      WRITE(6,130)(AMW(I),I=1,NM)
  130 FORMAT(/,1X,'WT',F9.2,11(F10.2),//)
      GO TO 99
  999 STOP
      END
```

## TABLE XLVII

## PROGRAM TO COMPUTE DIGESTIBLE ENERGY AND DIGESTIBLE PROTEIN REQUIREMENTS FOR BEEF CATTLE

```
C       THIS PROGRAM COMPUTES DIGESTIBLE ENERGY AND DIGESTIBLE PROTIEN
C  REQUIREMENTS FOR BEEF CATTLE.
C  -------------------INPUT-(ONE CARD PER PROGRAM-NO. OF PROGRAMS UNLIMITED)--
C  CC 01-06-- CWT=  AVG. WT. (LBS.) OF BROOD COW(S) JUST PRIOR TO CALVING
C  CC 07-12-- HWT=  WT. (LBS.) OF HERD BULL
C  CC 13-18-- CPB=  RECIPROCAL OF THE NUMBER OF BROOD COWS PER BULL
C                   (ENTERED AS FRACTION, DECIMAL PUNCHED)
C  CC 19-24--  CP=  CALVING PERCENTAGE (FRACTION, DECIMAL PUNCHED)
C  CC 25-30-- ROR=  CULLING RATE FOR BROOD COWS (FRACTION, DECIMAL PUNCHED)
C  CC 31-36--ADJA=  ADJUSTMENT IN AVG. LEVEL OF MILK PRODUCTION PER COW DURING
C                   FIRST MONTH POST-PARTUM -NOTE: ADJUSTMENT IS FROM 10 LBS.,
C                                               EX.- IF 15 LBS. IS DESIRED ADJA=5.
C  CC 37-42-- ADG=  AVG. DAILY RATE OF GAIN (LBS.) FOR CALVES PRIOR TO WEANING
C  CC 43-48--ADGR=  AVG. DAILY RATE OF GAIN (LBS.) FOR WEANED REPLACEMENTS
C  CC 49-50-- IWA=  AGE (MONTHS) AT WEANING
C  CC 51-52-- NCU=  NUMBER OF BROOD COWS PER BULL UNIT--INTEGER, RIGHT JUSTIFIED
C  CC 53------NOMO= 1 IF LAST CARD (LAST PROGRAM)
C                   BLANK OTHERWISE
C
C---------------------------------OUTPUT-----------------------------------
C   AVERAGE DAILY REQUIREMENTS BY MONTH (BEGINNING FIRST MONTH POST-PARTUM)
C   ARE GIVEN FOR 1. DIGESTIBLE ENERGY (DE, MEGACALORIES)
C             AND 2. DIGESTIBLE PROTEIN(DP, KILOGRAMS)
C   FOR THE FOLLOWING:
C  1. ONE BROOD COW
C  2. ONE BROOD COW PLUS HER CALF
C  3. ONE BROOD COW UNIT (COW+CALF+PRO RATA SHARE OF REPLACEMENTS AND HERD BULL)
C  4. ONE BULL UNIT OF SPECIFIED SIZE
C  CALF WEIGHT AT WEANING IS ALSO GIVEN
C
      DIMENSION AWM(12),CDE(12),CDP(12),SMILK(12),PMILK(12),
     1CFWT(12),WKG(12),CFDE(12),CFDP(12),RDE(12),RDP(12),FMP(12),
     1TCP(12),TDE(12),HCP(12),HDE(12),BTDE(12),BTDP(12)
    9 FORMAT(8F6.0,2I2,I1)
   12 FORMAT('1',32X,42H MONTHS,BEGINING FIRST MONTH AFTER CALVING)
   19 FORMAT(' ',5X,1H1,8X,1H2,8X,1H3,8X,1H4,8X,1H5,8X,
     11H6,8X,1H7,8X,1H8,8X,1H9,7X,2H10,7X,2H11,7X,2H12)
   11 FORMAT(//'0',    43H AVERAGE MONTHLY WEIGHTS FOR COWS WEIGHING
     1F6.0,24H POUNDS PRIOR TO CALVING)
   10 FORMAT('0',12F9.1)
   60 FORMAT(//'0',61H AVERAGE DAILY MILK PRODUCTION FOR COWS PRODUCTING
     1 AN AVG. OF,F6.2,33H LBS/DAY IN 1ST MO. AFTER CALVING)
   61 FORMAT('0',12F9.1)
  113 FORMAT('0',12F9.3)
   63 FORMAT(//'0',39H AVERAGE DAILY DE REQUIREMENTS FOR COWS)
   64 FORMAT(//'0',39H AVERAGE DAILY DP REQUIREMENTS FOR COWS)
   15 FORMAT(//'0',48H AVG.DAILY DE REQ. FOR COWS PLUS CALVES GAINING ,
     1F5.2,27H LBS. PER DAY UNTIL WEANING ,/,' ',25H AND REPLACEMENTS GA
     1INING ,F5.2,30H LBS. PER DAY AFTER WEANING AT ,I2,7H MONTHS)
   17 FORMAT(//'0',48H AVG.DAILY DP REQ. FOR COWS PLUS CALVES GAINING ,
     1F5.2,27H LBS. PER DAY UNTIL WEANING ,/,' ',25H AND REPLACEMENTS GA
     1INING ,F5.2,30H LBS. PER DAY AFTER WEANING AT ,I2,7H MONTHS)
  172 FORMAT(//'0',36H AVG. DAILY DE REQ. FOR ONE COW UNIT)
  173 FORMAT(//'0',36H AVG. DAILY DP REQ. FOR ONE COW UNIT)
   73 FORMAT(//'0','AVG. DAILY DE REQUIREMENTS FOR HERD OF'I3,
     1' COW UNITS')
   74 FORMAT(//'0','AVG. DAILY DP REQUIREMENTS FOR HERD OF'I3,
     1' COW UNITS')
   24 FORMAT(//'0',43H WEANING WT. OF CALVES FROM THIS PROGRAM IS F6.0,
     1' LBS')
  999 READ(5,9) CWT,BWT,CPB,CP,ROR,ADJA,ADG,ADGR,IWA,NCU,NOMO
      WA60=CWT-(CWT*.15)
      WAC=WA60*1.05
      WA30=(WA60+WAC)/2.
      AWM(1)=(WAC+WA30)/2.
      AWM(2)=(WA30+WA60)/2.
      WA266=WA60+(.10*CWT)
      DRG=(WA266-WA60)/206.
      AWM(3)=WA60+(DRG*16.)
      DO 48 I=4,9
      J=I-1
   48 AWM(I)=AWM(J)+(DRG*30.4)
      DRG1=(CWT-WA266)/99.
      DO 49 I=10,11
      J=I-1
   49 AWM(I)=AWM(J)+(DRG1*30.4)
      AWM(12)=CWT-(DRG1*15.)
      WRITE(6,12)
      WRITE(6,19)
      WRITE(6,11) CWT
      WRITE(6,10) (AWM(I),I=1,12)
      BC=10.97246+ADJA
      DO 50 I=1,IWA
      LX=I
   50 FMP(I)=80-(.67696429*LX)
      A=FMP(1)
      J= IWA+1
      DO 150 I=J,12
```

TABLE XLVII (Continued)

```
15C   FMP(I)=0.
      WRITE(6,60) A
      WRITE(6,61)(FMP(I),I=1,12)
      DC 51 I=1,12
      EMILK(I)=FMP(I)*.33
51    PMILK(I)=FMP(I)*.035*.4536
      DC 45 I=1,2
      CFWT(I)=0.0
      CFCP(I)=0.0
      CFCE(I)=0.0
   45 WKG(I)=0.0
      CFWT(3)=190.0+(15*ACG)
      DC 46 I=4,IWA
      J=I-1
   46 CFWT(I)=CFWT(J)+(30.0*ADG)
      J=IWA+1.0
      DC 47 I=J,12
      K=I-1.0
   47 CFWT(I)=CFWT(K)+(30*ADGR)
      DC 40 I=1,12
   40 WKG(I)=CFWT(I)*.4536
      CGKG=ADG*.4536
      RGKG=ADGR*.4536
      DO 41 I=3,IWA
      X=.137*(WKG(I)**.75)
      CFDE(I)=((X+(X*CGKG*1.28))-EMILK(I))*CP
      X=2.79*(WKG(I)**.75)
      CFDP(I)=(((X+(X*(CGKG*1.905)))-PMILK(I))*CP)*1.25
   41 CFCP(I)=CFDP(I)/1000
      J=IWA+1
      DC 42 I=J,12
      X=.137*(WKG(I)**.75)
      ROE(I)=(X+(X*RGKG*1.28))*ROR
      X=2.79*(WKG(I)**.75)
      RCP(I)=((X+(X*RGKG*1.905))*ROR)*1.25
   42 RDP(I)=RDP(I)/1000
      DC 13 I=1,IWA
      CDE(I)=(6.764+(.CC98*AWM(I)))+(.61*FMP(I)*CP)
   13 CDP(I)=((.11759+(.00031*AWM(I)))+(.043*FMP(I)*CP))*.4536
      J=IWA+1
      DC 14 I=J,12
      CDE(I)=4.12408+(.C1115*AWM(I))
14    CDP(I)=(.11759+(.00031*AWM(I)))*.4536
      WRITE(6,63)
      WRITE(6,113)(CDE(I),I=1,12)
      WRITE(6,64)
      WRITE(6,113)(CDP(I),I=1,12)
      DO 43 I=1,IWA
      TCP(I)=CDP(I)+CFDP(I)
   43 TCE(I)=CDE(I)+CFDE(I)
      J=IWA+1
      DC 44 I=J,12
      TDP(I)=CDP(I)+RDP(I)
   44 TDE(I)=CDE(I)+ROE(I)
      WRITE(6,15)ADG,ADGR,IWA
      WRITE(6,113)(TDE(I),I=1,12)
      WRITE(6,17)ADG,ADGR,IWA
      WRITE(6,113)(TDP(I),I=1,12)
      BDE=(3.88975+(.01933*BWT)-(.0000055*(BWT*BWT)))*CPB
      BDP=((.5798+(.002766*BWT)-(.000001*(BWT*BWT)))*CPB)*.4536
      DC 71 I=1,12
      BTCE(I)=TDE(I)+BDE
71    BTCP(I)=TDP(I)+BDP
      DC 72 I=1,12
      HCE(I)=BTDE(I)*NCU
72    HCP(I)=BTDP(I)*NCU
      WRITE(6,172)
      WRITE(6,113)(BTDE(I),I=1,12)
      WRITE(6,173)
      WRITE(6,113)(BTDP(I),I=1,12)
      WRITE(6,73) NCU
      WRITE(6,113) (HOE(I),I=1,12)
      WRITE(6,74) NCU
      WRITE(6,113) (HOP(I),I=1,12)
      AWT= CFWT(IWA)
      WRITE(6,24) AWT
      RCR=RCR*100
      CP=CP*100
      WRITE(6,25)CP
      WRITE(6,26)ROR
      WRITE(6,27)AWT
      WRITE(6,28)NCU
   25 FORMAT('0CALVING PERCENTAGE (CALVES WEANED/COWS EXPOSED TO BULL)'
     X,' IS ',F3.0,'%')
   26 FCRMAT('0RATE OF REPLACEMENT IS ',F3.0,'%')
   27 FCRMAT('0HERD BULL WEIGHT IS ',F5.0,' POUNDS')
   28 FCRMAT('0RATIO OF BROOD COWS TO BULLS IS ',I2,' TO 1')
      IF(NCMO.EQ.0) GO TO 999
      WRITE(6,1999)
1999  FCRMAT('1')
      STCP
      FND
```

VITA

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