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A Study of Drought Effects on Livestock Feeds and Products in the Western United States

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A STUDY OF DROUGHT EFFECTS ON LIVESTOCK FEEDS AND PRODUCTS IN THE WESTERN UNITED STATES

by

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Robert Blakeslee

TABLE OF CONTENTS

		Page
ACKNOWLEDGEMENTS		ii
LIST OF TABLES		iv
LIST OF FIGURES		vii
ABSTRACT		viii
Chapter		
I.	INTRODUCTION	1
	Problem and Purpose of the Study	2
	Objectives	2
II.	THEORETICAL FRAMEWORK	4
	Interregional Competition	4
	Linear Programming	9
	Review of the Literature	11
III.	METHODOLOGY	14
	Model Development	14
	Data Collection	28
	Drought Simulation	37
IV.	RESULTS AND ANALYSIS	47
	Base Year Solution	49
	Drought A	56
	Drought B	63
	Simulation Comparison	68
V.	CONCLUSIONS AND RECOMMENDATIONS	78
	Conclusions	78
	Recommendations	80
LITERATURE CITED		82
APPENDICES		88
	Appendix A	89
	Appendix B	103

LIST OF TABLES

Table		Page
1.	Regions and Regional Centers Used in the Study	18
2.	Feeds Available to be Fed to Livestock in the Study	19
3.	Seasons of Production in the Study	19
4.	Livestock Classes and Products Utilized in the Study	20
5.	Nonfeed Costs of Livestock Production, 1979 (per livestock unit)	32
6.	Index Used for Updating Costs	33
7.	Live Weight Equivalent Coefficients for Livestock Products	33
8.	Truck Transportation Cost Equations for Feed Grains	35
9.	Liquidation Costs	38
10.	Percentage Reductions in Production of Feed Grains and Hay by Region for "40-Year" Drought	43
11.	Range Response Equations and Corresponding States' Coefficients for Determing Grazing Feeds' Percentage Reduction	44
12.	Percentage Reductions in Production of Private Pasture, BLM, and Forest Service by Region for "40-Year" Drought	45
13.	Summary of Total Costs and Net Profits for Base Year, Drought A, and Drought B (1000 dollars)	48
14.	Acutal and Shadow Prices of Yearly Feeds--Base Year, 1979	51
15.	Actual and Shadow Prices for Seasonal Feeds--Base Year, 1979	52
16.	Shadow Prices of Yearly Feeds with Percentage Increases from Base Year--Drought A	59
17.	Shadow Prices of Seasonal Feeds with Percentage Increases from Base Year--Drought A	60
18.	Shadow Prices of Yearly Feeds with Percentage Increases from Base Year--Drought B	65
19.	Shadow Prices of Seasonal Feeds with Percentage Increases from Base Year--Drought B	66

LIST OF TABLES (continued)

Table | Page

20. Feed Allocation of Selected Livestock Grazing Activities for Selected Regions--Base Year, Drought A, and Drought B 69

21. Feed Allocation of Selected Nongrazing Livestock Activities for Selected Regions--Base Year, Drought A, and Drought B 71

22. Reduced Costs and Shadow Prices of Livestock and Livestock Products--Base Year, Drought A, and Drought B . . 74

23. Actual and Optimal Production of Nongrazing Feeds--Base Year, 1979 89

24. Seasonal Optimal and Actual Production of Grazing Feed AUM's--Base Year, 1979 90

25. Actual and Optimal Production of Livestock and Livestock Products--Base Year, 1979 92

26. Optimal Production of Nongrazing Feeds--Drought A 94

27. Seasonal Optimal Production of Grazing Feed AUM's--Drought A 95

28. Optimal Production of Livestock and Livestock Products--Drought A 98

29. Optimal Production of Nongrazing Feeds--Drought B 99

30. Seasonal Optimal Production of Grazing Feed AUM's--Drought B 100

31. Optimal Production of Livestock and Livestock Products--Drought B 102

32. Nutrients Furnished by One Ton of Feed in Mcal M.E. or Tons of D.P. when Fed to Various Classes of Livestock . . 103

33. Nutrients Furnished by One AUM in Mcal M.E. and Tons D.P. on Forest Service, BLM, and Private Pasture per season 104

34. Nutrient Requirements for Nongrazing Livestock Classes per Unit of Livestock Product 105

35. Nutrient Requirements for Grazing Livestock Classes per Unit of Livestock Product 106

36. Percentage Increase in 1979 Feed Prices--Droughts A and B 107

LIST OF TABLES (continued)

Table Page

37. Revenue Received at Farm Gate for Livestock Products 108

38. Allowable Deviations in Production of Livestock Products from 1979 Totals 109

39. Production Bounds on Production of Livestock Products . . . 111

40. Rail Transportation Costs for Feed Grains 113

41. Transportation Mileage Between Region Centers 114

LIST OF FIGURES

Figure — Page

1. Regional breakdown for the United States 15
2. Regional breakdown of the eleven western United States . . . 17
3. Condensed tabular illustration of linear programming matrix for one region 26
4. Regions affected by drought A 39
5. Regions affected by drought B 41

ABSTRACT

A STUDY OF DROUGHT EFFECTS ON LIVESTOCK FEEDS AND PRODUCTS IN THE WESTERN UNITED STATES

by

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Through the use of a regionalized Linear Programming model, a profit maximized optimal solution was obtained for livestock feed and product production for a selected base year (1979). Production data, seasonality, transfer activities, and herd liquidation are developed for ten feeds and seven livestock products and incorporated within the model. Two drought induced simulations were imposed affecting feed production and feed prices, procuring new optimal results. Drought is simulated by the use of crop-weather indexes and range response equations.

Results are discussed and presented in tables for the base year and drought simulations. Results include profits, costs, feed and livestock production, transfer activities, and herd liquidation. Seasonality of feeds, allocation of feeds, and shadow prices are also analyzed. Policy implications and recommendations are presented.

(114 pages)

CHAPTER I

INTRODUCTION

Of all the changes and problems that the farmer-rancher faces, the weather can be the most unpredictable. There is always a high degree of uncertainty and risk involved in producing crops and raising livestock due to this weather factor.

In years of low rainfall, procuring feed for livestock is one of the rancher's first priorities. Low rainfall generally reduces feed grain production and also reduces the number of AUMs (animal unit month) available on private or public range. The government's course of action will be to reduce the number of available grazing permits. The immediate consequence for the rancher is that he must either find an alternate feed source or cut back on the number of head he plans to raise. Either of these options will obviously have a detrimental effect on the rancher's operation.

Whenever drought conditions exist, alternate feed sources become very costly, particularly when compared to the price of public land (government owned) grazing. On the other hand, if ranchers choose to reduce herd size, a temporary glutted market results and livestock prices fall. Obviously, the rancher again is the one who is hurt the most.

Drought is unpredictable in occurence, severity, and length. The worse drought on modern record occurred during the 1930's. The entire nation was affected to some degree. Very little was known of the effects of drought and very little could be done to alleviate this drought which paralleled the time of the great depression.

Recently, the government has taken measures to improve the rancher's plight during periods of drought. During the late 1970's, low interest government loans were made available to ranchers for water conservation projects. These projects include funding for concrete lined irrigation ditches and trucking of water for livestock.

Knowledge of adjustments in production for feed and range face both the rancher and government. Some studies have been completed and more are needed. When a drought problem arises, the rancher needs to know the alternatives for feeds that are available. The policy makers need to know how these changes will affect the nation and the regions of drought. Continuing research is necessary to lessen the effect of the drought.

Problem and Purpose of the Study

This study addresses two problems: (1) What adjustments and changes will take place in feed production during a drought period? (2) What are the consequences of these changes? With these results, information valuable to ranchers, businessmen, and government can be gained, and the proper actions can be carried out during drought. This study uses a model that depicts the present, and will predict adjustments to drought. Results dictate which adjustments can be made to help alleviate the uncertainty associated with drought.

Objectives

The specific objectives of this thesis are:

1. To update and expand previously used feed allocation linear programming models in order to better depict the present situation in the feed and livestock industry.

(2) To develop an optimal base year solution showing yearly feed production, seasonal public and private range production, corresponding shadow prives, and yearly livestock production. These results will be compared with actual 1979 statistics.

(3) To impose two droughts upon different regions within the model and compare the optimal solutions to the base year results.

(4) To show the differences between simulations in feed allocation and reduced costs of livestock products.

(5) To present conclusions available to ranchers, legislators, and other interested groups concerning alternative actions that can be taken to lessen the severity of drought

(6) To suggest model improvement and recommendations for areas of further research using a similar LP model.

The following chapter will provide the theoretical background for this study. Explanation of the model used, along with a summary of previous related studies will lay the groundwork for the methodology in Chapter III.

CHAPTER II

THEORETICAL FRAMEWORK

A general knowledge of interregional competition and linear programming is essential in the use of this model. A brief explanation of these subjects is made in this chapter along with a review of the literature of linear programming, applications, and weather-crop yield interactions.

Interregional Competition

When one region has a surplus of a good, trading with other regions for scarce goods follows. Regardless of how the Western United States is divided, no single region can be completely self-supporting in all goods. By definition, interregional competition is competition in trade between regions that produce the same commoditites for the same markets (Mighell and Black, 1951). For example, Idaho and Montana are self-surrporting in beef production. They rely on trade to deplete their surplus and therefore compete with each other for those markets that have a demand for beef.

Specialization, comparative advantage, location theory, and general equilibrium analysis are elements of interregional competition. A brief look at each of these will help define interregional competition.

Specialization and Comparative Advantage

Society relies heavily on specialization. The majority of consumers produce few of the goods and services they consume and at the same time

consume little if any of what they produce (McConnell, 1978). Specialization focuses on the idea that a region could gain by specializing in one product and trading or selling the surplus for the goods or services it lacks. Some regions can produce a wide variety of crops while other regions produce relatively few. Limited resources, climate, topography, and biological problems result in regional specialization. The more a region specializes in producing products for which it has resources, the more advantage it will have when trading its surplus (Ohlin, 1935).

Comparative advantage is simply an outgrowth of specialization. Comparative advantage determines what product(s) will be produced and specialized in each region. The principle of comparative advantage states that a product will be produced where its ratio of advantage (or disadvantage) compared with alternative products is greatest in exchange for products from other areas (Buse and Bromley, 1975).

Ideally, a region which has absolute advantage (the lowest production cost) over all other regions for a certain product will produce that product for every region. In reality, the situation is usually more complex. Transportation costs and product mobility must be considered. No single region can produce the total amount of a particular good required by all other regions. Usually a region will have an advantage in production when resources for the product are abundant and are located within its boundaries.

A simple example will demonstrate the concepts of specialization and comparative advantage. Ignoring transportation costs, assume there are two regions producing the same two products. Assume that one of the regions can produce both products cheaper than the other. According to the principle of comparative advantage, both regions would be better off producing only one product and exchanging it for the other. Suppose

that Nevada and Washington each produce only beef and wheat, and that Washington can produce 1800 pounds of wheat per acre of 450 pounds of beef per acre. Nevada can produce 900 pounds of wheat or 300 pounds of beef per acre. Therefore, Nevada can produce one-half as many bushels of wheat and two-thirds as much beef per acre as Washington. This puts Nevada in the situation of an absolute disadvantage (higher production costs); however, the disadvantage is less for beef. According to the principle of comparative advantage, Nevada should produce beef and Washington should produce wheat.

Comparing costs, the trading price of a pound of wheat in Washington is one-quarter of a pound of beef; in Nevada, a pound of beef is worth three pounds of wheat. Specialization and trade can commence when Washington beef costs less than four pounds of wheat and Nevada can get more than three pounds of wheat per pound of beef. In order for both states to benefit, the price per pound of beef must be between three and four pounds of wheat. If a price of 3.5 pounds of wheat per pound of beef was agreed upon, Nevada could trade 100 pounds of beef for 350 pounds of wheat. Nevada now has 350 pounds of wheat and 200 pounds of beef, compared to only 300 pounds of wheat and 200 pounds of beef before specialization. Washington also benefits with 100 pounds of beef and 1450 pounds of wheat as compared to the prespecialization figures of 87.5 pounds of beef for 1450 pounds of wheat produced. Both states improve their standing by specializing in a product and trading where the comparative advantage (disadvantage) is greatest (least).

Location and General Equilibrium Theory

In deciding upon the location for an enterprise, great care must be taken to consider all costs and to keep the sum of these costs as low as

possible. This, in essence, is the theroy of location. Procurement and distribution costs are important and must not be overlooked. This may mean locationg near the market so that distribution costs will not be excessive. If procurement costs are higher than distribution costs, the site should be near the resource supply. Sometimes the best site is halfway between the resource supply and the market. In general, most location decisions are the result of one of the following production conditions: 1) output access is the major consideration, 2) input access is the major consideration, or 3) both are of approximately equal importance (McKee, Dean, Leahy, 1970).

When regions specialize and production is located at a least-cost site, trade will occur between regions if the imported price (transportation costs included) is lower than the domestic price.

Interregional competition in trade is affected by the concept of spatial general equilibrium. The general model used in this study is the one introduced by Lefeber (in Wright, 1968). Lefeber's model analyzes utilization and allocation of resources among industries in different regions to yield an optimal set of goods and services.

Lefeber defines the conditions associated with an optimal set of goods and services as follows:

(1) If a good produced at two different locations is shipped to the same market, the difference between the marginal prices of the good at the two locations must exactly equal the differences between the respective marginal costs of transporting a unit of that good from the two production locations to that market.

(2) If a good produced at a location is shipped to two different markets, then the difference between the two prevailing market prices must exactly equal the difference between the respective marginal costs

of transporting a unit of that good from the production location to the two markets.

(3) If a factor such as labor is employed locally in both industries and in transportation, its rent has to be uniform. This rent in turn has to equal the value of the factor's marginal product in each occupation, evaluated in terms of the shadow prices of the respective goods.

(4) If a factor is exported to another location for use in either one or both industries, its rent must equal the rent obtained by identical factors locally employed in the second location. This in turn must equal the values of the marginal products, evaluated in terms of the shadow prices of the goods in that location. Finally, this same rent paid in the second location must equal the sum of the factor's rent in the first location and the cost of transportation. It follows that identical factors originating from one location and employed in the production of the same good at two different locations must have different values of marginal products. The difference between the respective values of the marginal product of the same factor employed in the same industry in both locations will equal the marginal cost of transporting a unit of the factor from the first to the second location.

(5) Factors orginating in a location which imports identical factors from abroad must not be employed in the production of transportation services.

When the location of the enterprise has been determined in agreement with Lefeber's formulation of spatial allocation of factors and distribution of products, it is possible to determine the movement, resource allocation, and output among regions.

Linear Programming

Linear Programming (LP) is one type of model which can be used in problem solving. LP was first used in World War II for minimizing travel distances in allocating scarce resources (Heady and Candler, 1958). LP has been widely used with a high rate of success. LP has proved to be one of the most successful quantitive aids in managerial decision making. Many LP models have been developed which focus on livestock and feed production industries. A similar LP model will be used in this study to determine interregional impact and reallocation of livestock feeds and products due to drought. By using the model, interregional comparisons can be made to determine which feeds or products increase or decrease in availability. Predictions can also be made concerning the effect of changes in available resources in the different regions.

Linear Programming is a method for finding optimal values for variables that are contained in an objective function. These optimal values can be either maximum (highest profit) or minimum (least cost). Included with an objective function is a series of equations called constraints. Constraints limit the degree to which the objective function can be pursued. Simple LP models contain one or two decision variables and constraints and are usually worked by hand. Large models (as in this study) can contain thousands of variables and constraints. Computers are generally used in running the large LP models.

Assumptions of Linear Programming

A number of assumptions must be stated in order to analyze the results of an LP model (Heady and Candler, 1958; Takayama and Judge, 1971; Judge and Wallace, 1958).

(1) Markets are competitive. No interference or restraints on trade or prices are allowed. Competitive behavior means costs will be minimized (Dorfman, 1953).

(2) Resources and products are homogeneous, so consumers are indifferent to the supply source.

(3) Within a region, the technical co-efficients of production are known and fixed, although the processes may vary between regions.

(4) Inputs and outputs are in constant proportion for all levels of each process so that constant returns to scale exist.

(5) There is no substitutability between inputs or the co-efficients in the objective function.

(6) Resource supplies and final demand for each region are known.

(7) The factor and output markets are represented by a fixed point for each region.

(8) Regional prices are known with certainty.

(9) The number of alternative activities is limited with each activity being independent and capable of being undertaken at any positive level.

(10) Per unit transportation costs are independent of quantity shipped.

(11) Transportation can occur only at positive levels.

(12) The level of activity in other sectors of the economy is assumed known.

Limitations of Linear Programming

The above assumptions must be made in order to run any LP model. In the "real world" situation, however, some of these assumptions will be distorted. All resources and products are not completely homogeneous,

all markets are not competitive, and producers do not have the same production functions.

A large amount of primary and secondary data had to be collected to develop this large scale LP model. It was also necessary to convert some of the data into useable form. In any conversion, the chance of error is increased.

In testing the drought simulation, the assumption is made that all points within a region will be affected to the same degree. This is not entirely true, as drought effects can be different just a few miles apart. Realizing the limitation, an LP model can be constructed which will relate closely to reality and will produce analyses which will be useful in predicting the effects of changes in current conditions.

Review of the Literature

Linear Programming Studies

LP has been widely used in determining optimal resources in agriculture for the past 30 years. Brokken and Heady (1968) utilized LP to combine a crop producing model with a livestock producing model. Results included optimal location of feed and livestock production on a multiregional basis. This model also had a multiple livestock product production and thus allowed for the interaction of livestock products and feeds in production. This model has now been adapted to and serves as the U.S. national linear programming model used by the U.S. Department of Agriculture in Washington D.C.

Grimshaw (1972) developed a model to determine the feasibility of livestock production expansion in the Pacific Northwest. Several livestock classes and feeds were analyzed. Transportation costs of feeds

were included. Through cost minimization, optimum production and location of livestock and feed products were determined. Results showed that each region has a comparative advantage in producing the livestock products that are consumed within the region until locally produced feed grains are exhausted.

Several other studies have emerged from Grimshaw's model. Gray (1972) modified this model to examine Utah's competitive position in livestock product production as compared to other regions of the country. His results show Utah has an advantage in producing locally consumed products like beef, pork, and turkeys. He concluded also that Utah could compete with other regions in supplying eggs and milk to deficit California markets.

Andersen (1975) used an LP model to determine optimal feed and livestock production within the state of Utah. He then adjusted his feed production to examine the profitability of importing grain for use as a feed. He also examined the effects of a price change for one region.

Sorensen (1978) used an updated Grimshaw and Gray model. By obtaining optimal production solutions for 1972, 1973, and 1974, he determined that Utah could profitably expand its milk, egg and pork production.

Bailey (1980) and Mwangi (1981) used an updated Grimshaw model to find optimal feed and livestock production for regions in the United States and Kenya, respectively. Both used simulated decreases in available grazing and showed the adjustment and reallocation of feeds that took place.

Weather-Crop Interaction Studies

Because of so many factors influencing crop production, measurement of the effect of weather on crop yields is very difficult. Attempts to

predict weather, however, have been occuring for some time. Sanderson (1954) presents a review of studies dealing with weather-crop yields that began in the 1870's.

More recently, Perrin and Heady (1975) developed a yield-weather index, by regressing yield samples from different locations over a period of time, and using the ratio of trend yield to actual yield. These predictions of weather effects were valid assuming other factors remained constant. Therefore, an estimate was obtained on how much yields differed to normal as a result of weather. Stallings (1960) first used this index for prediction of crop yields. Johnson and Gustafson (1962) concluded that the index was as good as the results obtained when using a rainfall variable approach to predict yield.

Another approach of studying a meterological drought was conducted by Oury (1965). He developed drought severity as a function of accumulated weighted differences between actual precipitation and the precipitation requirement for crops. The obtained results provided monthly index values that permit comparison of a particular period with the average climate conditions for the area in question.

Koo, Boggess, and Heady (1978) developed a weather index for predicting reductions in food and feed grains for each state within the United States. Each state's weather was compared to the United States as a whole to determine effects on yield.

Perry (1981) developed range response equations for all grazing feeds. Monthly range condition data were obtained from each state and regressed against monthly Palmer-indices to predict decreases in range availability. Both the Koo and Perry studies were used in this thesis to generate drought simulations and are explained more fully in Chapter III.

CHAPTER III

METHODOLOGY

Model Development

The linear programming model used for this thesis was originally developed by Grimshaw (1972), and subsequently expanded by Nef (1979), Bailey (1980), and Mwangi (1981). This study expanded the model to include seasonality of production in public and private range and other feeds. The possibility of liquidation of livestock herds in drought in included within the model.

Regions

The United States was divided into sixteen regions as shown in Figure 1. Since public (federal) grazing is nearly all located in the eleven western United States, the determination of proper regional boundaries was critical. Besides individual farmers and ranchers, those agencies which would be interested in the results of this study include: (1) individual state government agricultural agencies, (2) the federal government's Bureau of Land Management and Forest Service, and (3) state climatologists. By studying vegetation and rangeland maps, tentative regions were established based on separating grazing land from crop producing areas. These results were combined with climate-precipatation data from each state (Richardson, 1981). Each state's BLM district boundaries were then compared to the above proposed regions. The final region boundaries were formulated by following each state's county lines.

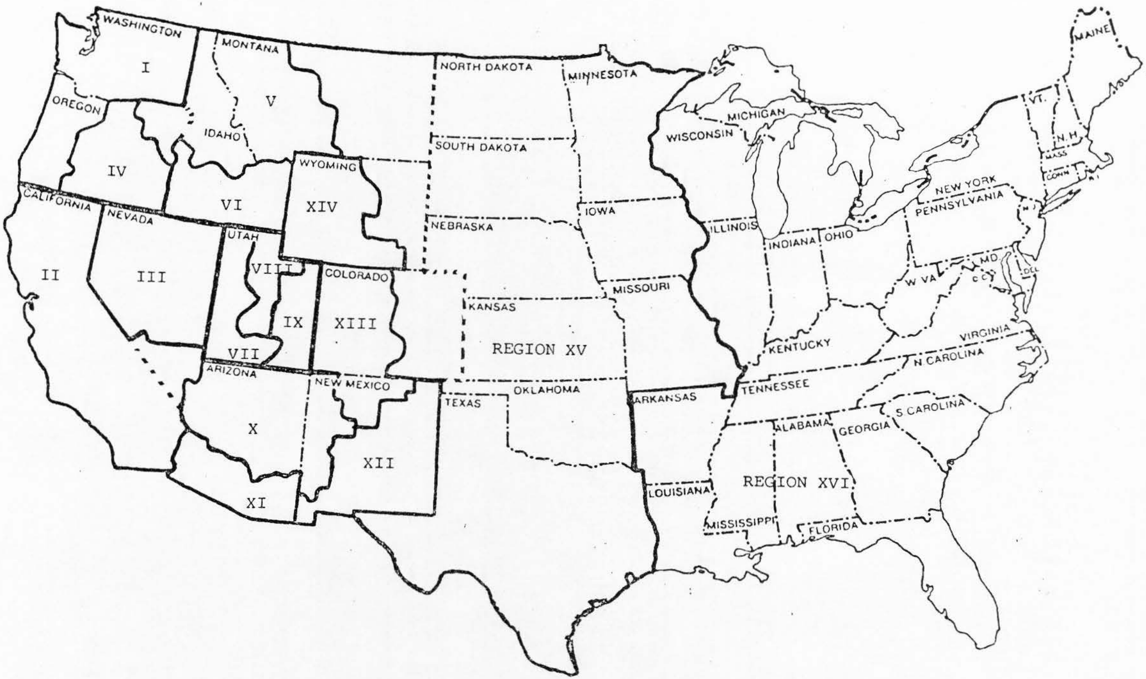

Figure 1. Regional breakdown for the United States

The fourteen regions of the eleven western states are shown in Figure 2. The midwest region is comprised of North and South Dakota, Minnesota, Nebraska, Missouri, Kansas, Iowa, Oklahoma, Texas, and the eastern sections of Montana, Wyoming, and Colorado. The eastern region is comprised of the states east of the Mississippi River.

In each region, a regional or market center was selected for calculating transportation of feed grains and livestock products. These regions and centers are listed in Table 1. Transportation costs between regions were calculated by using the distance between the market centers.

The feeds used in the analyses for this study are those which are commonly used for producing livestock products. These ten feed grains and grazing classes are listed in Table 2. All the feeds are produced yearly except for private and public pasture which are produced seasonally.

Livestock grazing is not always possible year-round due to different climates in the various regions. This model has therefore been expanded to include seasons of production. To best represent all regions, the traditional four seasons will be used in this model and are listed in Table 3. Besides the grazing feeds, grazing animals could consume barley, hay and protein supplement on seasonal levels.

The livestock classes used for anlysis are those that compete for any of the feeds contained in Table 2. The eleven livestock classes used to produce seven livestock products can be found in Table 4. Livestock production was on an annual basis.

Feeds must be converted into livestock products in order for the model to function. In this study an approach developed by Grimshaw (1972) is employed. Each feed contains a certain amount of megacalories of metabolizable energy (Mcal/ME) and pounds of digestible protein

Figure 2. Regional breakdown of the eleven Western United States.

TABLE 1.--Regions and Regional Centers Used in the Study

Region	State(s)	Regional Center
I	Washington, Western Oregon	Seattle
II	California, Southern Nevada	Sacremento
III	Nevada	Winnamucca
IV	Eastern Oregon	Burns
V	Northern Idaho, Western Montana, Northwest Oregon	Missoula
VI	Southern Idaho	Twin Falls
VII	Western Utah	Delta
VIII	Central Utah	Ogden
IX	Eastern Utah	Price
X	Northern Arizona, Western New Mexico	Flagstaff
XI	Southern Arizona	Phoenix
XII	Eastern New Mexico	Roswell
XIII	Western Colorado	Grand Junction
XIV	Western Wyoming	Lander
XV	Midwest (S.D., N.D., Minn., Neb., MO., KS., Iowa, OK., TX.)	Omaha
XVI	The East (All states east of the Mississippi River)	Chicago

TABLE 2.--Feeds Available to be Fed to Livestock in the Study

Feeds Considered in this Study
1. Barley
2. Wheat
3. Corn
4. Oats
5. Milo
6. Hay
7. Protein Supplement
8. Private Range (Pasture)
9. BLM Rangeland
10. Forest Service Rangeland

TABLE 3.--Seasons of Production in the Study

Seasons	Time of the Year
1. Winter	December, January, February
2. Spring	March, April, May
3. Summer	June, July, August
4. Fall	September, October, November

TABLE 4.--Livestock Classes and Products Utilized in the Study

Livestock Classes	Livestock Product Produced
Fed Beef	Beef
Hogs	Pork
Broilers	Chicken
Turkeys	Turkey
Layers	Eggs
Milk Cows	Milk
Sheep	Lamb
Cow/Calf*	
Backgrounders*	
Dairy Calf*	
Dairy Backgrounder*	

*The calf activities and the backgrounding activities were intermediate steps to the fed beef category and fed beef was the only beef product available for consumption in the model.

(converted into tons of DP). In order to gain a unit of product, each class of livestock requires specific amounts of metabolizable energy and digestible protein. Any excess nutrients after livestock unit requirements is met cannot be used by another livestock class. The classes of livestock are analyzed in units of 1000 pounds liveweight. Calves and backgrounders are analyzed as per head units. The LP model matches feed requirements with livestock classes to produce the needed livestock products. This model functions by producing feeds, transporting these feeds between regions, converting feeds to livestock products, liquidating herd size if economically justified, and transporting these products to meet the final demand.

The LP model utilized for this thesis is summarized in the following section.

Objective Function and Restraints

The problem is as follows:

Maximize

(1) $\sum_{jk}\sum P_{jk}Q_{jk} - \sum\sum_{ikg}\sum A_{ikg}B_{ikg} - \sum\sum_{ikhg}\sum\sum C_{ikhg}D_{ikhg} - \sum\sum_{jkh}\sum E_{jkh}F_{jkh} - \sum_{jk}\sum N_{jk}Q_{jk} -$

$\sum_{rk}\sum Z_{rk}X_{rk}$

Subject to

(2) $V_{ikg} \leq B_{ikg} + \sum_{h} D_{ihkg} - \sum_{k} D_{ihkg}$

(3) $\sum_{ij}\sum M_{ijkg}V_{ijkg} \geq \sum_{j} S_{jk}Q_{jk}$

(4) $\sum_{ij}\sum T_{ijkg}V_{ijkg} \geq \sum_{j} W_{jk}Q_{jk}$

(5) $Q_{rk} \geq L_{rk} - X_{rk}$

(6) $Y_{jk} \leq Q_{jk} + \sum_{h} F_{jkh} - \sum_{k} F_{jkh}$

(7) $B_{ikh}, D_{ikhg}, F_{jkh}, Q_{jk} \geq 0$

where

P_{jk} = the per unit revenue received for producing the jth livestock product in the kth region.

Q_{jk} = the quantity of the jth livestock unit produced in the kth region.

A_{ikg} = the per unit cost of purchasing the ith feed in the kth region of the gth season.

B_{ikg} = the quantity of the ith feed produced in the kth region of the gth season.

C_{ikhg} = the per unit cost of transporting the ith feed from region k to region h during season g.

D_{ikhg} = the quantity of feed i transported from region k to region h during season g.

E_{jkh} = the per unit cost of transporting the jth livestock unit from region k to region h.

F_{jkh} = the quantity of the jth livestock unit transported from region k to region h.

N_{jk} = the per unit non-feed cost of producing the jth livestock unit in region k.

V_{ikg} = the quantity of the ith feed available for feeding in region k in season g.

M_{ijkg} = the metabolizable energy supplied per unit of the ith feed when fed to the jth class of livestock in region k in season g.

S_{jk} = the metabolizable energy required per unit of product by the jth class of livestock in region k.

T_{ijkg} = the digestible protein supplied per unit of the ith feed when fed to the jth class of livestock in region k in season g.

W_{jk} = the digestible protein required per unit produced by the jth class of livestock in region k.

L_{jk} = the total available quantity of the jth livestock unit produced in the kth region.

Z_{rk} = the per unit cost of liquidating production of the rth livestock unit produced in the kth region.

Y_{jk} = the quantity of the jth livestock product consumed in region k.

The subscripts i, j, h, k, g, and r, represent the following:

*i = 1,2,3,4,5,6,7,8,9,10

where

1 = barley

2 = wheat

3 = corn

4 = oats

5 = milo

6 = hay

7 = protein supplement

8 = private range (pasture)

9 = BLM rangeland

10= Forest Service rangeland

j = 1,2,3,4,5,6,7,8,9,10,11

where

1 = beef

2 = hogs

3 = broilers

4 = turkeys

5 = layers (eggs)

6 = milk cows (milk)

7 = cow/calf

8 = backgrounders

9 = sheep

10 = dairy calf

11 = dairy backgrounders

k,h = 1,2,3,.....,16

where

1 = Region I

2 = Region II

3 = Region III

4 = Region IV

5 = Region V

6 = Region VI

7 = Region VII

8 = Region VIII

9 = Region IX

10= Region X

g = 1,2,3,4,5

where

1 = winter

2 = spring

3 = summer

4 = fall

5 = yearly

r = 1,2

where

1 = cow/calf

2 = sheep

*the reader is referred to Tables 1, 2, 3, and 4.

11 = Region XI

12 = Region XII

13 = Region XIII

14 = Region XIV

15 = Region XV

16 = Region XVI

Written, the objective function is:

(1) To maximize profit of livestock production by selling livestock products at greatest value minus the sum of feed production costs, all livestock production costs (feed and nonfeed), transportation costs, and liquidation costs.

Subject to the bounds (constraints) that:

(2) The quantity of a feed available for feeding in a region per season is less than or equal to local production plus the amount imported minus the amount exported.

(3) Metabolizable energy consumed by livestock in each region must be greater than or equal to the metabolizable energy requirement for each livestock class.

(4) Digestible protein consumed by livestock in each region must be greater than or equal to the digestible protein requirement for each livestock class.

(5) Local livestock production available in a region must be greater than or equal to total livestock production available minus the quantity of livestock liquidated.

(6) Consumption of a livestock product in a region must be less than or equal to the amount of local production plus the amount of imports minus the amount of exports.

(7) All quantities of feed, livestock products produced, and ship-

ments must be greater than or equal to zero (non-negative).

A tabular illustration of a linear programming matrix for one region per season is contained in Figure 3.

Assumptions

In addition to the general linear programming assumptions stated in Chapter II, the specific assumptions of this model are as follows:

(1) The year 1979 is the base year and is considered a "normal" year.

(2) Only the feeds used in this model were considered to be available.

(3) Protein supplement was not produced within the model but was assumed available in each region and season at the seasonal price.

(4) Transportation costs within a region are zero.

(5) Corn silage was converted into hay equivalents and not considered as a separate feed.

(6) Only the livestock classes used in this model were considered to be competing for the feed.

(7) Only 5% of wheat production is consumed by livestock.

(8) Production of livestock products was limited between an upper and lower bound in each region. These bounds were determined by the highest percentage increase and decrease in production of each livestock product in each region over the last 20-25 years. This percentage increase or decrease was then assigned as the acceptable deviation for each individual region from actual 1979 production (Nef, 1979).

(9) Private pasture and public range were nontransferable and available as feed for cow/calf, beef backgrounder, dairy backgrounder, and sheep only.

Activities / Restraints	Production of Feed	Feed Transfer	Feed Conversion	Production of Livestock	Liquidation of Livestock	Livestock Transfer	RHS
Seasonal feed production account	+1	-1					= 0
Yearly feed production account	+1						Act. Prod.
Feed available account		+1	-1				= 0
Mcal/M.E.			+a	-a			= 0
Tons of D.P.			+a	-a			= 0
Yearly livestock production account				+1		-1	= 0
Total livestock production account				+1	+1		Act. Prod.
Consumption of livestock products						+1	Reg. Dmd.
Objective function	-c	-c		+P	-c	-c	
Bounds	b		b	b			

a = data coefficient; c = cost of activity; P = profit of activity; Mcal/M.E. = megacalories of metabolizable energy; tons of D.P. = digestible protein.

Fig. 3. Condensed tabular illustration of linear programming matrix for one region.

(10) One Animal Unit Month (AUM) of grazing was assumed to meet one month's requirement of metabolizable energy for a cow, and five month's requirement for sheep.

(11) 30% of beef cows, 60% of dairy cows, and 20% of ewes were produced as replacements and no revenue was considered.

(12) Because livestock production was not available by county for some regions, livestock population based on the 1978 Agricultural Census was used to extrapolate county production. Therefore all points within each region were assumed to be equally efficient in producing livestock and livestock products.

(13) The number of AUMs available each season of BLM and Forest Service were constrained to represent actual consumption patterns. Private pasture AUMs were constrained in like manner in winter and spring season. Feeds not used within a season were assumed to be lost.

(14) The cow/calf activity produced a 400 pound calf which serves as an input for the backgrounding activity. A 5% decrease in calf numbers was assumed to account for death losses.

(15) The backgrounding activity adds 250 pounds to a calf and thus yields a 650 pound animal which serves as an input for the beef activity.

(16) The beef activity adds 400 pounds to a backgrounder generating a 1050 beef animal. Since only 62% of beef consumed in 1979 was fed beef, final demand was limited to fed beef (Bailey, 1980).

(17) The sheep activity produced a 120 pound lamb. At this point it is assumed the lamb is marketable for immediate slaughter.

(18) Only fluid milk was considered in the model. All other consumption of milk products was converted to the equivalent of fluid milk. Transportation costs were figured only for fluid milk.

(19) Seasons used for this study were considered to be the same for

all regions (Table 3).

(20) Nongrazing feeds produced within the year were assumed to be available for use during any season.

(21) The cow/calf and sheep feed diets were constrained to 50% concentrate feeds to guarantee the necessity of roughage within the diet.

(22) The beef backgrounding activity begins in late summer and enters the feedlot for the fed beef activity in spring allowing the beef backgrounding activity to graze only in fall and winter seasons.

Data Collection

Large quantities of data were gathered from many states for use in this model. Current sources were not readily available; therefore, data used was primarily from secondary sources. This section explains the procedure for collection of the data and its uses. Additional information can also be found within the Appendices. Appendix A contains supplemental Tables of results referred to in Chapter IV. Appendix B contains Tables of data used in the formulation of this model not cited within the text.

Reagional production of feed grains was calculated in tons and obtained from Crop Production 1979 Annual Summary (USDA, 1980). The eleven western state's Agricultural Statistics or Crop and Livestock Commodity Data Sheets (Crop and Livestock Reporting Service, 1979 and 1980; Extension Economic Information Office, 1979) was used for county production figures when states contain more than one region.

Production of range feeds was calculated in AUMS. Range feeds consist of Forest Service, BLM, and private range. An AUM is defined as the amount of forage a 1000 pound cow would eat or five sheep in one month. The number of AUMs available on Forest Service rangeland was determined

from data gathered from Forest Service regional offices (USDA, Forest Service; 1980). The number of AUMs available on BLM rangeland was condensed from a master tape containing all BLM permit holders in the United States (US Department of Interior, 1980). Private range (pasture) consists of irrigated and non-irrigated pasture and crop residue. As estimate of the number of AUMs available on private range was calculated by using information from the Economic Research Service at Colorado State University (Gee, 1981) and combining this with livestock numbers per region listed in Livestock and Meat Statistics Supplement for 1979 (USDA, 1981).

Production of livestock products was obtained from various sources. The units of livestock products were defined as 1000 pounds live-weight of fed beef, hogs, broilers, turkeys, and sheep. Calves and backgrounder production are in number of head. Cattle, hog, and sheep production was obtained from Meat Animals Production, Disposition, Income 1979-1980 (USDA, 1981), and Livestock Slaughter Annual Summary 1979 (USDA, 1981). Actual production of dairy calves was obtained from milk production. For every 1000 pounds of milk produced within a region, a dairy calf was brought into beef production. Milk production was in 1000 pounds and obtained from Dairy Products Annual Summary 1979, (USDA, 1980). The dairy calf at 450 pounds was then transfered into the dairy backgrounding activity. Dairy backgrounders is transfered into fed beef production at the same time as the beef backgrounder. Production of broilers, turkeys, and eggs (1000 dozen) was obtained from Poultry Production, Disposition, & Income 1979 (USDA, 1980). Exports for both feeds and livestock products were obtained from U.S. Foreign Agriculture Trade Statistical Report, Fiscal Year 1979 (USDA, 1980). Because production of livestock products for some states was not available by county, production figures for some regions were calculated on a weighted average. Actual state production

of a particular livestock product was weighted against the percentage of the number of animals per county to the state's animal total obtained from the Census of Agriculture (US Department of Commerce, 1978). An example of determining a weighted average is as follows:

In 1979 for Colorado:

Production of turkeys (1000 pounds) = 98,679

The number of turkeys (1000 head) = 3,885

The number of turkeys in Region 13 = 144

The number of turkeys in Region 15 = 3,741

144 ÷ 3885 = 4%, Region 13

3741 ÷ 3885 = 96%, Region 15

The weighted average is then calculated as follows:

.04 x 98,679 = 3,947 pounds production for Region 13

.96 x 98,679 = 94,732 pounds production for Region 15

The costs of feeds or prices reveived by farmers were taken from Agricultural Prices Annual Summary, 1979 (USDA, 1980). Barley, protein supplement, and hay were the only nongrazing feeds where seasonal prices were used. The costs of grazing on public land were the actual 1979 grazing fees paid, $1.89/AUM on BLM rangeland and $2.03/AUM on Forest Service land. Private pasture grazing fees were obtained from studies at Oklahoma State University (USDA, Firm Enterprise Data System; 1979). In order to show different shadow prices for grazing feeds, seasonal prices on grazing feeds were used. Even though grazing fees are constant year around, nutritive values of an AUM of grazing feed are different for each season. Actual prices for grazing feeds were adjusted by the same percentage of increases or decreases of nutrient values of seasonal AUMs. These actual prices along with shadow prices are presented in table form in the results and analysis chapter.

Nonfeed costs for hogs and sheep were obtained from the previous Firm Enterprise Data System, Oklahoma State University studies. The remaining livestock non-feed costs were updated costs obtained from national studies conducted by the USDA and are presented in Table 5. The index used for updating all costs is presented in Table 6.

Final demand or consumption of livestock products was calculated by using the national per capita consumption for each livestock product and the current population for each region taken from the Census of Population and Housing, Preliminary Report (US Department of Commerce, 1980). Demand for beef, pork, lamb, chicken, and turkey was adjusted to the live weight equivalent. These live-weight equivalent co-efficients for livestock products are presented in Table 7. Final demand was set equal to U.S. production plus export demand. An exception to this was the demand for beef and lamb which was set to less than or equal to actual production. This was done to allow for herd liquidation of yearlings or possible potential breeding stock if a shortage of feed actualy occurred. Only those livestock classes that use public and private range (cattle and sheep) were allowed to liquidate.

Production of feed grains was limited to an upper bound equal to each region's actual 1979 production. Production of livestock products was limited by an upper and lower bound. These bounds were established by actual 1979 production levels with the allowable deviations upward and downward to obtain recommended bounds. These bounds took in to account periods of drought to reflect those years of lower production. The calculation of these deviations was presented in the assumptions of the model.

Transportation costs for feed grains were obtained through transportation cost equations from Texas A&M University (Fuller, 1981).

TABLE 5.--Nonfeed Costs of Livestock Production, 1979 (per livestock unit)

Region	Fed Beef	Cow/ Calf	Back- grounders	Hogs	Sheep	Broilers	Turkeys	Eggs	Milk	Dairy Calf
I	58.28	181.75	36.66	146.17	215.75	120.32	127.00	174.53	57.71	187.86
II	65.85	189.51	40.53	146.17	215.75	120.32	127.00	181.30	51.15	195.88
III	48.39	122.05	29.78	146.17	183.62	120.32	120.30	175.83	56.59	126.15
IV	53.43	146.20	34.43	146.17	183.62	120.32	127.00	174.53	57.71	151.11
V	58.89	158.60	29.78	136.18	154.56	120.32	120.30	187.10	65.11	163.93
VI	65.30	169.10	40.13	136.18	154.56	120.32	120.30	172.43	64.21	174.78
VII	64.90	175.26	39.94	146.17	183.62	120.32	122.50	170.33	67.46	181.15
VIII	64.90	175.26	39.94	146.17	154.56	120.32	122.50	170.33	67.46	181.15
IX	64.90	175.26	39.94	146.17	154.56	120.32	122.50	170.33	67.46	181.15
X	68.19	178.76	43.30	146.17	183.62	120.32	120.30	176.45	57.70	184.77
XI	71.25	181.45	43.69	146.17	183.62	120.32	120.30	178.30	53.67	187.55
XII	65.13	184.13	42.90	146.17	154.56	120.32	120.30	174.62	61.73	190.32
XIII	60.39	173.80	37.15	136.18	128.46	120.32	122.50	169.30	67.66	179.64
XIV	58.79	169.31	36.26	136.18	128.46	120.32	120.30	170.11	66.64	175.00
XV	55.62	175.87	36.79	121.11	133.95	128.42	123.40	167.25	59.70	181.78
XVI	65.26	202.87	40.78	126.88	289.88	128.42	104.00	163.42	68.50	209.69

SOURCES: Dennis L. Nef, 1979, "A National Interregional Study of Ag. Sector Adjustments to Drought with Emphasis on Utah," M.S. thesis (Utah State University, Logan, Utah); U. S. Department of Agriculture, Firm Enterprise Data System, 1979, Budgets (Stillwater, Oklahoma); and E. L. Michalson and I. A. Noteboom, 1966, *Resource Requirements, Costs, and Expected Returns for Alternative Crop and Livestock Enterprises*, Bulletin 641 (Pullman, Washington: Washington Agricultural Experiment Station); and L. A. Voss, B. Rogers, H. B. Jones, and W. L. Henson, 1976, "Turkey Production Costs in Major Regions, 1973-1975," *Poultry and Egg Situation* (June 1976):30-31.

TABLE 6.--Index Used for Updating Costs

Items used for production	
1967 = 100	
1968 = 100	1974 = 166
1969 = 104	1975 = 182
1970 = 108	1976 = 193
1971 = 113	1977 = 200
1972 = 121	1978 = 217
1973 = 146	1979 = 248

SOURCE: U.S. Department of Agriculture; Economics, Statistics, and Cooperative Service, 1980, *Agricultural Prices Annual Summary, 1979* (U.S. Government Printing Office, Washington, D.C.).

TABLE 7.--Live Weight Equivalent Coefficients for Livestock Products

Livestock product:	
Fed beef	Live weight = carcass weight ÷ .598
Hogs	" " = " " ÷ .711
Sheep	" " = " " ÷ .500
Broilers	" " = ready to cook ÷ .755
Turkeys	" " = " " " ÷ .800

SOURCE: U.S. Department of Agriculture, 1980, *Agricultural Statistics--Food Consumption, Prices, and Expenditures* (U.S. Government Printing Office, Washington, D.C.).

Both truck cost equations and rail costs were analyzed for each state. The transportation costs which depict the best method of transport were used in the model. Truck transportation cost equations for each region are presented in Table 8. Hay is also transferable within the model. The formula used for transporting hay is:

$$Y = 7.64 + .04X$$

where

Y = transportation cost in dollars per ton of hay.

X = mileage between regions.

Transportation costs for livestock products were calculated by using a weigh bill study by Dietrich, (1971). These figures were then updated by using the above cost index to 1979.

The formula was:

$$Y = 19.5375 + .02519X \text{ (livestock carcasses)}$$

where

Y = transportation cost in dollars per 1000 pounds.

X = mileage between regions

The carcass weight had to be converted to live weight equivalent since production was in live weight. If for example, the carcass weight of a hog equaled 160 pounds, this figure would be divided by .711 to reach the live weight equivalent of 225 pounds.

Transportation costs for milk and eggs were derived from Witt (1970) and updated using the above cost index. The formula used for milk was:

$$Y = 3.704 + .02963X$$

where

Y = transportation cost in dollars per 1000 pounds.

X = mileage between regions.

The formula for eggs was:

TABLE 8.--Truck Transportation Cost Equations for Feed Grains

Region	Cost Equations
I	$Y^{*} = 3.27401 + .22194\ x^{**}$
II	$Y = 3.30669 + .22382\ x$
III	$Y = 3.14327 + .21663\ x$
IV	$Y = 3.27401 + .22194\ x$
V	$Y = 3.47230 + .23278\ x$
VI	$Y = 3.26622 + .22162\ x$
VII	$Y = 3.30280 + .22312\ x$
VIII	$Y = 3.30280 + .22312\ x$
IX	$Y = 3.30280 + .22312\ x$
X	$Y = 3.22498 + .21996\ x$
XI	$Y = 3.30669 + .22328\ x$
XII	$Y = 3.02033 + .21164\ x$
XIII	$Y = 3.33937 + .22462\ x$
XIV	$Y = 3.32331 + .22396\ x$
XV	$Y = 3.78495 + .25511\ x$
XVI	$Y = 3.78495 + .25511\ x$

SOURCE: Stephen Fuller, 1981, Letter correspondence, April 22 (Department of Agricultural Economics and Sociology, Texas A&M University, College Station, Texas).

*Y = transportation cost in dollars per ton of feed.

**x = mileage between regions.

$$Y = 28.98 + .06238X$$

where

Y = transportation cost, dollars per 1000 dozen.

X = mileage between regions.

Calves and backgrounders were shipped at a flat rate of $1.64 per mile. This is based on the assumption that trucks haul loads of 44,000 pounds of calves or 48,000 pounds of backgrounders (Miller, 1981).

All feeds within the model were converted into livestock products. The feed conversion process required calculation of the megacalories of metabolizable energy and the tons of digestible protein contained in each feed. M.E. is defined as the actual energy that contributes to the maintainence and bodily functions of an animal. DP is the number of tons of protein that an animal can digest. Each unit of livestock has specific nutrient requirements in M.E. and DP in order to produce a livestock product. The model used the above relationships to convert feed to Mcal M.E. and tons of DP and then converts these to livestock products. The exact feed and livestock requirements are presented in Appendix B. The data was calculated from the NRC Tables (National Academy of Sciences, 1975, 1976, 1977, 1978, 1979) and (Bailey, 1980).

Liquidation of cow/calf and sheep activities is incorporated into this model. When liquidation occurs, a cost is incurred which represents potential income forgone above variable costs of production. This cost represents the income expected from the livestock unit over its remaining lifetime, discounted to the present. Several assumptions were made in calculating this cost. One unit of cow/calf culled was one cow with a remaining productive life of four years. In order to rebuild a herd to original size in the remaining three years, a farmer would have to save the equivalent of one-third calf per year. It was assumed that

one unit of sheep culled was equal to 10 ewes, that each ewe had two years of productive life, and that the rancher would replace all ewes culled in the following production year. The income flow was discounted at a 12% annual rate. The method of calculation and liquidation costs used within the model are summarized in Table 9.

Drought Simulation

With all other conditions remaining constant, the amount of feed produced during a drought will obviously be less than normal. Severity of the drought will determine to what extent production will be cut back. Simulation requires some measure of the intensity of a drought and the reduction of production of feeds.

For this model, two types of measures will be used. A weather index will be utilized to measure the effects of rainfall on feed grains. Range response equations will be utilized to measure the effects of rainfall on pasture and rangeland.

Two simulations of drought were examined for this thesis. Drought was simulated by bounding feed production activities to reflect the decreases in production in the regions of drought while increasing prices as implied by their respective elasticities. Production in regions not affected by drought were unchanged. Prices for all regions were directly affected whether or not drought was induced upon that region.

Drought simulation A is a "40-year" drought that affects the regions comprising the Intermountain Area. A "40-year" drought is the worst annual drought expected in a 40 year period. The 1930's drought is equivalent to a "40-year" drought. The regions directly affected by drought A are shown in Figure 4.

Drought B is also a "40-year" drought that affects not only the

TABLE 9.--Liquidation Costs

Cattle:		
Revenue		
Cull Cow 900 lbs. @ $47.68/cwt	$429.12	
Cost		
Year 1 - 1.00 calves @ $160.00/calf; .15 replacement @ $544.00/cow		$241.60
Year 2 - 1.03 calves @ $127.54/calf; .14 replacement @ $433.62/cow		192.07
Year 3 - .82 calves @ $113.87/calf; .10 replacement @ $387.16/cow		132.11
Year 4 - .31 calves @ $101.68/calf; .05 replacement @ $345.71/cow		48.81
Cull cow 900 lbs. @ $30.30/cwt		272.71
Total Cost		$887.32
Cattle Liquidation Cost		$458.20
Sheep:		
Revenue		
10 Cull Ewes 120 lbs. @ $19.20/cwt	$230.40	
Cost		
Year 1 - 19.6 lambs @ $26.46/lamb		$518.62
Year 2 - 10 Cull Ewes 120 lbs. @ $15.30/cwt		183.67
Total Cost		$702.29
Sheep Liquidation Cost		$471.89

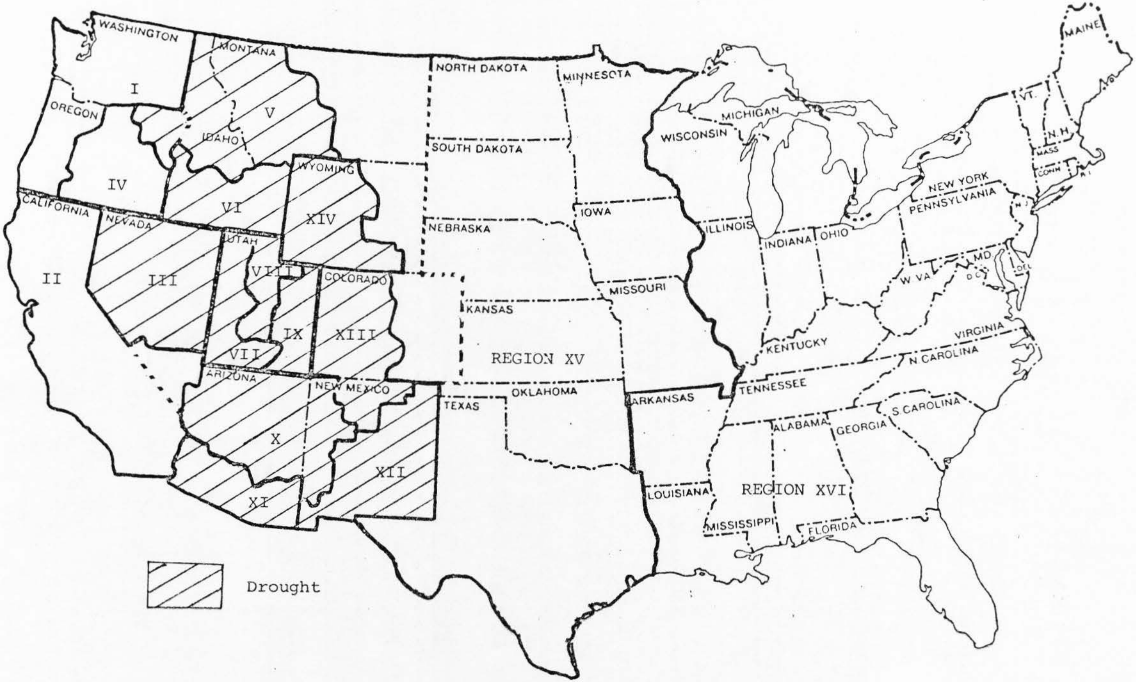

Figure 4. Regions affected by drought A

intermountain area but the midwest. The regions affected by drought B are shown in Figure 5.

Weather indexes for both food and feed grains have been developed by Koo (in Nef, 1979). These indices show the response of crop yields on a state by state basis to weather in that state, compared to the response of crop yields to the weather over the entire United States. For example, Idaho's weather index number of 58 indicates the response of crop yield to weather is 58 percent of the national average response yield. That is, weather has less effect on yields in Idaho than the national average. In New Mexico an index of 151 says that the state's production varies 1.51 times the national average (weather has greater effect). This weather index takes into account those states that have substantial irrigation because their index numbers are lower than 100 (100 being the national average).

Listed within the same study are estimated percentage reductions in production of food and feed grains for a "bad weather" year. A "bad weather" year is one in which the worst weather expected in a certain (ten, twenty, or forty year) period actually occurred in a given year. By combining the weather index for a state with the percentage decrease in production for a given time period, a percentage change in the state's production can be calculated. For example, the weather index for Wyoming is 81 and the percentage reduction in barley for a "40-year" period is 23.68. The percentage change in barley for a "40-year" drought then would be .81 times 23.68 or 19.2 percent decrease of actual production. For those regions that cross state boundaries, a weighted average was used. Weather indices for the states were weighted against the amount of production from each state. Percentage reductions in production of feed grains and hay by region for a "40-year" drought is

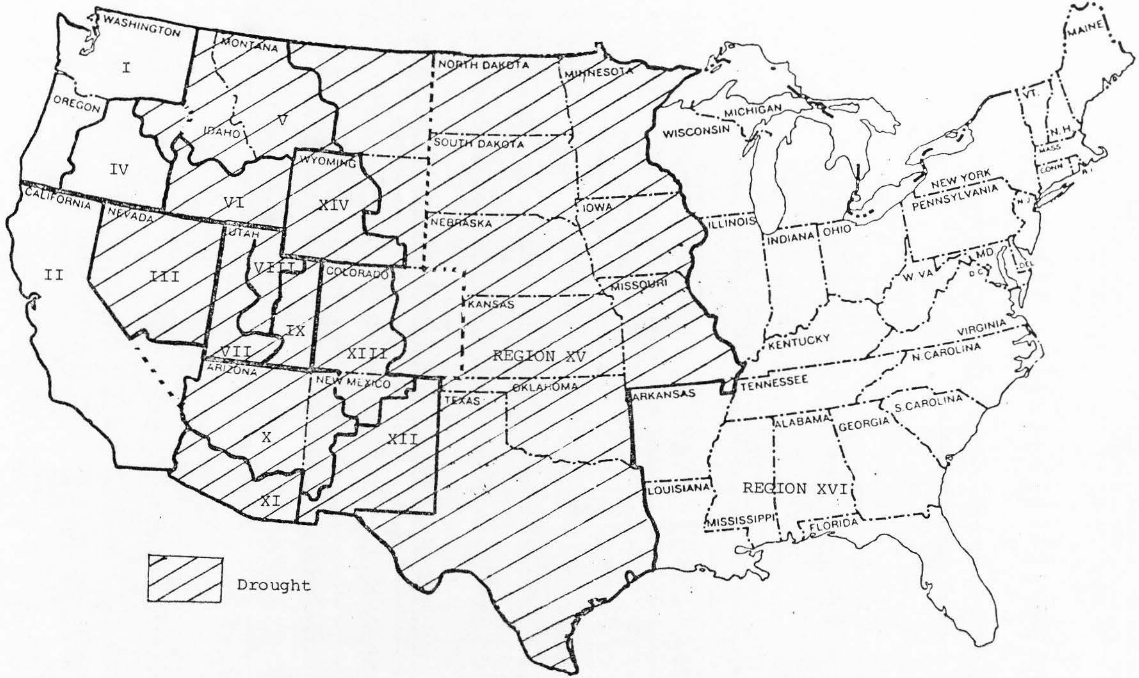

Figure 5. Regions affected by drought B.

shown in Table 10.

Little if any research has been done in pasture production responses. Currently, research on a project of weather modification for livestock feeds has produced range response equations (Perry, 1981). An equation for each state was calculated using range condition data gathered by Crop and Livestock Reporting Service and the Palmer Weather Index. The Palmer value from the drought year being studied is then used to calculate the expected range condition (denoted by C). Reduction is then 1 minus the predicted range condition divided by the mean year's condition. The general range response equation and the co-efficients for each state (excluding region XVI) are listed in Table 11. Percentage reductions in production of public and private pasture per region are listed in Table 12.

Prices in this model will also be affected by the changes in production. With the changes in quantity as calculated above, the change in price was estimated using the percentage decrease in quantity on a national level and the own-price elasticity of demand. Price elasticities for hay and pasture are unavailable. It was assumed that unitary elasticity (-1.0) for hay and pasture would be close enough to reality to avoid distortion (Godfrey, 1981). This means that on a national model, the percent change in production (decrease) causes the same percent change in price (increase). The own price elasticities of demand for other feeds are: Barley -.605; Wheat -2.627; Corn -.317; Oats -.750; Milo -.605; and Protein Supplement -.290 (Womack, 1981). If production of public land (BLM and Forest Service) was decreased due to drought, government action would be to reduce the number of AUMs allowed to be grazed. Prices for BLM and Forest Service AUMs therefore are not affected by drought.

TABLE 10.--Percentage Reductions in Production of Feed Grains and Hay by Region for "40-Year" Drought

Region	Barley	Wheat	Corn	Oats	Milo	Hay
I	16.6	11.4	16.6	16.6	--	16.7
II	16.8	13.5	16.8	16.8	16.8	16.8
III	13.5	10.9	--	--	--	13.5
IV	17.0	12.9	17.0	17.0	--	17.0
V	20.5	13.5	17.0	19.3	--	21.2
VI	13.7	10.0	13.7	13.7	--	13.7
VII	12.8	12.7	12.8	12.8	--	12.8
VIII	12.8	12.7	12.8	12.8	--	12.8
IX	12.8	12.7	12.8	12.8	--	12.8
X	31.9	14.0	24.9	--	16.0	29.2
XI	14.9	12.2	14.9	--	14.9	14.9
XII	35.8	30.4	35.8	--	35.8	35.8
XIII	22.5	26.4	23.1	22.5	24.9	23.6
XIV	19.2	23.3	19.2	19.2	--	19.2
XV	26.5	22.6	25.1	26.9	28.9	27.3
XVI	21.2	13.1	19.7	18.3	22.9	19.4

SOURCE: Calculated by author using weather index and production figures.

TABLE 11.--Range Response Equations and Corresponding States' Coefficients for Determining Grazing Feeds' Percentage Reduction

$$1 - \left(\frac{\text{Anti-log } C}{\alpha}\right)$$

$$C = \log \alpha + \beta P + \gamma P^2$$

where

C = Production as % of normal

α = Mean year range condition

P = Mean Palmer value

State	(α)Alpha	(β)Beta	(γ)Gamma	(P)Palmer
Washington	82.2037	.06020	-.016638	-3.225
Oregon	82.9883	.04576	-.006116	-4.803
California	85.7726	.08336	-.018123	-2.918
Nevada	77.9993	.07966	-.011862	-5.548
Idaho	80.5518	.06579	-.010306	-5.730
Utah	81.5405	.06383	-.012047	-5.052
Arizona	78.3041	.06762	-.006161	-2.944
New Mexico	72.7916	.07642	-.008753	-2.462
Colorado	75.2413	.03784	--	-4.967
Wyoming	84.0070	.03784	-.009745	-4.172
Montana	75.1961	.06726	-.006045	-3.532
North Dakota, South Dakota, Minnesota, Nebraska	73.0395	.10392	-.016406	-5.168
Kansas, Iowa, Missouri	79.0990	.05818	-.007971	-3.851
Oklahoma, Texas	74.8885	.06211	--	-3.615

SOURCE: Gregory M. Perry, "Economic Value of Precipitation Modification on the Livestock Industry in the State of Utah," (unpublished manuscript).

TABLE 12.--Percentage Reductions in Production of Private Pasture, BLM, and Forest Service by Region for "40-Year" Drought

Region	Private Pasture, BLM, and FS
I	30.73
II	35.82
III	53.96
IV	30.30
V	31.60
VI	51.10
VII	46.73
VIII	46.73
IX	46.73
X	21.58
XI	22.31
XII	20.12
XIII	18.11
XIV	27.24
XV	25.32
XVI	--

SOURCE: Calculated by author using range response equations and production figures.

Livestock prices for this study were not changed as the drought simulations were induced. This was due to difficulty in determining appropriate prices. Short run effects would be decrease in prices, caused by increases in culled livestock in the market. Long run effects would be higher prices because of the limited supply of livestock products.

CHAPTER IV

RESULTS AND ANALYSIS

This chapter contains the "optimal solutions" to the base year LP model, drought A simulation, and drought B simulation. The base year solution is analyzed to show the amounts of feed and livestock products that would be produced by each region to meet final demand. Comparison of these to actual production data is presented. The results of the two drought simulations will show the production differences, value changes, and movement of feed between regions.

Care must be taken in interpretation of the results. Base year solutions may or may not represent the"real" world. It should be remembered that this study maximizes profit of livestock production over the entire United States. This optimal solution could differ greatly if compared to solutions where profits were maximized for each region.

Total costs and net profits received by livestock producers are national figures. Costs are incurred at five different levels. These levels are feed production costs, feed transfer costs, livestock production or nonfeed costs, livestock transfer costs, and herd liquidation costs. Total revenue is obtained from the price farmers receive for each livestock product multiplied by total production. Profit is determined by taking total costs from total revenue. Feed export profit is excluded to determine net profit for livestock producers. All costs and profits for the base year and two drought simulations are presented in Table 13.

TABLE 13.--Summary of Total Costs and Net Profits for Base Year, Drought A, and Drought B(1000 Dollars)

	Base Year	Drought A	Drought B
Feed Production Costs	27,472,834	28,466,275	27,789,321
Feed Transfer Costs	271,336	360,372	404,561
Livestock Production Costs	22,958,163	22,968,301	22,953,081
Livestock Transfer Costs	961,683	993,848	959,397
Liquidation Costs	0	4,586	90,933
Total Production Costs	51,664,016	52,793,382	52,197,293
Total Revenue	63,177,766	63,178,142	55,129,877
Feed Export Profit	1,198,404	1,197,977	1,652
Net Livestock Production Profit	10,315,346	9,186,783	2,930,932

Base Year Solution

The base year optimal solution used actual 1979 production figures. Total production costs amounted to over 51 billion dollars. Total revenue was in excess of 63 billion. Livestock producers profit totaled over 10.3 billion dollars.

Feed Production

Optimal feed production of both grazing and nongrazing feeds were generally produced at actual 1979 production levels. Production of all feeds was bounded and could not exceed actual production. Feed grains, hay and private pasture were produced yearly. BLM and Forest Service are produced yearly. Hay production equalled actual production for all regions. Forest Service had excess AUMs in the summer season in regions V and IX. BLM had unused AUMs in winter season for region IX. Region IX also had unused private pasture AUMs. All unused grazing AUMs occurred in the sheep activity while cattle were utilizing all available AUMs. Production of barley was at actual levels except in regions XIV and XV. Wheat was either produced at actual levels or not at all. Regions VI, VII, and XIII through XVI did not produce any wheat. Region XVI had corn production that was less than actual 1979 production levels. Oat production was less than actual levels in regions V, IX, XIV and XV. Most regions do not produce milo. Region XV generally is the largest producer of milo and production was about one-fourth of actual production. This excess feed can be explained by recognizing that not all livestock activities are considered in the model and that some wastage of feed occurs.

Since grazing feeds are cheaper than feed grains, it is easy to

understand their nearly complete utilization. Ranchers anticipate their feed needs by knowing how much grazing and roughage are available and then allow for concentrates to fill the balance. The excess sheep AUMs can be explained in two ways: 1) ranchers set aside too many AUMs for sheep in those regions, or 2) sheep are being brought in from other regions to graze the excess. Tables containing optimal production levels and actual production are presented in Appendix A.

Feeds exported outside of the U.S. were at upper limits or at actual 1979 foreign export levels. Exported feeds consist of barley, corn, oats, and milo.

The marginal value of an additional unit of feed is calculated within the model and is called the shadow price. This is the maximum price for which it would be profitable to pay for another unit of feed. Actual and shadow prices of yearly and seasonal feeds for the base year are presented in Tables 14 and 15. Where actual price equals the shadow price, no additional gain could be made if another unit was brought into production. Identical actual and shadow prices occur where optimal production is less than actual production.

Most shadow prices are higher than, but close to, actual prices. This shows the model agrees relatively closely with actual 1979 conditions. Large differences between shadow and actual prices would indicate the scarcity and value of the feed to that region. This can be seen in barley and corn in region I. Milo is valuable in regions XII and XIII. Shadow prices for the seasonal feeds again indicate that these feeds are the most scarce to the producer. Barley and hay have both seasonal and yearly shadow prices. The model was organized in this manner in order to allow the grazing livestock to consume their available feed in any season. These shadow prices tend to follow the

TABLE 14.--Actual and Shadow Prices of Yearly Feeds--Base Year, 1979

Region		Barley	Wheat	Corn	Oats	Milo	Hay
		---------------------$/ton---------------------					
I	Actual	96.86	126.80	94.63	100.00	--	62.79
	Shadow	121.42	130.33	130.18	119.59	160.27	82.77
II	Actual	105.80	126.70	114.30	120.30	176.40	82.42
	Shadow	122.37	129.60	128.64	120.53	176.40	84.32
III	Actual	91.65	111.70	--	--	--	70.00
	Shadow	116.77	123.81	123.67	115.18	145.15	72.51
IV	Actual	102.10	128.30	107.10	99.06	--	64.00
	Shadow	120.64	129.50	129.35	111.87	139.02	72.48
V	Actual	97.91	122.20	92.26	97.61	--	58.83
	Shadow	102.11	122.20	115.46	97.61	137.41	69.87
VI	Actual	102.10	117.30	93.92	103.10	--	58.00
	Shadow	108.41	117.30	116.42	107.67	131.60	64.73
VII	Actual	91.98	111.00	89.08	106.30	--	52.42
	Shadow	101.47	111.00	109.38	106.30	127.56	60.76
VIII	Actual	91.98	111.00	89.08	106.30	--	52.42
	Shadow	109.58	117.62	117.49	108.40	127.56	68.20
IX	Actual	91.98	111.00	89.08	106.30	--	52.42
	Shadow	109.09	117.10	116.96	106.30	135.18	65.17
X	Actual	104.20	119.90	105.40	--	100.00	73.75
	Shadow	117.01	123.91	123.77	115.96	127.10	81.13
XI	Actual	108.30	125.70	110.70	--	111.10	78.50
	Shadow	118.56	127.25	127.11	115.96	127.10	83.32
XII	Actual	100.00	114.20	100.00	--	88.93	69.00
	Shadow	123.47	127.54	127.40	115.69	127.10	83.51
XIII	Actual	98.61	115.80	95.24	100.00	81.55	58.67
	Shadow	103.27	115.80	110.71	101.73	127.10	77.35
XIV	Actual	81.84	107.40	89.08	91.82	--	57.79
	Shadow	81.84	107.40	99.65	91.82	147.99	61.98
XV	Actual	82.88	110.90	81.52	82.03	127.10	41.50
	Shadow	82.88	110.90	86.90	82.03	127.10	56.96
XVI	Actual	87.88	123.60	86.90	87.97	118.80	48.92
	Shadow	104.97	123.60	86.90	89.86	127.10	68.72

TABLE 15.--Actual and Shadow Prices for Seasonal Feeds--Base Year, 1979

Region	Season	Forest Service Actual	BLM Actual	Private Pasture Actual	FS, BLM, PP Shadow		Barley		Hay	
					Cattle	Sheep	Actual	Shadow	Actual	Shadow
		--------$/AUM--------					--------$/ton--------			
I	W	2.71	2.52	7.60	34.56	21.42	103.54	128.10	78.00	97.98
	Sp	2.12	1.97	5.97	36.73	20.06	102.22	126.78	88.83	108.22
	Su	1.48	1.37	4.15	29.57	17.97	97.98	122.54	63.66	86.64
	F	1.95	1.81	5.97	30.89	19.29	105.76	130.32	66.83	86.81
II	W	2.71	2.52	10.80	38.52	18.00	119.44	135.98	106.34	108.24
	Sp	2.03	1.84	8.10	37.57	21.68	117.08	133.58	103.67	105.57
	Su	1.62	1.51	6.48	29.62	13.68	108.06	125.00	81.33	83.23
	F	1.95	1.81	7.78	30.92	14.98	113.61	130.15	86.17	88.07
III	W	3.04	2.84	11.40	31.80	7.74	97.68	122.80	89.00	91.51
	Sp	2.21	2.06	8.29	28.69	9.64	96.88	122.00	94.17	96.68
	Su	1.44	1.33	5.36	25.62	5.36	92.43	117.55	69.50	72.01
	F	2.03	1.89	7.60	28.00	7.10	99.77	124.89	77.67	80.18
IV	W	2.71	2.52	7.73	30.24	29.73	101.25	120.93	76.50	84.98
	Sp	2.14	1.99	6.11	26.63	11.94	101.66	121.34	82.00	90.48
	Su	1.48	1.37	4.22	22.12	10.05	98.88	118.56	53.67	62.15
	F	1.95	1.81	5.57	26.09	11.40	102.78	122.46	64.83	73.31
V	W	3.05	2.84	10.95	25.07	24.65	96.94	101.14	59.42	70.46
	Sp	2.44	2.27	8.76	27.23	26.77	99.72	103.92	65.50	76.54
	Su	1.34	1.26	4.87	20.86	1.35	87.01	91.21	48.92	59.96
	F	2.03	1.89	7.30	23.29	22.90	96.46	100.66	54.42	65.46
VI	W	2.87	2.67	10.87	21.02	20.71	102.92	109.25	63.50	70.23
	Sp	2.32	2.16	8.80	27.46	21.81	112.50	118.83	77.50	84.23
	Su	1.43	1.33	5.44	18.76	18.45	95.98	102.31	46.00	52.73
	F	2.03	1.84	7.70	21.02	20.71	103.33	109.66	52.67	59.40

TABLE 15--Continued

Region	Season	Forest Service Actual	BLM Actual	Private Pasture Actual	FS, BLM, PP Shadow		Barley		Hay	
					Cattle	Sheep	Actual	Shadow	Actual	Shadow
		------------------$/AUM	------------------				---------------$/ton	---------------		
VII	W	2.87	2.67	10.59	25.68	6.24	104.58	114.07	63.83	72.17
	Sp	2.32	2.16	8.57	23.66	8.57	107.22	116.71	62.67	71.01
	Su	1.43	1.33	5.29	20.38	5.29	90.14	99.63	51.17	59.51
	F	2.03	1.89	7.50	22.59	7.50	99.31	108.80	55.83	64.17
VIII	W	2.87	2.67	10.59	28.33	27.85	104.58	122.18	63.83	79.61
	Sp	2.32	2.16	8.57	27.92	24.42	107.22	124.82	62.67	78.45
	Su	1.43	1.33	5.29	13.58	21.14	90.14	107.74	51.17	66.95
	F	2.03	1.89	7.50	15.79	23.35	99.31	116.91	55.83	71.61
IX	W	2.87	2.67	10.59	27.25	2.67	104.58	121.69	63.83	76.58
	Sp	2.32	2.16	8.57	25.23	8.09	107.22	124.33	62.67	75.42
	Su	1.43	1.33	5.29	21.95	1.43	90.14	107.25	51.17	63.92
	F	2.03	1.89	7.50	24.16	7.50	99.31	116.42	55.83	68.58
X	W	2.71	2.52	9.53	31.24	12.43	125.08	142.10	87.84	95.22
	Sp	2.03	1.89	7.15	17.06	11.34	105.29	122.31	79.50	86.88
	Su	1.62	1.51	5.72	7.05	8.62	109.67	126.69	72.16	79.54
	F	1.96	1.83	6.92	16.83	9.82	118.63	135.65	74.84	82.22
XI	W	2.56	2.39	9.60	37.54	12.81	127.08	137.34	100.67	105.49
	Sp	2.03	1.89	7.60	33.03	12.11	107.29	117.55	88.00	92.82
	Su	1.62	1.51	6.08	29.53	9.32	111.67	121.93	78.16	82.98
	F	2.03	1.89	7.60	31.05	10.84	120.63	130.89	83.00	87.25
XII	W	2.56	2.39	8.46	31.84	11.68	103.89	127.36	75.00	89.51
	Sp	2.03	1.89	6.70	12.02	11.16	91.94	114.60	71.00	85.51
	Su	1.62	1.51	5.36	10.68	8.58	92.08	114.85	66.17	80.68
	F	2.03	1.89	6.76	12.08	9.98	100.56	124.03	66.67	81.18

TABLE 15--Continued

Region	Season	Forest Service Actual	BLM Actual	Private Pasture Actual	FS, BLM, PP Shadow		Barley		Hay	
					Cattle	Sheep	Actual	Shadow	Actual	Shadow
		\$/AUM					\$/ton			
XIII	W	3.05	2.84	10.73	25.81	25.37	103.89	108.55	53.84	72.52
	Sp	2.44	2.27	8.58	24.16	25.08	91.94	96.60	53.00	71.68
	Su	1.35	1.26	4.77	10.59	9.29	92.08	96.74	52.50	71.18
	F	2.03	1.89	7.15	16.88	11.67	100.56	105.22	52.84	71.52
XIV	W	3.05	2.84	11.70	21.34	20.99	104.58	104.58	55.83	60.02
	Sp	2.44	2.27	9.36	19.69	19.36	105.86	105.86	51.16	55.35
	Su	1.35	1.26	5.20	8.41	7.37	99.31	99.31	52.33	56.52
	F	2.03	1.89	7.80	11.01	9.97	108.33	108.33	57.17	61.36
XV	W	2.86	2.67	7.91	21.10	20.74	88.06	88.06	43.83	59.29
	Sp	2.32	2.16	6.40	19.73	19.40	87.64	87.64	40.00	55.46
	Su	1.43	1.33	3.95	18.67	7.02	87.29	87.29	38.33	53.79
	F	1.95	1.81	5.38	20.09	8.44	89.58	89.58	41.00	56.46
XVI	W	2.71	2.52	8.17	25.30	10.80	84.07	101.16	45.30	71.10
	Sp	2.03	1.89	6.13	23.88	8.76	82.10	99.19	41.33	67.13
	Su	1.62	1.51	4.90	22.03	7.53	81.60	98.69	41.33	67.13
	F	1.95	1.81	5.88	23.01	8.51	83.47	100.56	42.50	68.30

[a]Actual prices for cattle and sheep are the same on forest service, BLM, and private pasture in all regions.

expected pattern for grazing feeds; rising to their highest point in the winter and early spring when they are scarce and falling to their lowest value in the summer and early fall when abundant. The shadow prices of Forest Service, BLM, and private pasture range from as high as $38 for cattle in region II to as low as the actual price of $1.35 for sheep in region V where excess forage is available.

Shadow prices, particularly for grazing feeds and hay, are much higher than the actual prices shown for these feeds. Several reasons could explain these results. Not all costs of using grazing feeds are recognized in the prices paid for these feeds. If these costs of management, improvements, and losses were included with the fee cost, total cost to use public land would be much closer to the shadow price. Estimates of AUMs available from private pasture were low and if energy requirements to produce a livestock product were high, the net effect would be using up available pasture much faster and shifting to the next best resource. This is turn causes higher shadow prices than normal. High shadow prices for hay can be explained partly by the quality of hay being used. Hay in the model was assumed to be alfalfa hay. Hay fed to cow/calf and sheep are of poorer quality and lower price. The price used in the model is that of all alfalfa which represents a higher price for the resource than what ranchers actually pay for it. Hay being the next best resource for grazing feeds, explains why shadow prices are high for grazing feeds. One must look at the changes in shadow prices from season to season and from simulation to simulation to get true representation of real conditions.

Feed transfer occurred within the model but in small amounts. Barley and corn were transferred between the three Utah regions (VII, VIII, and IX). Corn was shipped from the midwest (XV) to nearly all western

regions. Seasonal transfer occurred in barley and hay from regions V to I, and from regions VI to III.

Livestock Production

A table listing production of livestock by region is in Appendix A. Production of livestock products seems to reflect reality quite well. One exception would be the backgrounding activity. Both beef and dairy backgrounders are not produced at all in some regions where cow/calf and milk production is high. The model tends to transport these activities to more profitable producing regions like the midwest or east. The model shows that beef and layers are unprofitable to produce in all regions except XIV and XV. Hogs are unprofitable to produce in all regions except XV and XVI. Regions III through XIV do not actually produce broulders but could profitably produce them according to the model. Of the regions that actually produce turkeys, only XVI does so profitably. Again the model indicates several non-producing western regions could produce turkeys at a profit. Milk is profitable to produce in regions II, X, XI, and XVI. Dairy calf production is tied to milk production and generally moves parallel to it. Dairy backgrounding production does not follow the dairy calf movement at all.

No liquidation occurred in the base year, therefore, final demand or consumption requirements were met. Transportation of livestock products occurred normally in order for high consuming regions to obtain needed livestock products from high producing regions.

Drought A

The areas directly affected by drought A are the Intermountain States consisting of regions III through XIV, excluding region IV. The

severity of Drought A was a "40-year" drought or the worst drought in the past 40 years to happen in a single year. All costs and profits for for Drought A are summarized in Table 13. Net profit was in excess of 9.1 billion dollars, which was a 10.8 percent decrease from the base year. Feed export profit decreased slightly because of higher production costs even though export amounts were the same. Feed production costs were higher due to the increased feed prices. Transportation costs were higher because transfer activities increased to meet the shortages of feeds in certain regions. Feed production costs increased by nearly a billion dollars. Feed transfer costs increased about 90 million dollars. Feed transfer costs increased about 90 million dollars. Of the total costs, feed production amounted to 54 percent, livestock production was 43.5 percent and transfer costs accounted for the remaining 2.5 percent. A small amount of sheep liquidation occurred at a national cost of 4.5 million dollars.

Feed Production

Feed production amounts dropped to lower levels due to the induced drought. Production in previous surplus areas increased to meet feed demand. Tables of feed production for drought A are located in Appendix A. Both grazing and nongrazing feeds were generally produced at their upper bounds. Barley production was expanded in region XV. Wheat was produced at upper levels in regions VI, VII, XIII, and XIV. Oats production not only dropped in drought regions, but was not produced at all in region II. This shows that it is generally cheaper to expand barley and wheat compared to oats to meet requirements. Milo production in surplus regions does not increase to meet shortages of other feeds. Roughage feeds become even more constrained during drought. Hay is at

its upper level of production. Private pasture and BLM all go to their upper levels of production. Sheep, in region IX summer season, do not utilize all available Forest Service AUMs, and the model does not allow cattle to use the surplus.

Shadow prices and their percentage increases from the base year of both yearly and seasonal feeds are presented in Tables 16 and 17. Examination of these prices show increased values of additional units of feed. Hay peaks at a 38 percent increase in price for region VII. This means that ranchers would be willing to pay $84 rather than base price of $61 in region VII to get another ton of hay. Regions XIV, IX, VI, and III also have large increases in shadow prices for hay. Shadow prices for the feed grains increase relatively moderately (.2 to 16 percent). Region VII shows higher than average prices compared to other regions for barley, wheat, corn and oats.

Shadow prices for cattle feed range from under one percent increase in many regions to as high as 92 percent in region X for the summer season. Those regions affected by drought show about a 30 percent increase in prices for cattle on the average. Sheep AUMs are even more scarce. Region V for the summer season has a shadow price 17 times above the base year price. Region III has a 250 percent and 475 percent increase in sheep range shadow prices in the spring and summer seasons. Other large increases in sheep grazing shasow prices occur in regions VII and IX. Sheep grazing prices are generally higher than cattle shadow prices for all regions.

Feed transfer is nearly identical to the base year. Exceptions include an increase in corn transfers from the midwest to the west. Oats, barley, and corn are shipped into regions VI, and VII. Hay is now being transfered in all seasons to region III from regions VI and XIV.

TABLE 16.--Shadow Prices of Yearly Feeds with Percentage Increases from Base Year--Drought A

Region		Barley	Wheat	Corn	Oats	Milo	Hay
		----------------------$/ton----------------------					
I	Price	122.95	130.53	130.38	121.02	168.72	85.46
	% change	1.3	0.2	0.2	1.2	5.3	3.2
II	Price	122.51	129.77	128.84	120.67	181.52	84.45
	% change	0.1	0.1	0.2	0.1	2.9	0.2
III	Price	125.00	126.07	123.87	116.90	153.60	88.56
	% change	7.0	1.8	0.2	1.5	5.8	22.1
IV	Price	133.90	129.70	129.55	112.02	147.47	82.12
	% change	10.9	0.2	0.2	0.2	6.1	13.3
V	Price	118.91	122.64	122.44	106.40	145.86	82.23
	% change	16.5	0.4	6.0	9.0	6.1	17.7
VI	Price	117.41	126.02	125.88	116.10	140.05	82.51
	% change	8.3	7.4	8.1	7.8	6.4	27.5
VII	Price	117.33	126.11	125.80	115.67	131.25	84.01
	% change	15.6	13.6	15.0	8.8	2.9	38.3
VIII	Price	114.13	119.87	117.69	112.67	136.01	77.14
	% change	4.2	1.9	0.2	3.9	6.6	13.1
IX	Price	115.99	124.62	124.10	108.05	138.87	82.72
	% change	6.3	6.4	6.1	1.6	2.7	26.9
X	Price	122.36	127.32	123.97	119.15	131.70	92.75
	% change	4.6	2.8	0.1	2.8	3.6	14.3
XI	Price	133.59	127.45	127.31	118.51	130.79	83.45
	% change	12.7	0.2	0.2	2.2	2.9	0.2
XII	Price	123.50	127.74	127.60	118.24	130.79	83.64
	% change	0.1	0.2	0.2	2.2	2.9	0.2
XIII	Price	112.44	119.46	116.02	106.55	130.79	87.91
	% change	8.9	3.2	4.8	4.7	2.9	13.7
XIV	Price	100.84	111.49	109.31	99.53	154.10	80.30
	% change	9.8	3.8	9.7	8.4	4.1	29.6
XV	Price	94.08	111.30	87.10	82.28	130.79	57.09
	% change	7.1	0.4	0.2	0.3	2.9	0.2
XVI	Price	105.45	124.04	87.10	90.01	130.79	68.83
	% change	0.5	0.4	0.2	0.2	2.9	0.2

TABLE 17.--Shadow Prices[a] of Seasonal Feeds with Percentage Increases from Base Year--Drought A

Region	Season	BLM, FS, PP Cattle	% Inc.	Sheep	% Inc.	Barley	% Inc.	Hay	% Inc.
I	W	35.92	3.9	24.81	15.8	130.10	1.6	100.94	3.0
	Sp	39.84	8.5	24.70	23.1	128.69	1.5	111.96	3.5
	Su	30.51	3.2	21.26	18.3	124.15	1.3	89.40	3.2
	F	31.87	3.2	22.62	17.3	132.48	1.7	89.57	3.2
II	W	38.71	0.5	18.14	0.8	137.08	0.8	108.79	0.5
	Sp	37.74	0.5	21.94	1.2	134.51	0.7	106.07	0.5
	Su	29.66	0.1	13.70	0.1	125.33	0.3	83.34	0.1
	F	31.41	1.6	15.04	0.4	130.84	0.5	88.27	0.2
III	W	38.21	20.2	7.74	-0-	131.46	7.1	107.90	17.9
	Sp	40.27	40.4	33.81	250.7	130.60	7.5	113.16	17.0
	Su	31.33	22.3	30.80	474.6	125.84	7.1	88.05	22.3
	F	34.29	22.5	33.10	335.5	133.69	7.0	96.36	20.2
IV	W	33.75	11.6	33.18	11.6	133.01	9.9	94.84	11.6
	Sp	30.08	12.9	17.59	47.3	133.45	9.9	100.44	11.0
	Su	25.48	15.2	15.64	55.6	130.47	10.0	71.61	15.2
	F	29.52	13.1	17.03	49.4	134.65	9.9	82.97	13.2
V	W	29.48	17.6	28.98	17.6	117.87	16.5	82.83	17.6
	Sp	31.68	16.3	31.14	16.3	120.85	16.3	89.02	16.3
	Su	25.16	20.6	24.70	1729.6	107.24	17.6	72.15	20.3
	F	27.66	18.8	27.20	18.8	117.36	16.6	77.74	18.8
VI	W	31.35	25.5	30.82	25.4	118.31	8.3	88.10	25.4
	Sp	33.95	23.6	33.37	53.0	128.56	8.2	102.35	21.5
	Su	25.01	33.1	24.59	33.3	110.88	8.4	70.29	33.3
	F	27.43	30.5	26.96	30.2	118.75	8.3	77.08	29.8
VII	W	34.03	32.5	11.53	84.8	130.82	14.7	95.62	32.5
	Sp	33.61	42.1	30.35	254.1	133.65	14.5	94.44	32.9
	Su	28.85	41.6	26.97	409.8	115.36	15.8	82.74	39.0
	F	31.13	37.8	29.25	290.0	125.18	15.1	87.48	36.3
VIII	W	31.58	11.5	31.05	11.5	127.62	4.5	88.75	11.5
	Sp	31.16	11.6	30.63	25.4	130.45	4.5	87.57	11.6
	Su	26.40	94.4	25.92	22.6	112.16	4.1	75.87	13.3
	F	28.68	81.6	28.20	20.8	121.98	4.3	80.61	12.6
IX	W	33.57	23.2	9.55	257.7	129.48	6.4	94.33	23.2
	Sp	33.15	31.4	28.98	258.2	132.31	6.4	93.15	23.5
	Su	28.39	29.3	1.43	-0-	114.02	6.3	81.45	27.4
	F	30.67	26.9	27.88	271.7	123.84	6.4	86.19	25.7
X	W	32.80	4.9	15.81	27.2	149.22	5.0	107.08	12.5
	Sp	32.02	87.7	13.36	17.8	128.03	4.7	98.60	13.5
	Su	13.56	92.3	11.89	37.9	132.72	4.8	91.13	14.6
	F	22.50	33.7	13.12	33.6	142.32	4.9	93.85	14.1

TABLE 17--Continued

Region	Season	BLM, FS, PP Cattle	% Inc.	Sheep	% Inc.	Barley	% Inc.	Hay	% Inc.
XI	W	37.72	0.5	14.46	12.6	153.69	11.9	106.01	0.5
	Sp	33.14	0.3	12.40	2.4	132.50	12.7	93.12	0.3
	Su	29.57	0.1	10.84	16.3	137.19	12.5	83.10	0.1
	F	31.13	0.3	12.40	14.4	146.79	12.1	88.03	0.9
XII	W	31.92	0.3	12.35	5.7	127.65	0.2	89.75	0.3
	Sp	19.41	61.5	13.02	16.7	114.87	.0.2	85.68	0.2
	Su	12.02	12.5	9.16	6.8	115.02	0.1	80.76	0.1
	F	13.46	11.4	10.60	6.2	124.10	0.1	81.27	0.1
XIII	W	29.53	14.4	29.03	14.4	118.09	8.8	82.99	14.4
	Sp	29.23	20.9	28.73	14.6	105.30	9.0	82.14	14.6
	Su	16.31	54.0	24.81	150.0	105.45	9.0	81.63	14.7
	F	18.76	11.1	27.26	133.6	114.53	8.8	81.98	14.6
XIV	W	27.87	30.6	27.39	30.5	114.48	9.5	78.31	30.5
	Sp	26.18	32.9	25.73	32.9	115.85	9.4	73.56	32.9
	Su	11.62	38.2	9.75	32.3	108.84	9.6	74.75	32.3
	F	14.30	29.9	12.43	24.7	118.50	9.4	79.67	29.8
XV	W	21.16	0.3	20.80	0.3	94.28	7.1	59.47	0.3
	Sp	19.77	0.2	19.44	0.2	93.83	7.1	55.57	0.2
	Su	18.71	0.2	7.03	0.1	93.45	7.1	53.87	0.1
	F	20.18	0.4	8.50	0.7	95.90	7.1	56.59	0.2
XVI	W	25.35	0.2	12.14	12.4	101.38	0.2	71.25	0.2
	Sp	23.91	0.1	10.04	14.6	99.27	0.1	67.21	0.1
	Su	22.08	0.2	8.77	16.5	98.73	0.1	67.21	0.1
	F	23.15	0.6	9.78	14.9	100.73	0.2	68.40	0.1

[a]Shadow prices are dollars per AUM for forest service, BLM, and private pasture; dollars per ton for barley and hay.

Livestock Production

Livestock production levels for all activities in Drought A can be viewed in Appendix A. Production trends are nearly the same. Beef is no longer profitable in region XIV and drops to its lower level of production. Region XV picks up the balance of beef production. Broiler production in region XII drops to zero, which is actual production. Pork, milk, turkeys, eggs, beef calves, and dairy calves have production identical to the base year. Both beef and dairy backgrounding activities are at the same production levels but production sites vary between base year and Drought A. Region II which did not produce any beef backgrounders is now producing actual 1979 amounts. Region X actually produced dairy backgrounders, but in Drought A, production went to zero.

Liquidation of sheep occurred in Drought A. A total of 9,715 units or 97,150 ewes were culled from regions III, VI, VII, and VIII. This dropped sheep production levels to lower limits. These regions also became unprofitable production regions showing higher shadow prices for feed and new destination points of feed transfer activities. Actual prices received by sheep producers were held constant when liquidation occured. Liquidation would effect these prices in the near future, but current market prices was used for the immediate effects of liquidation.

Costs of producing sheep in these regions along with the limited supply of feed, made liquidation of sheep the only alternative. Even though liquidation did occur, total consumption demand was met by other regions producing more sheep. Regions XV and XVI increased production to make up the deficit of those regions that culled. Increased transportation of products to meet final demand was necessary in Drought A.

Drought B

Drought B is the same as Drought A in severity but affects a much larger area. The area affected by Drought B includes the Intermountain States (Drought A) plus region XV (midwest), which produces a large percentage of the total amount of feed grains produced in the United States.

Total costs from Drought B showed a one percent or 600 million dollar decrease as compared to Drought A. This lower cost resulted from lower costs in feed and livestock production and livestock transfer costs. Even with feed prices higher, production costs were lowered by 700 million dollars. Liquidation occured in both cattle and sheep amounting to a 87 million dollar increase in cost. Liquidation caused lower livestock production and transfer costs. Total revenue dropped 8 billion dollars as a result of the decreased livestock production. Feed export profit dropped to a little over a million dollars. The changes in cost and revenue caused a decrease in livestock production profit of near 70 percent to 2.9 billion dollars.

Feed Production

Feed production in Drought B varies from the previous simulation. Barley, wheat, and oats are now produced at upper levels. Foreign exports of barley and wheat were zero. Corn and milo production actually declines. With increases in price, it was cheaper not to produce milo and corn (region II only) and meet shortages by herd liquidation. Milo exports decreased but still amount to over 71 thousand tons, all from region XII. Grazing feeds and hay are at their upper levels of production with no surplus except a small amount of summer grazing on Forest Service for sheep in region IX. Drought B feed production tables are

located in Appendix A.

Shadow prices show the severity of drought B. Tables 18 and 19 contain Drought B's shadow prices and percentage increases from the base year for yearly and seasonal feeds. Barley shadow prices increase up to 66 percent above the base year, because barley is the only grain that grazing livestock can consume. All grazing livestock feeds are at upper levels and very valuable. Other grain feeds average about a 25 percent increase from base year prices with certain regions slightly higher. Grazing prices are up on the average of 20 to 30 percent. All regions except I, II, VI, and XI show increases from 100 percent to over 200 percent in certain seasons in both cattle and sheep. Seasonal barley and hay prices follow the same trend as their yearly shadow prices indicate.

Feed transfer has increased in drought B as can be expected. The transferring of barley, wheat, and oats has increased amoung the western regions, replacing some of the corn that was being transported in from region XV. Corn transfer to western regions occurs less frequently.

Livestock Production

Liquidation occurred in both cattle and sheep. Culling was heavy in the sheep industry with 57,774 livestock units or 579,774 ewes culled. Culling took place in regions I, III, V, VI, VII, VIII, XIII, and XV. Region XV (midwest) culled about 70 percent of the total. In contrast, 140,372 beef cows were culled in the western regions of I, II, III, VII, IX, AND XI. Prices received for livestock products were again held constant at the existing market prices. These results indicate that the beef industry would take scarce resources away from the sheep industry under drought conditions. With a large amount of liquidation, consumption demands could not be met in either beef or lamb. Consumption of

TABLE 18.--Shadow Prices of Yearly Feeds with Percentage Increases from Base Year--Drought B

Region		Barley	Wheat	Corn	Oats	Milo	Hay
		----------------------$/ton----------------------					
I	Price	149.61	160.58	160.40	140.18	189.72	105.14
	% change	23.2	23.2	23.2	17.2	18.4	27.0
II	Price	148.17	159.04	164.21	147.62	256.20	104.13
	% change	21.1	22.7	27.7	22.5	45.2	23.5
III	Price	164.53	155.67	153.89	135.79	175.72	106.64
	% change	41.6	25.7	24.4	17.9	21.1	47.01
IV	Price	162.20	159.75	159.57	139.97	168.47	101.42
	% change	34.4	23.4	23.4	23.4	21.2	39.9
V	Price	149.58	152.63	152.46	132.74	166.86	103.60
	% change	46.5	24.9	32.0	35.9	21.4	48.3
VI	Price	145.41	156.08	155.90	139.19	162.17	102.19
	% change	34.1	33.1	33.9	29.3	23.2	57.9
VII	Price	145.33	156.00	155.82	136.66	160.88	102.14
	% change	43.2	40.5	42.5	28.6	26.1	68.01
VIII	Price	139.41	149.21	147.71	131.56	157.66	99.55
	% change	27.2	26.9	25.7	21.4	23.6	45.9
IX	Price	147.03	155.99	154.12	135.97	159.33	107.09
	% change	34.7	33.2	31.8	27.9	17.9	64.3
X	Price	159.37	157.93	153.99	139.54	161.20	114.43
	% change	36.2	27.5	24.4	20.3	26.8	41.0
XI	Price	163.44	157.51	159.04	139.65	161.36	103.13
	% change	37.9	23.8	25.1	20.4	26.9	23.8
XII	Price	162.78	158.46	157.62	137.34	150.23	110.98
	% change	31.8	24.2	23.7	18.7	18.2	32.9
XIII	Price	151.66	151.21	146.04	134.26	151.25	116.75
	% change	46.9	30.6	31.9	31.9	19.0	50.9
XIV	Price	128.48	142.44	139.33	123.34	174.56	102.57
	% change	39.9	32.6	29.8	34.3	17.9	65.5
XV	Price	146.45	124.21	117.12	112.37	184.60	100.42
	% change	66.7	12.0	34.8	36.9	45.2	76.3
XVI	Price	136.88	136.40	124.85	118.34	172.53	90.13
	% change	30.4	10.4	43.7	31.7	35.7	31.2

TABLE 19.--Shadow Prices[a] of Seasonal Feeds with Percentage Increases from Base Year--Drought B

		BLM, FS, PP							
Region	Season	Cattle	% Inc.	Sheep	% Inc.	Barley	% Inc.	Hay	% Inc.
I	W	41.52	20.1	28.69	33.9	157.99	23.3	122.49	25.0
	Sp	47.99	30.7	28.34	41.3	156.34	23.3	134.85	24.6
	Su	37.51	26.9	24.68	37.3	151.02	23.2	109.55	26.2
	F	39.05	26.4	26.22	35.9	160.78	23.4	109.75	26.4
II	W	46.77	21.4	26.00	44.4	165.25	21.5	131.42	21.4
	Sp	45.68	21.6	33.62	55.1	162.23	21.4	128.38	21.6
	Su	36.61	23.6	20.98	53.4	151.47	21.2	102.89	23.6
	F	38.58	24.8	22.49	50.1	157.93	21.3	108.41	23.1
III	W	45.46	42.9	7.79	0.6	172.10	40.1	128.32	40.2
	Sp	47.76	66.5	44.05	476.6	171.09	40.2	134.22	38.8
	Su	37.74	47.3	37.11	592.4	165.51	40.8	106.07	47.3
	F	40.34	44.1	40.37	431.2	174.72	39.9	115.39	43.9
IV	W	41.16	36.1	40.47	36.1	161.16	33.3	115.68	36.3
	Sp	37.05	39.1	29.78	141.4	161.67	33.2	121.95	34.8
	Su	31.89	44.2	22.24	121.3	158.18	33.4	89.63	44.2
	F	35.42	39.6	23.81	108.8	163.08	33.2	102.36	39.6
V	W	37.10	47.9	36.47	47.9	148.36	46.7	104.27	48.0
	Sp	39.57	45.3	38.90	45.3	151.85	46.1	111.21	45.3
	Su	32.25	54.6	31.66	2245.2	135.90	47.8	92.29	53.9
	F	35.07	50.6	34.48	48.0	147.76	46.8	98.57	50.6
VI	W	38.60	54.5	37.95	54.5	146.46	34.1	108.47	54.4
	Sp	41.58	51.4	40.88	87.4	158.49	33.4	124.44	47.7
	Su	31.49	67.9	30.96	67.8	137.76	34.6	88.50	67.8
	F	34.20	62.7	33.62	62.3	146.98	34.0	96.11	61.8
VII	W	40.97	59.5	22.97	268.1	161.14	41.3	115.15	59.6
	Sp	38.97	64.7	38.33	347.3	164.45	40.9	113.83	60.3
	Su	35.16	72.5	34.52	552.6	143.02	43.6	100.71	69.2
	F	37.73	67.2	37.09	394.5	154.52	42.0	106.03	65.2
VIII	W	40.05	41.4	39.38	41.4	155.22	27.0	112.56	41.4
	Sp	39.58	41.7	38.91	59.3	158.53	27.0	111.24	41.8
	Su	34.24	152.1	33.62	59.0	137.10	27.3	98.12	46.6
	F	36.81	133.1	36.19	55.0	148.60	27.1	103.44	44.4
IX	W	42.74	56.8	9.55	257.7	162.84	33.8	120.10	56.8
	Sp	42.27	67.5	38.97	381.7	166.15	33.6	118.78	57.5
	Su	36.58	66.7	1.43	-0-	144.72	34.9	105.66	65.3
	F	39.15	62.0	37.73	403.1	156.22	34.2	110.98	61.8
X	W	44.19	41.5	25.03	101.4	190.85	34.3	130.51	37.1
	Sp	41.52	143.4	25.18	122.0	166.02	35.7	120.99	39.3
	Su	13.56	92.3	20.61	139.1	171.51	35.4	112.62	41.6
	F	41.16	144.6	22.00	124.0	182.76	34.7	115.67	40.7

TABLE 19--Continued

Region	Season	BLM, FS, PP Cattle	% Inc.	BLM, FS, PP Sheep	% Inc.	Barley	% Inc.	Hay	% Inc.
XI	W	45.70	21.7	16.94	31.9	187.00	36.2	128.42	21.7
	Sp	40.55	22.8	14.16	16.1	162.17	38.0	113.97	22.8
	Su	36.56	23.8	12.84	37.8	167.66	37.5	102.74	23.8
	F	38.33	23.4	14.61	34.8	178.91	36.7	108.26	24.1
XII	W	41.93	31.7	14.68	17.7	167.66	31.6	117.83	31.6
	Sp	36.42	203.0	21.36	91.4	152.67	33.2	113.26	32.5
	Su	23.38	118.9	11.08	29.1	152.84	33.1	107.75	33.6
	F	25.01	107.0	12.71	27.4	163.48	31.8	108.32	33.4
XIII	W	39.58	53.4	38.91	53.4	158.28	45.8	111.24	53.4
	Sp	39.24	62.4	38.58	53.8	143.29	48.3	110.28	53.9
	Su	32.65	208.3	31.98	222.4	143.46	48.3	109.71	53.5
	F	35.42	109.8	34.75	197.8	154.10	46.5	110.10	53.9
XIV	W	35.70	67.3	35.10	67.2	144.83	38.5	100.34	67.2
	Sp	33.81	71.7	33.24	71.7	146.43	38.3	95.01	71.7
	Su	28.14	234.6	19.48	164.3	138.21	39.2	96.34	70.5
	F	31.16	183.0	22.50	125.7	149.53	38.0	101.87	66.0
XV	W	36.68	73.8	36.06	73.9	146.68	66.6	103.08	73.9
	Sp	35.13	78.1	34.53	78.0	146.15	66.8	98.71	77.0
	Su	33.88	81.5	31.09	342.9	145.71	66.3	96.80	80.0
	F	35.53	76.9	32.74	287.9	148.58	65.9	99.85	76.9
XVI	W	33.04	30.6	13.89	28.6	132.10	30.6	92.84	30.6
	Sp	31.42	31.6	11.52	31.5	129.63	30.7	88.31	31.6
	Su	29.99	36.1	10.09	34.0	129.00	30.7	88.31	31.6
	F	31.13	35.3	11.23	32.0	131.35	30.6	89.65	31.3

[a]Shadow prices are dollars per AUM for forest service, BLM, and private pasture; dollars per ton for barley and hay.

lamb was cut back in region XVI by 56,269 units. Region XVI was the most logical region for cutback because of high consumption demands over production and high transfer costs from large production areas. Beef consumption was cut back 136,284 units all in region II which is another high consuming region.

Beef backgrounding production was proportionate to cow/calf production. This was somewhat different than the previous simulation where large amounts occurred in specific regions.

Pork, milk, dairy calves, turkeys, and egg production were at identical levels as previous solutions. Broiler production quantities shifted around in regions I, XII, and XVI; however, total production remained unchanged. Optimal livestock production tables for Drought B are located in Appendix A.

Simulation Comparison

LP models of this size generate large output of results for analysis. Two important areas yet to be discussed are feed allocation to the different livestock classes, and the shadow prices and reduced costs of livestock production.

Feed Allocation

To present seasonal feed allocation for each livestock class for each region would be excessive. Feed allocation for selected livestock activities for selected regions are presented in Tables 20 and 21. These tables show comparisons of the three simulations and how feed is allocated to each livestock class. The author selected those regions that showed the most interesting results.

The feed allocation of the cow/calf activity is shown for region VII

TABLE 20.--Feed Allocation[a] of Selected Livestock Grazing Activities for Selected Regions--Base Year, Drought A, and Drought B

Simulation	Activity	Region	Season	FS	BLM	Private Pasture	Barley	Hay	Protein
Base	Cow/calf	VII	W	0	87,621	41,873	0	47,390	0
			Sp	1,444	96,097	193,773	0	9,678	0
			Su	63,526	67,406	198,277	0	0	0
			F	7,219	58,260	188,833	0	0	0
Drought A			W	0	46,680	0	16,420	53,498	0
			Sp	769	51,190	161,000	19,915	9,225	0
			Su	33,840	35,910	207,979	12,875	0	0
			F	3,846	31,040	33,320	0	66,229	0
Drought B			W	0	46,680	0	16,420	43,748	0
			Sp	769	51,190	142,288	19,915	4,083	0
			Su	33,840	35,910	225,122	0	0	0
			F	3,846	31,040	34,950	0	56,209	0
Base	Sheep	XV	W	0	23,337	1,218,036	0	162,143	0
			Sp	15,068	23,657	2,030,060	0	275,641	0
			Su	48,971	32,823	2,286,336	0	182,646	0
			F	11,301	27,800	2,585,807	0	0	0
Drought A			W	0	23,340	1,218,000	0	177,253	0
			Sp	15,070	23,660	2,030,000	0	300,961	0
			Su	48,970	32,820	2,219,740	0	203,789	0
			F	11,300	27,800	2,652,259	0	0	0
Drought B			W	0	17,430	909,600	0	205,306	0
			Sp	11,250	17,670	1,516,000	0	347,035	0
			Su	36,570	24,510	1,332,544	0	254,803	0
			F	8,440	20,760	2,301,855	0	0	0

TABLE 20--Continued

Simulation	Activity	Region	Season	FS	BLM	Private Pasture	Barley	Hay	Protein
Base	Backgrounders	II	W	0	0	0	0	0	0
			F	0	0	0	0	0	0
Drought A			W	0	0	0	343,057	0	0
			F	0	0	514,821	0	185,424	0
Drought B			W	0	0	0	320,141	0	0
			F	0	0	669,302	0	105,824	0

[a]Feeds are AUMs of forest service, BLM, and private pasture; tons of barley, hay, and protein.

TABLE 21.--Feed Allocation[a] of Selected Nongrazing Livestock Activities for Selected Regions--Base Year, Drought A, and Drought B

Simulation	Activity	Region	Season	Wheat	Corn	Oats	Barley	Milo	Hay	Protein
Base	Dairy Calf	VIII	Y	0	4,196	0	0	0	6,549	0
A	Dairy Calf	VIII	Y	0	4,196	0	0	0	6,549	0
B	Dairy Calf	VIII	Y	2,831	4,243	0	0	0	2.153	0
Base	Milk Cow	VIII	Y	3,243	59,687	0	0	0	245,578	0
A	Milk Cow	VIII	Y	0	118,854	0	0	0	160,272	0
B	Milk Cow	VIII	Y	0	122,466	0	0	0	154,762	0
Base	Beef	VI	Y	0	78,084	0	431,095	0	438,249	0
A	Beef	VI	Y	73,810	188,204	0	490,949	0	72,364	0
B	Beef	VI	Y	73,810	613,333	0	66,664	0	27,540	0
Base	Hogs	V	Y	0	7,812	0	54,702	0	--	0
A	Hogs	V	Y	0	56,190	0	0	0	--	0
B	Hogs	V	Y	0	56,190	0	0	0	--	0
Base	Turkeys	IX	Y	0	0	754	0	0	--	157
A	Turkeys	IX	Y	0	0	754	0	0	--	157
B	Turkeys	IX	Y	0	270	0	0	225	--	249

[a]All feeds are in tons.

for the base year. Drought A indicates that seasonal grazing feeds are reduced and barley is introduced to maintain production levels. Hay is increased in winter season and fed in the fall season. Drought B in region VII has no additional effect except to reduce the barley and hay transferred into region VII. Not enough feed is available so the only alternative is a herd liquidation of 8,166 units.

Comparison of the feed allocation for sheep in region XV shows similar results. Drought A does not effect region XV so seasonal grazing allotment in base year and drought A are nearly identical. However, sheep production increases in drought A by 8,092 units to compensate for reduced production in the western regions. Additional hay is fed to meet new production demands. Drought B does affect region XV. All the barley is fed to cattle, causing hay allotments to sheep to increase some but not near enought. A shortage of feed exists so a herd liquidation of 35,784 units occurs.

Feed allocation to backgrounders in region II shows interesting results. Region II is not affected by either drought. Region II actually is a large producer of backgrounders, but in the model shows xero production in the base year. As drought affects other regions, backgrounders are moved into region II but at small production levels. Their diets consist of straight barley in winter season and a combination of pasture and hay in the fall season.

The feed allocation of yearly livestock activities also is interesting (Table 21). All livestock production is at constant levels for each simulation. Drought effects upon dairy calf feed shows that wheat is the alternate feed source for reduced hay. The effect upon milk cows is increased corn consumption to take the place of wheat and hay shortages. Alternative feed sources available to beef producers are

increased consumption of corn and wheat. Reduced amounts of barley and hay are fed to beef. Corn is the only feed fed to hogs in region V during drought, in nearly all regions. Barley, originally fed to hogs, is now needed for the grazing livestock activities. Turkeys in region IX consume a diet of oats and protein supplement which is not realistic. The more rational feeds of corn, barley, and milo are either being used extensivly for other livestock or are too high priced for use. Oats is the excess feed available in region IX that can match the feed requirements of turkey production. During periods of drought, a more appropriate diet consisting of corn, milo, and protien is fed to turkeys.

Marginal Unit Values for Livestock Production

Discussion of marginal unit values for livestock production was postponed until comparisons of all simulations could be presented. Marginal units for livestock production are presented in two forms, shadow prices and reduced costs. These shadow prices and reduced costs are presented in Table 22 for each simulation and for all regions.

Shadow prices for livestock products are the amounts that the objective function value would change if an additional livestock unit could be produced. If the shadow price is above actual price, it would be profitable to increase one additional unit.

A number similar to shadow prices is produced in the column section of the model and called "reduced costs". Reduced costs represents a change in the objective function value when a column bound is increased one unit allowing that extra unit to be produced. Comparing reduced costs indicates the amount a given region would have to change its revenue to be equally marginally profitable as compared to the base solution with a zero reduced cost. Reduced costs show which regions have comparative

TABLE 22.--Reduced Costs and Shadow Prices[a] of Livestock and Livestock Products--Base Year, Drought A, and Drought B

Region	Simulation	Pork	Milk	Turkeys	Broilers	Eggs	Beef	Lamb	Calves	Backgrounders	Dairy Calves
		Reduced Costs						Shadow Prices			
I	Base	37.70	26.48	89.38	1.76	55.97	84.57	237.05	350.52	480.17	323.07
	A	37.70	26.53	91.21	3.52	59.20	104.38	135.23	354.63	499.14	315.11
	B	37.68	26.88	84.48	-2.37	45.26	85.91	17.70	272.58	442.20	199.35
II	Base	9.79	0	103.75	18.37	156.82	52.27	237.51	349.51	490.45	322.04
	A	9.79	0	103.75	18.37	156.80	72.07	135.69	357.64	509.42	315.82
	B	9.77	0	96.76	12.35	142.01	53.60	35.58	276.19	452.48	198.32
III	Base	52.50	15.62	0	-12.48	91.33	92.38	233.69	354.03	483.72	326.55
	A	52.50	17.09	0	-10.37	95.61	112.18	131.87	361.16	502.69	320.34
	B	52.49	18.29	0	-16.85	84.80	93.71	-31.76	280.10	445.75	202.83
IV	Base	44.74	20.39	10.59	-21.86	32.84	118.04	235.24	353.64	484.30	325.99
	A	44.74	20.51	10.67	-21.80	32.93	133.82	133.92	357.88	499.37	318.51
	B	44.60	22.58	15.62	-19.47	33.72	114.82	33.31	276.82	441.92	205.38
V	Base	58.40	10.05	14.52	-32.83	6.18	37.94	231.06	357.62	469.60	327.72
	A	70.37	16.71	26.78	-21.27	28.63	74.82	129.24	361.73	488.57	323.46
	B	70.39	20.60	30.43	-17.84	35.31	56.35	-29.13	279.32	431.63	206.45
VI	Base	67.42	28,83	35.36	-15.76	76.05	58.76	231.70	360.79	477.26	334.34
	A	84.22	32.33	47.06	-4.49	96.58	92.64	129.88	362.39	499.45	326.38
	B	84.28	32.27	45.96	-4.83	92.15	78.04	-29.77	278.82	439.29	210.62
VII	Base	41.63	15.63	40.60	-27.82	111.58	44.06	230.84	356.37	478.70	329.92
	A	70.28	22.06	61.43	-8.19	149.73	86.35	129.03	361.98	497.54	323.71
	B	70.35	21.73	57.53	-11.87	142.58	73.18	-28.91	274.74	449.05	206.20
VIII	Base	57.68	19.99	52.98	-15.87	137.25	41.98	229.63	357.82	476.54	331.37
	A	57.68	19.99	58.83	-10.36	147.96	61.82	127.81	363.41	495.54	325.14
	B	57.74	20.65	51.95	-16.84	135.36	47.67	-27.70	276.09	442.80	207.65

TABLE 22--Continued

Region	Simulation	Pork	Milk	Turkeys	Broilers	Eggs	Beef	Lamb	Calves	Backgrounders	Dairy Calves
		Reduced Costs						Shadow Prices			
	Base	56.85	18.89	32.00	-18.57	132.19	44.66	229.56	358.70	479.09	332.10
IX	A	69.10	21.75	34.30	-16.40	136.40	71.01	129.74	363.50	495.41	325.88
	B	69.17	22.88	39.65	-11.35	146.21	59.14	27.63	277.07	444.88	208.38
	Base	32.61	-10.89	0	-4.17	58.51	73.20	232.29	352.92	486.34	334.68
X	A	32.61	- 8.45	0	- .09	66.42	87.78	130.47	360.00	502.65	328.64
	B	32.54	- 6.92	0	-4.57	57.72	78.40	30.36	269.64	452.13	211.14
	Base	27.91	-11.71	0	-8.84	100.06	113.43	235.39	350.88	484.38	334.08
XI	A	27.91	-11.70	8.70	-5.60	116.34	130.49	133.57	356.60	505.69	327.86
	B	27.85	-10.59	42.20	-9.10	109.55	118.63	33.46	268.86	455.17	210.36
	Base	50.13	10.87	0	- .39	30.05	78.61	229.17	359.04	488.24	342.24
XII	A	50.13	10.87	17.06	0	36.33	85.54	127.35	363.96	494.72	336.02
	B	44.81	12.48	40.03	-10.91	9.61	72.47	27.24	277.02	443.02	218.52
	Base	18.70	2.67	75.44	-28.60	24.95	31.25	227.48	360.24	475.43	333.64
XIII	A	27.71	6.47	82.08	-22.34	37.09	55.14	125.66	365.96	491.75	327.69
	B	27.76	8.87	75.20	-28.83	24.49	43.28	-25.55	274.61	441.22	209.92
	Base	27.00	7.83	1.63	-42.94	-41.16	-16.84	228.59	366.08	464.24	339.63
XIV	A	43.73	13.31	13.27	-31.97	-19.84	17.03	126.77	367.68	484.59	331.67
	B	43.90	16.07	11.76	-33.39	-22.61	2.43	26.66	278.78	431.41	215.91
	Base	0	7.36	78.47	31.47	76.76	0	217.48	370.21	474.37	328.40
XV	A	0	7.53	78.64	31.64	77.08	0	115.66	377.80	474.11	339.53
	B	0	11.34	79.99	32.91	79.55	0	15.55	278.81	435.10	204.68
	Base	-27.69	0	0	0	0	-103.80	201.93	363.37	484.08	321.56
XVI	A	-27.69	0	0	0	0	83.30	100.11	370.96	463.92	336.68
	B	-13.77	0	0	0	0	93.64	0	277.73	424.91	211.52

[a] Costs and prices are $/1,000 pounds live weight for beef, pork, sheep, broilers, and turkeys; $/1,000 dozen eggs; $/1,000 pounds of milk; $/head for calves and backgrounders.

advantages in production. For example, a reduced cost of $26.48 in re- I in the base year for milk indicates that revenue to milk producers would have to rise that amount in order to be as profitable as region II, which is the most profitable milk producing region.

Beef calves, backgrounders, and dairy calves are intermediate states of beef production and are all in the base solution, so reduced costs are zero. Shadow prices have to be used for these activities. Actual prices for beef and dairy calves average about $300 for all regions. Shadow prices indicate that during the base year and Drought A, both activities are profitable. Drought B prices are considerably lower indicating high costs of feed and unprofitable production levels. Backgrounders show similar results. Average actual price is about $450. Several regions show unprofitable production during Drought B.

Sheep shadow prices cannot be compared to actual prices. Positive shadow prices indicate the objective function value would increase if an additional unit was introduced. Negative values indicate a decline in the objective function value. Liquidation does not necessarily have to occur in regions with negative shadow prices.

Pork, milk, turkeys, broilers, eggs and beef activities show reduced cost values. Each activity has at least one region in the base solution. The reduced costs with negative values indicate that revenue could be lowered by that amount and still be as profitable as the base solution. The regions with reduced costs closer to zero have the comparative advantage in production. Those regions with reduced costs of zero or negative values have the absolute advantage in production.

Actual broiler production in regions III through XIV is zero. Reduced costs indicate that broilers would be a profitable industry in these regions. Either region XV or XVI has the compartative advantage

in pork, milk, turkeys, broilers, eggs, and beef. Region XIV and XVI had a comparative advantage in beef production during the base year but lost that advantage when drought was induced. Milk is also profitable in regions II, X, and XI. Region XIV shows a big advantage in egg production.

CHAPTER V

CONCLUSIONS AND RECOMENDATIONS

Conclusions

The conclusions of this study are based on the assumptions and data used within the model. Any changes in production data, costs, or model format could cause different results to be obtained.

The base year solution yielded a close approximation to actual 1979 production figures. Additional hay needed to be produced in all regions. Actual hay production figures could be low for two reasons. (1) The corn silage conversion ratio used to get hay equivalents was identical for each region. (2) Since 38 percent of beef consumed is from sources other than fed beef, hay is also needed for feed for these other activities. Actual production for the model would then be understated. Additional hay production during drought would have avoided most of the liquidation. High shadow prices point out the value of additional hay when public grazing is cut back.

Cattle are utilizing all available AUMs on Forest Service, BLM, and pasture in all regions. Grazing feeds have the lowest cost of any alternate feed source. Summer and fall grazing is extremely scarce and would be worth the most if additional AUMs were available. As drought is induced, barley is the only alternate feed source available to grazing livestock. Hay is shifted from winter seasons in some regions to summer and fall seasons. As drought B is induced, cattle producers on the West Coast and in Nevada, Utah, and Arizona have no choice but to liqui-

date herd numbers.

Sheep AUMs are even more scarce. Except for the summer season in region IX, the additional unit values for sheep AUMs are higher for sheep than cattle. Drought results indicated that sheep are the first to be liquidated and that cattle herd size will decrease only if absolutely necessary.

Caution must be used in reading shadow prices of all livestock feeds. The prices are much higher in certain feeds and regions than actual prices. As explained in Chapter IV, comparing the changes in seasonal shadow prices and the percentage change from the base year for the drought simulations will give the true measurement of the value of the feeds at marginal units.

Barley, wheat, and oats are the alternate feed sources used to feed yearly livestock production activities. The sample feed allocation chart (previous chapter) showed that as drought increased in area, grain feed allocation replaced common feed rations. Corn production increased in the midwest where most livestock production exists, however, corn production decreased in region II (California). The effects of drought on milo was decreased production. These results show as actual milo prices increase, production demands are met with alternate feeds. Milo must be fed to other livestock classes that are not used in this study.

Cattle and sheep production are affected more by drought than poultry and hogs. As drought is induced, milk cows get hay first, leaving limited supplies available to the range cows and sheep who are already competing for scarce feeds. Poultry and hogs used the excess grain feeds to maintain current production levels.

As cow/calf liquidation occurs, the backgrounding and fed beef activities decline. The model chose the West Coast to cut back on consump-

tion of beef. Consumption of sheep dropped in the east (region XVI) in order to meet decreased production levels.

The midwest and east had the comparative advantage in producing beef, layers, turkeys, and hogs. Regions II and XVI had comparative advantage in producing milk. The model showed that even with drought, the west should engage in broiler production. Production and feed costs should be studied carefully before considering broiler production in regions that do not actually produce.

Sheep production was profitable in all regions in the base year. As drought is induced, California, Arizona, the midwest and east show a comparative advantage in sheep production. Liquidation that occurred in some of these regions was due to the lack of feed and not because of low profits.

Overall effects of drought are loss of production and increased costs. The loss of revenue from grain feed exports and herd liquidation is responsible for the large decline in profits. Lower costs would result if specialization could occur across the entire nation.

Recommendations

This thesis focused on the livestock feed economy and those livestock that competed for any of the feeds. Of all the feeds, the availability of range forage is the most critical. All other feeds are somewhat dependent upon the amount of grazing forage that is available. State agencies, the BLM, and Forest Service could use a model such as this to coordinate their AUM allotments.

This model is more accurate due to the division of the Western States into smaller regions and the addition of seasons of production. Future models should be adjusted to allow for different growing seasons

in each region.

It must be remembered that expanding LP models of this size incurs high computer costs which limits the number of simulations that can be made. Thoughtful consideration by the next researcher on the contents of the model must be made in order to obtain concise and valuable results.

The forage response equations used to predict forage reductions are relatively new. Improvement in tabulating biomass predictions associated with drought to already available precipitation data will result in more accurate response functions. Comparisons of drought effects on each region are now possible.

This model can now be used to determine the value of cloud seeding for range forage under drought conditions. Other uses of the model include crop reduction due to bug infestation, hail, blight, or the effects of too much moisture on forage. Smaller models of similar structure could be implemented to look at areas inside a state or small regions confined to a specific geological area. Valuable results could be obtained by local authorities within their own community.

Improvement in the internal structure of the model is recommended. Recalculation of the nutrient values supplied by each class of feed and the nutrient value required by each livestock class is advisable. Some of the values used in this study are outdated. Slight changes in these values could result in distortion of results.

Distinction between corn silage and hay could result in diets closer to what is actually being fed. Breakdown of private pasture into components and the addition of state land as range are possibilities for improvement. A weakness in some of the AUM totals for private pasture exist. Development of data for private forage production would be helpful.

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APPENDICES

Appendix A

TABLE 23.--Actual and Optimal Production of Nongrazing Feeds--Base Year, 1979

Region		Barley	Wheat	Corn	Oats	Milo	Hay
		tons					
I	Optimal	438,800	205,600	360,100	65,600	--	1,563,000
	Actual	438,800	205,591	360,100	65,600	--	1,563,000
II	Optimal	1,138,000	87,300	851,800	74,800	0	5,057,000
	Actual	1,138,000	87,300	851,800	74,800	336,000	5,057,000
III	Optimal	31,680	2,415	--	--	--	158,900
	Actual	31,680	2,415	--	--	--	158,900
IV	Optimal	98,330	21,730	6,160	25,420	--	534,000
	Actual	98,330	21,730	6,160	25,420	--	534,000
V	Optimal	648,000	0	7,812	20,578	--	2,311,000
	Actual	648,000	90,876	7,812	47,690	--	2,311,000
VI	Optimal	1,009,000	0	100,900	17,200	--	1,865,000
	Actual	1,009,000	82,010	100,900	17,200	--	1,865,000
VII	Optimal	101,400	0	11,390	0	--	207,900
	Actual	101,400	5,836	11,390	3,539	--	207,900
VIII	Optimal	106,900	3,243	26,370	4,621	--	502,300
	Actual	106,900	3,243	26,370	4,621	--	502,300
IX	Optimal	8,604	941	4,357	1,765	--	82,600
	Actual	8,604	941	4,357	4,015	--	82,600
X	Optimal	11,910	10,670	29,560	--	9,258	100,000
	Actual	11,910	10,670	29,560	--	9,258	100,000
XI	Optimal	75,220	13,830	129,500	--	133,100	779,000
	Actual	75,220	13,830	129,500	--	133,100	779,000
XII	Optimal	27,560	12,860	208,900	--	375,000	570,000
	Actual	27,560	12,860	208,900	--	375,000	570,000
XIII	Optimal	260,700	0	56,010	21,540	617	763,500
	Actual	260,700	6,423	56,010	21,540	617	763,500
XIV	Optimal	97,925	0	11,720	0	--	1,418,999
	Actual	172,900	355	11,720	11,930	--	1,418,999
XV	Optimal	1,523,788	0	109,000,000	5,117,300	5,653,313	65,830,000
	Actual	4,139,000	2,247,000	109,000,000	5,359,000	21,060,000	65,830,000
XVI	Optimal	641,600	0	71,742,945	2,949,000	889,100	46,120,000
	Actual	641,600	430,600	87,653,000	2,949,000	889,100	46,120,000

TABLE 24.--Seasonal Optimal and Actual Production of Grazing Feed AUM's--Base Year, 1979

Region		Season	Forest Service Cattle	Forest Service Sheep	BLM Cattle	BLM Sheep	Private Pasture[b] Cattle	Private Pasture[b] Sheep
I	Opt.	W	0	0	2,082	49	2,915,000	510,920
		Sp	5,053	281	11,310	383		
		Su	80,845	4,489	17,020	171		
		F	15,158	842	8,584	101		
II	Opt.	W	0	0	47,875	3,303	5,366,000	2,365,253
		Sp	20,007	2,401	90,940	9,445		
		Su	300,098	36,008	103,024	6,723		
		F	80,026	9,602	65,390	4,479		
III	Opt.	W	0	0	221,311	80,720	1,163,000	63,831
		Sp	0	0	381,458	45,760		
		Su	189,889	27,316	430,315	27,952		
		F	21,100	3,035	254,979	31,170		
IV	Opt.	W	0	0	27,703	52	1,505,000	69,170
		Sp	0	0	223,443	2,533		
		Su	221,017	7,547	590,986	1,493		
		F	39,003	1,332	129,903	437		
V	Opt.	W	0	0	5,017	734	4,804,000	130,758
		Sp	0	0	33,462	714		
		Su	871,023	84,034	65,532	1,225		
		F	153,710	15,460	30,104	665		
	Act.	W		0				
		Sp		0				
		Su		87,610				
		F		15,460				
VI	Opt.	W	0	0	42,530	16,818	2,903,000	598,085
		Sp	0	0	211,470	36,952		
		Su	229,219	108,646	332,700	57,610		
		F	25,470	12,072	160,572	35,410		
VII	Opt.	W	0	0	87,620	70,285	755,300	146,580
		Sp	1,444	294	96,097	41,116		
		Su	63,526	12,950	67,406	3,054		
		F	7,219	1,472	58,260	19,378		
VIII	Opt.	W	0	0	5,480	5,221	674,200	233,234
		Sp	0	0	8,739	3,444		
		Su	165,660	86,113	13,960	1,526		
		F	18,407	9,568	7,838	1,754		

TABLE 24--Continued

Region		Season	Forest Service Cattle	Forest Service Sheep	BLM Cattle	BLM Sheep	Private Pasture[b] Cattle	Private Pasture[b] Sheep
IX	Opt.	W	0	0	58,784	42,510	501,100	23,352
		Sp	0	0	70,197	36,400		
		Su	83,403	34,434	25,140	197		
		F	9,267	6,671	34,076	8,021		
	Act.	W		0		52,590		55,260
		Sp		0		36,400		
		Su		60,040		197		
		F		6,671		8,021		
X	Opt.	W	0	0	123,633	17,060	1,263,000	506,587
		Sp	52,066	1,566	132,170	17,260		
		Su	833,064	25,050	116,109	16,965		
		F	156,200	4,697	118,003	17,005		
XI	Opt.	W	0	0	56,544	361	1,971,000	310,594
		Sp	29,860	0	60,850	780		
		Su	209,037	0	58,030	663		
		F	59,725	0	57,700	512		
XII	Opt.	W	0	0	140,137	12,157	2,625,000	403,856
		Sp	23,690	733	148,071	12,436		
		Su	165,837	5,130	147,000	12,440		
		F	47,383	1,466	147,180	12,434		
XIII	Opt.	W	0	0	72,300	40,120	1,866,000	861,482
		Sp	33,640	7,630	108,781	29,430		
		Su	571,856	129,717	131,793	39,950		
		F	67,280	15,260	97,104	30,900		
XIV	Opt.	W	0	0	82,175	22,468	2,673,000	431,536
		Sp	0	0	175,487	22,144		
		Su	333,630	78,400	433,040	25,460		
		F	37,070	8,711	248,127	26,800		
XV	Opt.	W	0	0	129,153	23,340	130,700,000	8,120,240
		Sp	202,033	15,070	153,231	23,660		
		Su	656,606	48,970	244,618	32,823		
		F	151,524	11,300	199,068	27,800		
XVI	Opt.	W	5,890	361	0	0	118,500,000	2,348,130
		Sp	16,536	865	0	0		
		Su	27,560	1,442	0	0		
		F	17,914	938	0	0		

[a] Actual production is identical to optimal production unless specified.

[b] Private pasture AUMs are only available in yearly totals.

Table 25.--Actual and Optimal Production[a] of Livestock and Livestock Products--Base Year, 1979

Reg.		Dairy Calves	Pork	Milk	Turkeys	Broilers	Eggs	Beef	Lamb	Calves	Back-grounders	Dairy Back-grounders
I	Opt.	109,005	43,112	3,633,508	17,957	58,913	131,893	315,966	21,701	322,773	0	0
	Act.	102,310	53,755	3,742,027	24,283	72,660	142,019	363,138	21,701	322,773	--	--
II	Opt.	386,329	63,668	12,877,629	283,202	583,644	644,570	1,270,288	87,590	711,934	0	0
	Act.	327,528	79,387	12,561,400	377,100	605,440	726,112	1,401,311	87,590	711,934	--	--
III	Opt.	3,208	2,326	106,928	--	500	116	123,133	7,540	166,336	701,955	0
	Act.	3,101	2,812	110,600	--	--	121	134,425	7,540	166,336	--	--
IV	Opt.	5,712	3,842	142,801	--	500	4,220	208,021	3,507	218,379	213,574	0
	Act.	5,056	4,791	147,066	--	--	4,544	239,077	3,507	218,379	--	--
V	Opt.	13,873	31,835	277,469	--	500	7,689	233,507	11,406	575,942	898,715	0
	Act.	14,894	38,495	286,997	--	--	8,035	254,920	11,406	575,942	--	--
VI	Opt.	47,358	15,453	1,578,591	--	500	14,309	573,480	36,449	360,976	181,119	0
	Act.	47,351	18,686	1,632,800	--	--	14,952	626,070	36,449	360,976	--	--
VII	Opt.	6,681	1,887	222,726	2,137	500	2,334	53,157	10,379	78,290	44,083	0
	Act.	7,366	3,039	229,685	2,760	--	2,647	60,495	10,379	78,290	--	--
VIII	Opt.	19,154	5,194	638,484	51,019	500	25,818	89,500	14,506	82,225	47,297	0
	Act.	21,174	8,364	658,435	65,882	--	29,285	101,855	14,506	82,225	--	--
IX	Opt.	1,742	1,150	58,065	534	500	133	7,161	4,633	49,657	54,426	0
	Act.	1,924	1,852	59,879	690	--	151	8,150	4,250	49,657	--	--
X	Opt.	5,139	17,984	171,304	0	500	7,487	23,339	17,920	141,256	132,445	43,986
	Act.	5,656	21,746	161,364	--	--	7,823	25,479	17,970	141,256	--	--
XI	Opt.	28,156	27,875	938,564	0	500	8,418	511,555	8,027	244,057	0	0
	Act.	29,581	33,706	884,103	--	--	8,796	558,466	8,027	244,057	--	--
XII	Opt.	10,339	18,955	344,664	0	500	21,956	477,351	12,713	91,736	268,799	199,373
	Act.	10,632	22,920	356,500	--	--	22,943	521,126	12,713	91,736	--	--

Table 25--Continued

Reg.		Dairy Cows	Pork	Milk	Turkeys	Broilers	Eggs	Beef	Lamb	Calves	Back-grounders	Dairy Back-grounders
XIII	Opt.	4,960	19,210	165,333	2,788	500	6,851	22,911	57,061	242,415	318,219	0
	Act.	5,252	23,229	171,011	3,649	--	7,159	25,012	57,061	242,415	--	--
XIV	Opt.	3,023	4,089	75,582	0	500	707	88,702	20,988	184,382	609,722	404,296
	Act.	3,386	4,944	78,177	--	--	638	80,302	20,998	184,382	--	--
XV	Opt.	972,723	11,213,110	24,318,066	898,445	1,081,470	858,379	21,157,534	319,656	13,107,764	17,700,515	4,091,746
	Act.	901,194	12,441,484	26,250,071	1,135,834	1,197,641	945,351	19,555,114	319,656	13,107,764	--	--
XVI	Opt.	3,121,995	11,125,675	78,049,885	1,700,898	13,746,248	4,014,725	5,172,675	76,276	9,920,606	5,327,855	0
	Act.	2,709,080	9,836,155	76,269,885	1,348,335	13,600,985	3,638,341	6,797,208	75,285	9,920,606	--	--

[a]1,000 pounds live weight of beef, pork, broilers, and turkeys; 1,000 dozen eggs; 1,000 pounds of milk; and head of calves and backgrounders.

TABLE 26.--Optimal Production of Nongrazing Feeds--Drought A

Re-gion	Barley	Wheat	Corn	Oats	Milo	Hay
I	438,800	205,600	360,100	65,600	--	1,563,000
II	1,138,000	87,300	851,800	0	0	5,057,000
III	27,400	2,152	--	--	--	137,400
IV	98,330	21,730	7,160	25,420	--	534,000
V	515,200	78,168	6,484	38,490	--	1,821,000
VI	870,800	73,810	87,080	14,840	--	1,609,000
VII	88,420	5,095	9,932	3,086	--	181,300
VIII	93,220	2,831	22,990	4,030	--	438,000
IX	7,503	821	3,799	3,501	--	72,030
X	8,111	9,176	22,200	--	7,777	70,800
XI	64,010	12,140	110,200	--	113,300	662,900
XII	17,690	8,950	134,100	--	240,800	365,900
XIII	202,000	4,727	43,070	16,690	463	583,300
XIV	139,700	272	9,470	9,640	--	1,147,000
XV	1,928,503	0	109,000,000	5,126,128	5,811,188	65,830,000
XVI	641,600	0	80,866,094	2,949,000	889,100	46,120,000

TABLE 27.--Seasonal Optimal Production of Grazing Feed AUM's--Drought A

Region	Season	Forest Service Cattle	Forest Service Sheep	BLM Cattle	BLM Sheep	Private Pasture Cattle	Private Pasture Sheep
I	W	0	0	2,082	49	2,915,000[a]	510,920
	Sp	5,053	281	11,310	383		
	Su	80,850	4,489	17,020	171		
	F	15,160	842	8,584	101		
II	W	0	0	47,880	3,303	5,366,000	2,365,253
	Sp	20,010	2,401	96,940	9,445		
	Su	300,100	36,010	103,000	6,723		
	F	80,030	9,602	65,390	4,479		
III	W	0	0	101,900	37,160	535,400	46,480
	Sp	0	0	175,600	21,070		
	Su	87,420	12,580	198,100	12,870		
	F	9,714	1,397	117,400	14,350		
IV	W	0	0	27,700	52	1,505,000	69,170
	Sp	0	0	223,400	2,533		
	Su	221,000	7,547	591,000	1,493		
	F	39,000	1,332	129,900	437		
V	W	0	0	3,432	503	3,286,000	89,440
	Sp	0	0	22,890	489		
	Su	595,800	59,920	44,820	839		
	F	105,100	10,570	20,590	455		
VI	W	0	0	20,800	8,22	1,419,999	292,500
	Sp	0	0	103,400	18,070		
	Su	112,100	53,130	162,700	28,170		
	F	12,450	5,903	78,520	17,320		
VII	W	0	0	46,680	37,440	402,300	112,400
	Sp	769	157	51,190	21,900		
	Su	33,840	6,900	35,910	1,627		
	F	3,846	784	31,040	10,320		

TABLE 27--Continued

Region	Season	Forest Service Cattle	Forest Service Sheep	BLM Cattle	BLM Sheep	Private Pasture Cattle	Private Pasture Sheep
VIII	W	0	0	2,919	2,781		
	Sp	0	0	4,655	1,835		
	Su	88,250	45,870	7,427	812	359,100	124,200
	F	9,805	5,097	4,175	934		
IX	W	0	0	31,310	28,010		
	Sp	0	0	37,390	19,390		
	Su	44,430	31,663	13,390	105	266,900	29,440
	F	4,937	3,554	18,150	4,273		
X	W	0	0	96,950	13,380		
	Sp	40,830	1,228	103,600	13,540		
	Su	653,300	19,640	91,050	13,300	990,400	397,300
	F	122,500	3,683	92,540	13,340		
XI	W	0	0	43,930	280		
	Sp	23,200	0	47,280	606		
	Su	162,400	0	45,080	515	1,531,000	241,300
	F	46,400	0	44,830	398		
XII	W	0	0	111,900	9,710		
	Sp	18,920	586	118,300	9,934		
	Su	132,500	4,098	117,400	9,940	2,097,000	322,600
	F	37,850	1,171	117,600	9,932		
XIII	W	0	0	59,200	32,860		
	Sp	27,550	6,248	89,080	24,100		
	Su	468,300	106,200	107,900	32,720	1,528,000	705,500
	F	55,090	12,500	79,520	25,300		
XIV	W	0	0	59,790	16,350		
	Sp	0	0	127,700	16,110		
	Su	242,700	57,040	315,100	18,520	1,945,000	314,000
	F	26,970	6,338	180,500	19,500		

TABLE 27--Continued

Region	Season	Forest Service		BLM		Private Pasture	
		Cattle	Sheep	Cattle	Sheep	Cattle	Sheep
XV	W	0	0	129,200	23,340	130,700,000	8,119,000
	Sp	202,000	15,070	153,200	23,660		
	Su	656,600	48,970	244,600	32,820		
	F	151,500	11,300	199,100	27,800		
XVI	W	6,890	361	0	0	118,500,000	2,348,000
	Sp	16,540	865	0	0		
	Su	27,560	1,442	0	0		
	F	17,910	938	0	0		

[a]Data production of private pasture is only available on a yearly basis.

TABLE 28.--Optimal Production[a] of Livestock and Livestock Products--Drought A

Region	Dairy Calves	Pork	Milk	Turkeys	Broilers	Eggs	Beef	Lamb	Calves	Back-grounders	Dairy Back-grounders
I	109,005	43,112	3,633,508	17,957	58,913	131,893	315,966	21,701	322,773	0	0
II	386,329	63,668	12,877,629	283,202	583,644	644,570	1,270,288	87,590	711,934	711,934	0
III	3,208	2,326	106,928	0	500	116	123,133	6,934	166,336	170,453	0
IV	5,712	3,842	143,801	0	500	4,220	208,021	3,507	218,379	214,261	0
V	13,873	31,835	277,469	0	500	7,689	233,507	11,406	575,942	718,119	0
VI	45,357	15,453	1,578,591	0	500	14,309	573,480	32,061	360,976	0	0
VII	6,681	1,887	222,726	2,137	500	2,234	53,157	8,410	78,290	0	0
VIII	19,154	5,194	638,484	51,019	500	25,818	89,500	11,754	82,225	0	0
IX	1,741	1,150	58,065	534	500	133	7,161	4,250	49,657	0	0
X	5,139	17,984	171,304	0	500	7,487	23,339	17,970	141,256	0	0
XI	28,156	27,875	938,564	0	500	8,418	511,555	8,027	244,057	0	0
XII	10,339	18,955	344,664	0	0	21,956	477,351	14,206	91,736	55,531	256,065
XIII	4,959	19,210	165,333	2,788	500	6,851	22,911	57,061	242,415	0	0
XIV	3,023	4,089	75,582	0	500	707	73,557	20,988	184,382	545,358	121,090
XV	972,722	11,213,110	24,318,066	898,445	1,081,470	858,379	21,172,679	327,748	13,107,764	20,446,675	1,240,250
XVI	3,121,995	11,125,675	78,049,885	1,700,898	13,746,748	4,014,725	5,172,675	76,791	9,920,606	3,604,419	3,121,995

[a]Production is 1,000 pounds live weight for beef, pork, broilers, and turkeys; 1,000 dozen eggs; 1,000 pounds of milk; and head for calves and backgrounders.

TABLE 29.--Optimal Production of Nongrazing Feeds--Drought B

Region	Barley	Wheat	Corn	Oats	Milo	Hay
	tons					
I	438,800	205,600	360,100	65,600	--	1,563,000
II	1,138,000	87,300	0	74,800	0	5,057,000
III	27,400	2,152	--	--	--	137,400
IV	98,330	21,730	6,160	25,420	--	534,000
V	515,200	78,610	6,484	38,490	--	1,821,000
VI	870,800	73,810	87,080	14,840	--	1,609,000
VII	88,420	5,095	9,932	3,086	--	181,300
VIII	93,220	2,831	22,990	4,030	--	438,000
IX	7,503	821	3,799	3,501	--	72,030
X	8,111	9,176	22,200	--	7,777	70,800
XI	64,010	12,140	0	--	113,300	662,900
XII	17,690	8,950	134,100	--	240,800	365,900
XIII	202,000	4,727	43,070	16,690	463	583,300
XIV	139,700	272	9,470	9,640	--	1,147,000
XV	3,042,000	1,739,000	64,720,575	3,917,000	0	47,860,000
XVI	641,600	430,600	62,263,202	2,949,000	--	46,120,000

TABLE 30.--Seasonal Optimal Production of Grazing Feed AUM's--Drought B

		Forest Service		BLM		Private Pasture	
Region	Season	Cattle	Sheep	Cattle	Sheep	Cattle	Sheep
I	W	0	0	2,082	49	2,915,000[a]	510,920
	Sp	5,053	281	11,310	383		
	Su	80,850	4,489	17,020	171		
	F	15,160	842	8,584	101		
II	W	0	0	47,880	3,303	5,366,000	2,365,253
	Sp	20,010	2,401	90,940	9,445		
	Su	300,100	36,010	103,000	6,723		
	F	80,030	9,602	65,390	4,479		
III	W	0	0	101,900	36,160	535,400	46,480
	Sp	0	0	175,600	21,070		
	Su	87,420	12,580	198,100	12,870		
	F	9,714	1,397	117,400	14,350		
IV	W	0	0	27,700	52	1,505,000	69,170
	Sp	0	0	223,400	2,533		
	Su	221,000	7,547	591,000	1,493		
	F	39,000	1,332	129,900	437		
V	W	0	0	3,432	503	3,286,000	89,440
	Sp	0	0	22,890	489		
	Su	595,800	59,920	44,820	839		
	F	105,100	10,570	20,590	455		
VI	W	0	0	20,800	8,224	1,419,999	292,500
	Sp	0	0	103,400	18,070		
	Su	112,100	53,130	162,700	28,170		
	F	12,450	5,903	78,500	17,320		
VII	W	0	0	46,680	37,440	402,300	112,400
	Sp	769	157	51,190	21,900		
	Su	33,840	6,900	35,910	1,627		
	F	3,846	784	31,040	10,320		
VIII	W	0	0	2,919	2,781	359,100	124,400
	Sp	0	0	4,655	1,835		
	Su	88,250	45,870	7,437	812		
	F	9,805	5,097	4,175	934		
IX	W	0	0	31,310	28,010	266,900	29,440
	Sp	0	0	37,390	19,390		
	Su	44,430	31,663	13,390	105		
	F	4,937	3,554	18,150	4,273		
X	W	0	0	96,950	13,380	990,400	397,300
	Sp	40,830	1,228	103,600	13,540		
	Su	653,300	19,640	91,050	13,300		
	F	122,500	3,683	92,540	13,340		

TABLE 30--Continued

		Forest Service		BLM		Private Pasture	
Region	Season	Cattle	Sheep	Cattle	Sheep	Cattle	Sheep
XI	W	0	0	43,930	280	1,531,000	241,300
	Sp	23,200	0	47,280	606		
	Su	162,400	0	45,080	515		
	F	46,400	0	44,830	398		
XII	W	0	0	111,900	9,710	2,097,000	322,600
	Sp	18,920	586	118,300	9,934		
	Su	132,500	4,098	117,400	9,940		
	F	37,850	1,171	117,600	9,932		
XIII	W	0	0	59,200	32,860	1,528,000	705,500
	Sp	27,550	6,248	89,080	24,100		
	Su	468,300	106,200	107,900	32,720		
	F	55,090	12,500	79,520	25,300		
XIV	W	0	0	59,790	16,350	1,945,000	314,000
	Sp	0	0	127,700	16,110		
	Su	242,700	57,040	315,100	18,520		
	F	26,970	6,338	180,500	19,500		
XV	W	0	0	96,450	17,430	97,540,000	6,060,000
	Sp	150,900	11,250	114,400	17,670		
	Su	490,400	36,570	182,700	24,510		
	F	113,200	8,440	148,700	20,760		
XVI	W	6,890	361	0	0	118,500,000	2,348,000
	Sp	16,540	865	0	0		
	Su	27,560	1,442	0	0		
	F	17,910	938	0	0		

[a]Data production of private pasture was only available on a yearly basis.

TABLE 31.--Optimal Production[a] of Livestock and Livestock Products--Drought B

Region	Dairy Calves	Pork	Milk	Turkeys	Broilers	Eggs	Beef	Lamb	Calves	Back-grounders	Dairy Back-grounders
I	109,005	43,112	3,633,508	17,957	92,336	131,893	315,966	20,326	294,659	294,659	0
II	386,328	63,668	12,877,629	283,202	583,644	644,570	1,270,284	87,590	664,377	664,377	0
III	3,207	2,326	106,928	0	500	116	123,133	6,934	147,041	226,391	0
IV	5,712	3,842	142,801	0	500	4,220	208,021	3,506	218,379	208,549	5,712
V	13,873	31,835	277,469	0	500	7,689	233,507	9,573	575,942	575,942	97,587
VI	47,357	15,453	1,578,591	0	500	14,309	573,480	32,061	360,976	439,450	0
VII	6,681	1,887	222,726	2,137	500	2,334	53,157	8,410	70,124	0	0
VIII	19,154	5,194	638,484	51,019	500	25,818	89,500	11,754	78,474	0	0
IX	1,741	1,150	58,065	534	500	133	7,161	4,250	44,478	246,129	0
X	5,139	17,984	171,304	0	500	7,487	23,339	17,970	141,256	0	81,286
XI	28,156	27,875	938,564	0	500	8,418	511,555	8,027	215,746	62,946	0
XII	10,339	18,955	344,664	0	500	21,956	477,351	12,713	91,736	316,270	256,065
XIII	4,959	19,210	165,333	2,788	500	6,851	22,911	49,831	242,415	110,887	0
XIV	3,023	4,089	75,582	0	500	707	73,557	20,988	184,382	184,382	331,776
XV	972,722	11,213,110	24,318,066	898,445	1,081,470	858,379	21,036,395	283,871	13,107,764	13,107,764	714,235
XVI	3,121,995	11,125,675	78,049,885	1,700,898	13,712,825	4,014,725	5,172,675	76,791	9,920,606	9,920,606	3,252,737

[a]Production is 1,000 pounds live weight for beef, pork, broilers, and turkeys; 1,000 dozen eggs; 1,000 pounds of milk; head of calves and backgrounders.

TABLE 32.--Nutrients Furnished by One Ton of Feed in Mcal M.E. or Tons of D.P. When Fed to Various Classes of Livestock

Class of Livestock	Variables[a]	Early Bloom Hay	#4 Dent Yellow Corn[b]	Pacific Coast Barley	#4 Oats	#4 Wheat	#4 Sorghum	Soybean Extract
Beef Calves Backgrounder	Mcal M.E.	1,686	2,572	2,399	2,224	2,275	2,423	2,794
	Tons D.P.	0.114[c]	0.065	0.073	0.088	0.100	0.063	0.373
Hogs	Mcal M.E.	--	2,690	2,379	2,159	2,671	2,613	2,446
	Tons D.P.	--	0.070	0.075	0.099	0.117	0.079	0.394
Sheep	Mcal M.E.	1,715	2,770	2,311	2,195	2,575	2,515	2,455
	Tons D.P.	0.130	0.069	0.069	0.082	0.100	0.075	0.394
Poultry	Mcal M.E.	--	3,106	--	2,305	2,800	3,000	2,449
	Tons D.P.	--	0.088	--	0.118	0.108	0.111	0.438
Milk cows	Mcal M.E.	1,686	2,572	2,399	2,224	2,575	2,423	2,794
	Tons D.P.	0.114	0.065	0.073	0.088	0.085	0.114	0.373

SOURCES: Calculated from NRC tables (National Academy of Sciences: 1975, *Nutrient Requirements of Sheep* (5th rev. ed.); 1976, *Nutrient Requirements of Beef Cattle* (5th rev. ed.); 1977, *Nutrient Requirements of Poultry* (7th rev. ed.); 1978, *Nutrient Requirements of Dairy Cattle* (5th rev. ed.); and 1979, *Nutrient Requirements of Swine* (8th rev. ed.), Washington, D.C.).

[a]Mcal M.E. means megacalories of metabolizable energy; and tons of D.P. means tons of digestible protein.

[b]#4 energy feeds calculated on an as-fed basis.

[c]Tons of digestible protein for hay in regions XV and XVI were 0.086 and 0.068, respectively.

TABLE 33.--Nutrients Furnished by One AUM in Mcal M.E. and Tons D.P. on Forest Service, BLM, and Private Pasture per Season

Region	Variables	Winter	Spring	Summer	Fall
I	Mcal M.E.	600	600	600	600
	Tons D.P.	.0158	.0191	.0214	.0203
II	Mcal M.E.	600	600	600	600
	Tons D.P.	.0191	.0203	.0214	.0203
III	Mcal M.E.	600	600	600	600
	Tons D.P.	.0113	.014	.0324	.0225
IV	Mcal M.E.	600	600	600	600
	Tons D.P.	.014	.014	.0333	.0225
V	Mcal M.E.	600	600	600	600
	Tons D.P.	.0113	.014	.0324	.0225
VI	Mcal M.E.	600	600	600	600
	Tons D.P.	.014	.014	.0333	.0225
VII	Mcal M.E.	600	600	600	600
	Tons D.P.	.0113	.014	.0324	.0225
VIII	Mcal M.E.	600	600	600	600
	Tons D.P.	.014	.014	.0333	.0225
IX	Mcal M.E.	600	600	600	600
	Tons D.P.	.014	.014	.0333	.0225
X	Mcal M.E.	600	600	600	600
	Tons D.P.	.0170	.0170	.0170	.0170
XI	Mcal M.E.	600	600	600	600
	Tons D.P.	.0170	.0170	.0170	.0170
XII	Mcal M.E.	600	600	600	600
	Tons D.P.	.0170	.0170	.0170	.0170
XIII	Mcal M.E.	600	600	600	600
	Tons D.P.	.0170	.0170	.0170	.0170
XIV	Mcal M.E.	600	600	600	600
	Tons D.P.	.0170	.0170	.0170	.0170
XV	Mcal M.E.	600	600	600	600
	Tons D.P.	.0170	.0170	.0170	.0170
XVI	Mcal M.E.	600	600	600	600
	Tons D.P.	.0170	.0170	.0170	.0170

SOURCES: Calculated from DeeVon Bailey, 1980, "Economic Impacts of Public Grazing Reduction in the Livestock Industry with Emphasis on Utah." M.S. thesis (Utah State University, Logan, Utah); and Wayne C. Cook and Lorin E. Harris, 1977, *Nutritive Values of Seasonal Ranges*, Bulletin 472 (Utah Ag. Exper. Stat., Logan, Utah), March.

TABLE 34.--Nutrient Requirements for Nongrazing Livestock Classes per Unit of Livestock Product

Region	Variables	Beef	Hogs	Milk	Broilers	Turkeys	Layers	Dairy Calves
I	Mcal M.E.	3,442	4,745	938	3,582	3,962	6,122	1,140
	Tons D.P.	.08	.097	.04	.245	.296	.364	.042
II	Mcal M.E.	3,442	4,744	904	3,602	3,971	6,105	1,140
	Tons D.P.	.08	.097	.04	.245	.296	.364	.042
III	Mcal M.E.	3,442	4,745	1,034	3,562	3,965	6,452	1,140
	Tons D.P.	.08	.097	.04	.245	.296	.364	.042
IV	Mcal M.E.	3,442	4,733	984	3,562	3,988	6,055	1,140
	Tons D.P.	.08	.097	.04	.245	.296	.364	.042
V	Mcal M.E.	3,442	4,748	999	3,562	3,981	6,296	1,140
	Tons D.P.	.08	.097	.04	.145	.296	.364	.042
VI	Mcal M.E.	3,442	4,752	904	3,602	3,971	6,105	1,140
	Tons D.P.	.08	.097	.04	.245	.296	.364	.042
VII	Mcal M.E.	3,442	4,752	999	3,562	3,981	6,296	1,140
	Tons D.P.	.08	.097	.04	.245	.296	.364	.042
VIII	Mcal M.E.	3,442	4,752	999	3,562	3,981	6,296	1,140
	Tons D.P.	.08	.097	.04	.245	.296	.364	.042
IX	Mcal M.E.	3,442	4,752	999	3,562	3,981	6,296	1,140
	Tons D.P.	.08	.097	.04	.245	.296	.364	.042
X	Mcal M.E.	3,442	4,740	999	3,562	3,981	6,296	1,140
	Tons D.P.	.08	.097	.04	.245	.296	.364	.042
XI	Mcal M.E.	3,442	4,740	999	3,562	3,981	6,296	1,140
	Tons D.P.	.08	.097	.04	.245	.296	.364	.042
XII	Mcal M.E.	3,442	4,737	999	3,562	3,981	6,296	1,140
	Tons D.P.	.08	.097	.04	.245	.296	.364	.042
XIII	Mcal M.E.	3,442	4,750	999	3,562	3,981	6,296	1,140
	Tons D.P.	.08	.097	.04	.245	.296	.364	.042
XIV	Mcal M.E.	3,442	4,761	999	3,562	3,981	6,296	1,140
	Tons D.P.	.08	.097	.04	.245	.296	.364	.042
XV	Mcal M.E.	3,442	4,746	999	3,562	3,981	6,296	1,140
	Tons D.P.	.08	.097	.04	.245	.296	.364	.042
XVI	Mcal M.E.	3,442	4,766	999	3,562	3,981	6,296	1,140
	Tons D.P.	.08	.097	.04	.245	.296	.364	.042

SOURCE: Calculated from DeeVon Bailey, 1980, "Economic Impacts of Public Grazing Reduction in the Livestock Industry with Emphasis on Utah," M.S. thesis (Utah State University, Logan, Utah).

TABLE 35.--Nutrient Requirements[a] for Grazing Livestock Classes per Unit of Livestock Product

Season	Variables	Cow/ Calf	Back-grounder	Dairy/ Back-grounder	Sheep
Winter	Mcal M.E.	2,013	1,156	822	3,200
	D.P.	.03	.029	.029	.128
Spring	Mcal M.E.	2,441	0	822	5,362
	D.P.	.066	0	.029	.218
Summer	Mcal M.E.	2,523	0	822	4,485
	D.P.	.105	0	.029	.20
Fall	Mcal M.E.	1,949	873	822	4,927
	D.P.	.032	.035	.029	.130

SOURCES: Calculated from NRC tables (National Academy of Sciences: 1975, *Nutrient Requirements of Sheep* (5th rev. ed.); 1976, *Nutrient Requirements of Beef Cattle* (5th rev. ed.); 1977, *Nutrient Requirements of Poultry* (7th rev. ed.); 1978, *Nutrient Requirements of Dairy Cattle* (5th rev. ed.); and 1979, *Nutrient Requirements of Swine* (8th rev. ed.), Washington, D.C.).

[a]Nutrient requirements are considered the same for each season.

TABLE 36.--Percentage Increase in 1979 Feed Prices--Droughts A and B

Feed	Drought A	Drought B
Barley	7.06	25.49
Wheat	0.36	6.37
Corn	0.23	43.67
Oats	0.31	22.71
Milo	1.12	45.24
Hay	1.77	14.09
Private Pasture	2.90	16.20
BLM	0	0
Forest Service	0	0

SOURCE: Calculated from Abner W. Womack, 1981, "Crops Model," Cooperative Extension Service, University of Missouri, Columbia, Missouri (mimeographed).

TABLE 37.--Revenue[a] Received at Farm Gate for Livestock Products

Region	Beef	Pork	Sheep	Milk	Eggs	Broilers	Turkeys
I	642.50	433.00	635.00	120.00	523.50	310.00	420.00
II	690.90	459.00	666.00	114.00	508.00	295.00	410.00
III	636.00	413.00	615.00	115.00	515.00	322.50	467.00
IV	626.00	428.00	627.00	121.00	538.00	322.50	420.00
V	670.00	386.50	658.50	116.50	562.50	322.50	467.00
VI	669.00	378.00	635.00	114.00	500.00	322.50	467.00
VII	680.40	403.00	638.00	117.60	450.00	322.50	467.00
VIII	680.40	403.00	638.00	117.60	450.00	322.50	467.00
IX	680.40	403.00	638.00	117.60	450.00	322.50	467.00
X	674.50	434.50	689.00	127.50	545.00	322.50	467.00
XI	657.00	441.00	659.00	125.00	480.00	322.50	467.00
XII	692.00	428.00	718.08	129.54	618.33	322.50	467.00
XIII	679.00	423.00	667.00	128.00	550.00	322.50	410.00
XIV	714.00	394.00	696.00	119.00	585.00	322.50	467.00
XV	696.15	412.56	674.22	118.36	494.33	259.00	411.11
XVI	593.39	424.54	676.20	125.84	641.07	322.50	454.50

SOURCE: USDA; Economics, Statistics, and Cooperative Service. 1980. *Agricultural Prices Annual Summary, 1979*. Washington, D.C.

[a]Revenue is $/1,000 pounds live weight for beef, pork, sheep, broilers, and turkeys; $/1,000 dozen eggs; $/1,000 pounds of milk; $/head for calves and backgrounders.

TABLE 38.--Allowable Deviations in Production of Livestock Products from 1979 Totals

Region	Deviation	Beef	Pork	Broilers	Turkeys	Eggs	Milk	Cow/ Calf	Sheep
I	Increase	.2580	.2350	.2708	.1800	.0590	.0838	.0400	.1183
	Decrease	.1299	.1980	.1892	.2605	.0713	.0290	.0871	.1816
II	Increase	.1750	.2146	.1430	.2200	.1035	.0781	.0470	.0700
	Decrease	.0935	.2700	.0360	.2490	.1123	.0070	.0668	.1216
III	Increase	.1046	.1853	--	.8800	.1079	.0616	.0530	.1999
	Decrease	.0840	.1730	--	.2360	.0430	.0332	.1160	.0804
IV	Increase	.2580	.2350	--	.1800	.0590	.0838	.0400	.1183
	Decrease	.1299	.1980	--	.2605	.0713	.0290	.0871	.1816
V	Increase	.1046	.1853	--	.8800	.1079	.0616	.0530	.0961
	Decrease	.0840	.1730	--	.2360	.0430	.0332	.1160	.1607
VI	Increase	.1046	.1853	--	.8800	.1079	.0616	.0530	.0499
	Decrease	.0840	.1730	--	.2360	.0430	.0332	.1160	.1204
VII	Increase	.3505	.3810	--	.3690	.1837	.0848	.0556	.0900
	Decrease	.1213	.3790	--	.2256	.1184	.0303	.1043	.1897
VIII	Increase	.3505	.3810	--	.3690	.1837	.0848	.0556	.0900
	Decrease	.1213	.3790	--	.2256	.1184	.0303	.1043	.1897
IX	Increase	.3505	.3810	--	.3690	.1837	.0848	.0556	.0900
	Decrease	.1213	.3790	--	.2256	.1184	.0303	.1043	.1897
X	Increase	.1046	.1853	--	.8800	.1079	.0616	.0530	.1601
	Decrease	.0840	.1730	--	.2360	.0430	.0332	.1160	.1746
XI	Increase	.1046	.1853	--	.8800	.1079	.0616	.0530	.1700
	Decrease	.0840	.1730	--	.2360	.0430	.0332	.1160	.1867
XII	Increase	.1046	.1853	--	.8800	.1079	.0616	.0530	.1501
	Decrease	.0840	.1730	--	.2360	.0430	.0332	.1160	.1625

TABLE 38--Continued

Region	Deviation	Beef	Pork	Broilers	Turkeys	Eggs	Milk	Cow/ Calf	Sheep
XIII	Increase	.1046	.1853	--	.8800	.1079	.0616	.0530	.1700
	Decrease	.0840	.1730	--	.2360	.0430	.0332	.1160	.1267
XIV	Increase	.1046	.1853	--	.8800	.1079	.0616	.0530	.1000
	Decrease	.0840	.1730	--	.2360	.0430	.0332	.1160	.1132
XV	Increase	.1050	.1311	.2030	.2900	.0175	.0331	.0515	.1800
	Decrease	.0205	.1867	.0970	.2090	.0920	.0736	.1106	.1300
XVI	Increase	.3982	.0726	.1178	.2870	.0630	.0457	.0252	.0200
	Decrease	.2390	.1386	.0209	.1390	.0465	.0503	.1349	.0800

SOURCE: Dennis L. Nef, 1979, "A National Interregional Study of Ag. Sector Adjustments to Drought with Emphasis on Utah," M.S. thesis (Utah State University, Logan, Utah).

TABLE 39.--Production Bounds[a] on Production of Livestock Products

Region	Bound	Fed Beef	Pork	Broilers	Turkeys	Eggs	Milk	Calves	Sheep
I	Upper	456,828	66,387	92,336	28,654	150,398	4,055,609	335,684	24,268
	Lower	315,966	43,112	58,913	17,957	131,893	3,633,508	294,659	17,760
II	Upper	1,646,540	100,821	692,018	460,062	801,265	13,542,445	745,395	93,721
	Lower	1,270,288	63,668	583,644	283,202	644,570	12,473,470	664,377	76,939
III	Upper	148,486	3,333	500	560	134	117,413	175,152	9,047
	Lower	123,133	2,326	--	--	116	106,928	147,041	6,934
IV	Upper	300,758	5,917	500	304	4,812	159,390	227,114	3,922
	Lower	208,021	3,842	--	191	4,220	142,801	199,358	2,870
V	Upper	281,585	45,628	500	560	8,902	304,676	606,467	12,502
	Lower	233,507	31,835	--	--	7,689	277,469	509,133	9,573
VI	Upper	691,557	22,149	500	560	16,565	1,733,380	380,108	38,268
	Lower	573,480	15,453	--	--	14,309	1,578,591	319,103	32,061
VII	Upper	81,698	4,197	500	3,778	3,133	249,162	82,643	11,313
	Lower	53,157	1,887	--	2,137	2,334	222,726	70,124	8,410
VIII	Upper	137,555	11,551	500	90,192	34,665	714,270	86,797	15,812
	Lower	89,500	5,194	--	51,019	25,818	638,484	73,649	11,754
IX	Upper	11,006	2,558	500	945	179	64,957	52,418	4,633
	Lower	7,161	1,150	--	534	133	58,065	44,478	3,444
X	Upper	28,144	25,776	500	560	8,667	171,304	148,743	20,847
	Lower	23,339	17,984	--	--	7,487	156,007	124,870	14,832
XI	Upper	616,882	39,952	500	560	9,745	938,564	256,992	9,392
	Lower	511,555	27,875	--	--	8,418	854,751	215,746	6,528
XII	Upper	575,636	27,167	500	560	25,419	378,460	96,598	14,621
	Lower	477,351	18,955	--	--	21,956	344,664	81,095	10,647

TABLE 39--Continued

Region	Bound	Fed Beef	Pork	Broilers	Turkeys	Eggs	Milk	Calves	Sheep
XIII	Upper	27,628	27,533	500	6,860	7,931	181,545	253,263	66,761
	Lower	22,911	19,210	--	2,788	6,851	165,333	214,295	49,831
XIV	Upper	88,702	5,860	500	560	707	82,993	194,154	23,087
	Lower	73,557	4,089	--	--	611	75,582	162,994	18,612
XV	Upper	21,608,401	14,072,563	1,440,762	1,465,226	961,895	27,118,948	13,782,814	377,194
	Lower	19,154,234	10,118,659	1,081,470	898,445	858,379	24,318,066	11,658,045	278,101
XVI	Upper	9,503,856	11,125,675	15,203,181	1,735,307	4,080,156	79,755,419	10,170,605	76,791
	Lower	5,172,675	7,999,745	13,316,724	1,160,916	3,659,858	72,433,510	8,582,316	69,262

[a]Bounds are 1,000 pounds liveweight for fed beef, pork, broilers, turkeys, and sheep; 1,000 dozen eggs; 1,000 pounds of milk; and head of calves.

TABLE 40.--Rail Transportation Costs[a] for Feed Grains

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI
I	--[b]	31.92	38.89	--	24.75	--	40.82	32.71	40.33	42.95	45.30	55.89	38.47	51.25	43.28	47.45
II	31.92	--	21.47	--	36.41	--	35.12	27.01	34.63	27.83	30.18	41.65	32.78	47.39	41.74	49.41
III	38.89	21.41	--	--	31.44	--	30.11	22.00	29.62	39.30	41.65	56.82	27.80	42.42	36.77	44.45
IV	--	--	--	--	--	--	--	--	--	44.81	47.68	--	--	--	42.45	55.50
V	24.75	36.41	31.44	--	--	--	33.37	25.26	32.87	51.93	45.02	60.19	31.02	--	35.34	40.09
VI	--	--	--	--	--	--	--	--	--	50.51	52.83	--	--	--	38.78	51.83
VII	40.82	35.12	30.11	--	33.37	--	--	--	--	41.38	43.74	--	29.64	--	38.70	46.38
VIII	32.71	27.01	22.00	--	25.26	--	--	--	--	33.27	35.63	50.80	--	--	30.59	38.27
IX	40.33	34.63	29.62	--	32.87	--	--	--	--	40.89	43.25	--	29.15	--	38.21	45.89
X	42.95	27.83	39.30	44.81	51.93	50.51	41.38	33.27	40.89	--	19.91	--	--	--	36.87	44.60
XI	45.30	30.18	41.65	47.68	45.02	52.83	43.74	35.63	43.25	19.91	--	--	--	--	40.21	47.93
XII	55.89	41.65	56.82	--	60.19	--	--	50.80	--	--	--	--	--	--	40.50	53.55
XIII	38.47	32.78	27.80	--	31.02	--	29.64	21.53	29.15	--	--	--	--	--	28.92	36.64
XIV	51.25	47.39	42.42	--	--	--	--	--	--	--	--	--	--	--	35.83	48.88
XV	43.28	41.74	36.77	42.45	35.34	38.78	38.70	30.59	38.21	36.87	40.21	40.50	28.92	35.83	--	23.05
XVI	47.45	49.41	44.45	55.50	40.09	51.83	46.38	38.27	45.89	44.60	47.93	53.55	36.64	48.88	23.05	--

SOURCE: Stephen Fuller, 1981, Assistant Professor, Department of Agricultural Economics and Sociology, Texas A & M University, College Station, Texas, letter correspondence--April 22.

[a]Costs are dollars per ton.

[b]Infeasible rail route.

TABLE 41.--Transportation Mileage Between Region Centers

Region Region	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI
I	759	722	464	476	632	969	802	958	1,347	1,437	1,984	1,088	1,111	1,638	2,013
II		303	523	939	594	612	693	780	860	885	1,355	891	1,180	1,590	2,049
III			220	636	291	486	390	477	729	754	1,301	742	877	1,287	1,746
IV				560	317	664	568	655	949	974	1,444	820	915	1,410	1,869
V					388	667	503	659	1,053	1,190	1,548	823	799	1,078	1,537
VI						347	183	338	797	822	1,292	503	355	1,129	1,588
VII							167	156	447	584	942	273	651	1,061	1,520
VIII								156	550	687	1,045	320	554	965	1,424
IX									549	686	680	165	671	959	1,418
X										137	495	491	995	1,194	1,635
XI											547	628	1,132	1,422	1,881
XII												577	1,081	928	1,387
XIII													504	794	1,253
XIV														882	1,341
XV															459

SOURCE: Rand McNally, 1978, Road Atlas (54th ed.), Chicago, Illinois.