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ECONOMIC IMPACTS OF PUBLIC GRAZING REDUCTIONS IN THE LIVESTOCK INDUSTRY WITH EMPHASIS ON UTAH

by

DeeVon Bailey

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Agricultural Economics

Approved:

UTAH STATE UNIVERSITY
Logan, Utah

1980

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DeeVon Bailey

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ABSTRACT

Economic Impacts of Public Grazing Reductions in the Livestock Industry with Emphasis on Utah

by

DeeVon Bailey, Master of Science

Utah State University, 1980

Major Professor: Dr. Herbert H. Fullerton
Department: Agricultural Economics

The purpose of this paper was to determine the immediate impact of reductions in public grazing on livestock production in the United States. This was accomplished by the use of linear programming techniques. Different grazing reduction simulations were utilized to determine the short and long run effects of across-the-board reductions in public grazing.

The United States was divided into 13 regions. The 11 western states were considered as individual regions. Special emphasis was placed on the effects of grazing reductions on Utah. The availability and utilization of feed and livestock products during a "normal year", 1978, were considered in this study. Adjustments in the feed and livestock economies were noted through the simulated reduction in available public grazing lands. Recommendations and possible implications of such actions were also included.

(174 pages)

CHAPTER I

INTRODUCTION

The western United States today is a paradox of growth in its urban centers coupled with still wide areas of relatively untouched wilderness and semi-wilderness areas. The nation looks to the West as the symbol of what America once was--a vast, open, and beautiful land of promise.

Whenever there is a rich and abundant resource available, man is prone to use and exploit that resource to his benefit, thinking that it is in effect limitless. As time goes on, the resource may dwindle and many people noticing that the resource may not be limitless call for its conservation. Those who have grown accustomed to the use and availability of the resource and indeed whose economic existence has become closely associated with availability of the resource are immediately concerned about the possibility of that resource no longer being available in the desired quantities. Thus, the line becomes drawn, and a political conflict may ensue.

THe natural resource of land is such a case today in the western United States. The question of what uses should be made of western lands and specifically public* lands is a matter of great debate.

The agricultural sector, as all other economic sectors, tends to adjust to economic conditions. Adjustment is the natural result of reason and availability of alternative resources, but which adjustment and how much of an adjustment is the economic decision that may

---

*Public land is defined in this study as all land owned by the federal government.

sometimes be puzzling especially in the face of limited alternatives and increased costs.

Sixty-five percent of the land area of the 12 western states is owned by the federal government. Of this 65 percent, 95 percent is controlled by two government agencies--the Department of Interior (DOI) with 71 percent and the Department of Agriculture (USDA) with 24 percent. The Bureau of Land Management administers almost all of the land controlled by the Department of Interior in the 12 western states. The U.S. Forest Service administers 88 percent of the land controlled by the Department of Agriculture (Bromley, et al., 1968).

Much of this public land in the 12 western states administered by the Bureau of Land Management (BLM) is organized into grazing allotments. This is true also for the land administered by the U.S. Forest Service (USFS). The use of public land by ranchers and farmers in conjunction with their own private resources predates grazing allotments having been a common practice since the West became settled.

The use of this resource is intertwined with much of livestock production in the West. This resource, if reduced or eliminated, would cause farmers and ranchers presently dependent on public grazing lands to look to alternative feeds and/or possibly necessitate reduction in herd sizes.

This adjustment would have an impact on the immediate allocation of alternative resources and also possible long range effects. The magnitude of these effects should be of importance to livestock producers throughout the West, their competitors in the remaining areas of the United States, and the consuming public.

Background of the Problem

Regional economic adjustments to changes in the factors of production in the several regions of the United States have been the object of several studies. The concept of regional advantage and disadvantage can be loosely defined as follows: Different regions of the country are said to have a comparative advantage over others to produce certain agricultural products. Differences in soil fertility, climate, transportation costs to urban centers, the use or non-use of irrigation, etc. provide the basis for regional comparative advantage.

The principle of comparative advantage was developed by Ohlin (1935). This states simply that one region will have the advantage over another region to produce certain agricultural products due to its location, climate, and relatively easier access to necessary resource to produce those products. Different regions will "specialize" in those products with which they have a comparative advantage.

The use of linear programming as a means to determine the optimal allocation of resources in agriculture has been prevalent since the 1950's. Linear programming (LP) can be used to measure the changes necessary in allocation when there is a change in the availability of resources. This has been shown in several studies at Utah State University. Nef (1979) demonstrated the reallocation of resources in the agriculture sector for different areas of the country during droughts of differing severity. Other studies using LP by Gray (1972), Anderson (1975), Sorensen (1978) all developed the idea of interregional

competition with an emphasis on the state of Utah and its relative position with other areas of the United States. All of these studies indicated that the availability of resources, especially feed to produce livestock products, was essential to Utah to be able to compete effectively with other regions of the country in its sale of livestock products. Although only Anderson and Nef examined changes in production and their effect, the technique of using LP to determine the optimum (either least cost or maximum profit) reallocation of resources has proven feasible as a tool for measuring normative efficiency of current resource allocations and in comparing the economic efficiency of potential changes in resource allocations.

Problem and Purpose of the Study

The total magnitude of a change in available resources can only be measured by the use of a model. Some method of measurement must be used. By developing such a model which depicts production, costs, and livestock numbers in a given "normal" time period, the effect of reductions in available public grazing or other resources can be determined through the use of the model.

Current levels of use of public land for grazing of livestock is being questioned and management strategies are being introduced which, in many cases, severely limit its availability. With the growth of population in major urban centers in the western United States and with an increasing environmental awareness, expanded use of public lands for purposes other than grazing has been proposed. The demand for recreation lands, wilderness areas, and development of other resources such as timber and mining have also been recommended. Many

believe that public lands should be left in their pristine state thus precluding all current uses including grazing. The effect of these types of management proposals on ranchers and farmers who are accustomed to using these public lands for grazing is less than positive.

Land management measures that would cut public grazing AUMs (Animal Unit Months) up to 50 percent are a matter of great controversy. What are the alternatives if such action took place especially in the 11 western states where 94 percent of all public land is located? Are there enough available alternative resources to meet the demand if such an action did take place, and what would be the additional cost?

The purpose of this study is to measure the immediate impact that management measures of this type would have on the United States, the western United States, and Utah in that order. This information will assist in determining the economic consequences of management actions of this nature and the degree of impact associated with different percentages of reduction in AUMs available from public lands.

Objectives

The specific objectives of this study are as follows:

1. To expand and update models used by Gray, Sorensen, and Nef to more accurately depict the present situation in the feed and livestock industry.
2. To determine the feed and livestock products that would be produced in Utah and other regions of the country by using a least-cost method of production for the United States.

3. To determine the amounts of feed and livestock production in various regions with a 50 percent and 25 percent reductions in the availability of AUMs from public land.
4. To examine the impact of such a reduction on the immediate reallocation of agricultural resources.
5. To present recommendations to farmers, ranchers, legislators, and other interested groups concerning the economic implications of various reductions in available grazing.
6. To present policy implications and suggest research on important economic impacts and on the normative optimal production adjustments.

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

CHAPTER II

THEORETICAL FRAMEWORK

Interpreting the results of the model used in this study requires a basic understanding of the concepts of interregional competition and LP. These concepts are briefly explained in this chapter. The discussion includes a review of selected linear programming applications to the livestock industry and grazing reduction studies.

Interregional Competition

The concept of interregional competition is an integral part of this study. Different areas or regions trade in order to maximize their respective regional product. Very few areas could be considered self sufficient. Utahns, for instance, consumed 25,220,000 pounds* of pork in 1978, yet only 12,970,311 pounds* were actually produced within the state of Utah. At the same time, Utah produced 87,593,000 pounds* of turkey in 1978 but only consumed 15,306,000 pounds*within the state boundaries. Similar deficits and surpluses are common to all regions of the United States and the world. A process of trading is a natural result with each region attempting to arrange the "best deal" with the other regions.

Many times these different regions will produce the same or closely related products. Most agricultural products would fit into this category. The result is competition between the different regions in order to disperse their products (Mighell and Black, 1951).

---

*live weight equivalent

Specialization, comparative advantage, location theory, and general equilibrium analysis are the concepts associated with interregional competition.

Comparative Advantage

Different areas or regions in the United States by virtue of soil fertility, climate, reduced transportation costs to urban centers, and the use or non use of irrigation may display a comparative advantage over other regions in the production of certain products. The natural result of this process will be a tendency to "specialize" in those products which a region has a comparative advantage. This explains which product(s) will be produced in each region. The region where the ratio of advantage is greatest, (or disadvantage the least) for any given product(s) will be the region where that product or those products are produced (Ohlin, 1935).

Costs are a critical factor in determining regional comparative advantage. A region that has an absolute or comparative advantage over another region or regions in the production of a certain product or products will produce all of that product for all regions if no other factors are involved. Because significant costs are increased in shipping products between regions and since products may not be perfectly mobile, these costs must also be included in any analysis of comparative advantage and specialization.

Comparative advantage and specialization is best demonstrated by the use of an example. When two regions produce the same two products, one of them may be able to produce both products more cheaply than the other. Nevertheless, by producing the product

according to the principle of comparative advantage, both regions will be better off than if no exchange occurred. Suppose, for example, that Idaho and Colorado produce only beef and turkeys. Idaho can produce 300 turkeys or 60 head of beef cattle. Colorado, on the other hand, can produce only 200 turkeys or 50 head of beef cattle. Colorado can then produce only 2/3 as many turkeys, and 5/6 as many beef cattle as Idaho. Idaho could then be said to have an absolute advantage while Colorado has an absolute disadvantage in the production of these two products. This disadvantage is least in cattle (Idaho's advantage is greatest in turkeys), so Colorado produces beef and Idaho produces turkeys. In cost terms, the pre-trade price of beef in Idaho is 5 turkeys; whereas, in Colorado a turkey costs 1/4 of a beef. Specialization and trade will occur if Idaho can obtain a beef for less than five turkeys and if Nevada can get more than four turkeys for one head of beef cattle. (transportation costs ignored.) Clearly the two states can negotiate a price that will make both better off with trade than without trade (Nef, 1979).

The price would lie somewhere between 4 and 5 turkeys per head of beef. If 4.25 turkeys are agreed upon as a fair price for one beef, Colorado would then trade 12 head of beef cattle for 51 turkeys and keep 38 head of beef. Colorado now has 51 turkeys and 38 head of beef. Before specialization, Colorado could only produce 48 turkeys if 38 head of beef were produced. Similarly, Idaho now has 12 head of beef and 249 turkeys. Prior to specialization, they could only produce 249 turkeys and 10.2 head of beef cattle. This example demonstrates how production specialization in each region in the product(s) where its comparative advantage disadvantage is greatest

(least) and combined with trade between regions works to the greatest benefit of all.

Spatial General Equilibrium Theory

An essential part of the analysis conducted in this study involves allowing for transportation of feed and livestock products among several subnational regions. The concept of general spatial equilibrium is thus central to the analysis.

A general model of spatial equilibrium examined in this study will be the one introduced by Lefeber (in Nef, 1979). Lefeber's model allows evaluation of plans aimed at the optimal reallocation of resources and their utilization connected with production among industries and transportation of resources between regions over a period of time.

Lefeber defines the conditions associated with an optimal solution to his formulation as follows:

1) If a good produced at two different locations is shipped to the same market, the difference between the shadow 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 in both industries, locally, and in transportation, its rent has to be uniform in all

three employments. 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.

This formulation can be summarized as follows:

$$\text{Minimize } Z = \sum_{i=1}^{n} \sum_{j=1}^{m} C_{ij} X_{ij}$$

$$\text{Subject to: all } X_{ij} \geq 0$$

$$\text{and } \sum_{j=1}^{n} X_{ij} = a_i$$

$$\sum_{i=1}^{m} X_{ij} = b_j$$

hence

$$\sum_{i=1}^{m} a_i = \sum^{m} a_i = \sum_{j=1}^{n} b_j$$

with $(i = 1, 2, \ldots, m)$

$(j = 1, 2, \ldots, n)$ for all cases

where

X_{ij} = number of units shipped

C_{ij} = costs of shipping from origin i to destination j

m = Number of origins

n = Number of destinations

a_i = quantity available at origin i

b_j = quantity required at destination j

This problem can be transformed into a general linear programming model stated as:

$$\text{Minimize } Z = \sum_{j=1}^{n} C_j X_j \quad (j = 1, 2, \ldots, n)$$

$$\text{subject to: } \sum_{j=1}^{n} a_{ij} x_j \leq b_i \quad (i = 1, 2, \ldots, m)$$

$$\text{and } X_j \geq 0 \quad (j = 1, 2, \ldots, n)$$

where x_j = variable to be determined, n are being considered

c_j = per unit contribution of the jth variable to the objective function

Z = objective to be minimized

a_{ij} = exchange coefficient of the jth variable in the ith constraint

b_i = requirement to be met

By using this formulation, it is possible to determine the movement of feed and livestock products between the several regions and the optimal allocation and reallocation of these resources.

Linear Programming

Linear Programming (LP) has been used extensively in the United States and Utah since the 1950's and many models have been developed which focus on the livestock and feed producing sectors. In Utah, these sectors (livestock and feed production) account for 80 percent of annual agricultural cash receipts. Therefore, a similarly defined model appears to be appropriate for determining the impact on Utah and other regions of a reduction in feed available from public lands.

Interregional comparisons are essential to the correct interpretation of the data involved in this model. Interregional comparisons would consist of observing increases and decreases in projected production of feed and livestock products in each region in order to determine "gainers" and "losers". This information can be used to make inferences about the effect of changes in available resources on the different regions.

Basically, LP is a method for determining optimal (maximum; minimum) values for variables included in the objective function. A series of simultaneous equations, called the constraints, define the boundaries within which the optimum solution to the objective function may vary. Two approaches may be used in obtaining this optimal

solution: The profit maximizing and the least cost approaches. In this study the least cost approach was utilized. This method meets the demands of the constraints viz. (the demand and supply functions of all of the various regions through producing and allocating the available resources at the least possible cost.) This approach addresses the objectives of this study.

LP models vary in complexity from a simple objective function with one or two constraints that could easily be worked through by hand to a large objective function with several hundred variables and thousands of constraints. The use of the computer is essential for models of large size, such as the one developed in this study.

Assumptions of Linear Programming

Assumptions implicit to analyses based on linear programming (Heady and Chandler, 1958; Takayama and Judge, 1971; Judge and Wallace, 1958) are as follows:

(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 coefficients of production are known, 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) Resource supplies and final demand for each region are known.

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

(7) Regional prices are known with certainty.

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

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

(10) Transportation can occur only at positive levels.

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

Many of these assumptions are an oversimplification of the real world. The assumption of competitive markets, for instance, or the representation of the market for each region being a fixed point do not reflect fully the complexity of the "real" world. However, they do allow construction of a model which does correlate closely to reality and will facilitate analyses which should be useful in predicting the effects of changes in current conditions.

Review of Literature

LP has been a popular method to determine optimum allocations of agricultural resources and products for more than 25 years. Fox (1953) used a spatial equilibrium model to determine the optimum prices of livestock products and feed utilization, given livestock numbers and feed production. The results were then used to evaluate policy decisions affecting the U.S. feed and livestock industries. Judge and Wallace (1958) developed a spatial equilibrium model to determine equilibrium beef prices and production for 21 regions of

the United States. Later a similar analysis was made for pork.

Bokken and Heady (1968) utilized linear programming, in a multi-regional model of the United States to determine the optimum location of feed and livestock production in the United States. This model also had a multiple livestock product production and so allowed for the interaction of livestock products and feeds in production. This model now functions as the U.S. national linear programming model and is maintained by the USDA in Washington, D.C.

Dietrich (1971) developed a transportation model to identify the optimum location and levels of cattle feeding and cattle slaughter in 27 regions of the United States. His study also analyzed changes in the size of feedlots and determined least cost shipping routes for beef (live and slaughtered) and feed grains. Dietrich also developed econometric methods to determine costs of shipments of beef and feed grains. Equations developed from his analyses are utilized in this study.

Grimshaw (1972) set up a model to determine profitability of expansion of livestock production in the Pacific Northwest. This model included several livestock and feed activities. The model was used to minimize the cost of livestock product production, and through feed and transportation costs, the optimum production and location of livestock and feed products were determined. The basic conclusion of the study was that all regions included in the analysis have an advantage in producing livestock products consumed in that region until locally produced feed grains are fully utilized.

Several studies have expanded on Grimshaw's model. Gray (1972) utilized this model with some modification to examine Utah's

competitive position in livestock product production as compared with other regions of the country. Results indicated that Utah had comparative advantage in producing livestock products for local consumption i.e., beef, pork and turkeys. Utah was also determined to be in a position to compete with other subnational regions for the California market for eggs and milk.

LP can be used to determine normative optimal resource reallocation when there is a change in the availability of resources. This was shown by Nef (1979) who demonstrated the reallocation of resources in the agricultural sector for different regions of the country during droughts of differing severity.

Other studies using LP by Gray (1972), Anderson (1975), and Sorensen (1978) all conducted studies of interregional competition with an emphasis on Utah. These studies indicated that availability of resources and especially feed to produce livestock products were essential in Utah to be able to compete effectively with other regions of the country in its production and sale of livestock products. Although only Anderson and Nef examined changed in production and their effect, the technique of using linear programming to determine the optimum (either least cost or maximum profit) reallocation of resources has proven useful.

Studies of the Importance and Impact of Federal Grazing

Several studies have attempted to pinpoint the effect that public grazing has on the livestock economy. These studies have been conducted by both the federal government and numerous universities in the West.

Much of the literature has centered on the effects of different grazing fees on the demand and costs of grazing on public land. The Secretary of the Interior and the Secretary of Agriculture (1977) conducted a study to determine an equitable method of determining grazing fees on public land. The United States Senate Subcommittee on Public Lands (1969) held hearings concerning the disparity of costs between private and public grazing. Nielsen and Workman (1971) attempted to delineate the loss to rancher's incomes in the western United States as a result of increases in public grazing fees.

Bromley, Blanch, and Stoevener (1968) outlined the effects of changes in public land use on the rural economy of eastern Oregon. They determined the income losses to farmers and ranchers due to a 20 percent cut in available public grazing.

The federal government has attempted to determine proper management techniques and the potential forage production on public land in several studies. The Forest Service (1972) has provided information on the number of acres of land in the United States in both private and public ownership that lie within various ecosystems. The possible forage production on each ecosystem is also determined. The public land is broken down into different management practices with the acreage under each practice. The corresponding potential forage utilization and production under each management practice is then determined. The Soil Conservation Service (USDA, 1976) has attempted to provide guidelines for proper use of grazing lands, correct stocking rates, and other methods of evaluating the proper utilization of grazing lands.

One justification for this study may be to provide further analysis of environmental impact studies undertaken by the Bureau of Land Management (DOI, BLM, 1980) and the U.S. Forest Service (USDA, USFS, 1974). These environmental impact studies have suggested alternatives to present grazing policy for livestock on public lands which would mention significant changes in the effective availability of grazing on some grazing districts. The BLM has plans for introducing similar changes in management policy in 70 grazing districts throughout the West. It is important that the cumulative effects of these potential changes be evaluated in advance of actual experiencing potentially damaging economic consequences. Hopefully, a macro picture of the effects of substantial reductions in public grazing will be established as a first step in further analyzing the regional and national costs which are implied with these changes in public grazing and land management policy.

CHAPTER III

METHODOLOGY

Model Development

Given the similarity in data base and objectives of this study, with those of Grimshaw (1972), Andersen (1975), Sorensen (1978), and Nef (1979), it was useful to follow and expand on their basic groundwork. This groundwork facilitated the further application of a LP model which focused on problems of the range livestock industry.

Regions

The United States was delineated into 13 different regions for analysis in this model. Because the western United States was deemed to experience the greatest potential impact due to reductions in public grazing, it was decided that the eleven western states should be examined as separate regions. These states included Washington, Oregon, California, Idaho, Nevada, Utah, Arizona, New Mexico, Colorado, Wyoming and Montana. The other two regions were the Midwest (comprised of the states of North and South Dakota, Minnesota, Nebraska, Missouri, Kansas, Iowa, Oklahoma, and Texas) and the eastern United States (states east of the Mississippi River). These regions are depicted in Figure 1.

In order to construct a transportation activity in the model it was necessary to select a center within each region from which transportation of feed grains and livestock products to other regional centers could be calculated. These regional centers are listed in Table 1. All intraregional transportation costs were assumed to be

Figure 1: Regions of the United States designated for this study.

Table 1. Regions and regional centers used in the study.

Region	State(s)	Regional Center
I	Washington	Ellensburg
II	Oregon	Burns
III	California	Los Angeles
IV	Idaho	Pocatello
V	Nevada	Winnemuca
VI	Utah	Salina
VII	Arizona	Phoenix
VIII	New Mexico	Santa Fe
IX	Colorado	Denver
X	Wyoming	Rock Springs
XI	Montana	Helena
XII	Midwest (S.D., N.D. Minn., Neb., Mo., Ks., Iowa, OK, TX)	Omaha
XIII	The East (All states east of the Mississippi River)	Chicago

zero or the same within all regions. An example of this assumption would be that any movement of livestock products or feed grains between Region III (California) and Region VI (Utah) would only consider transportation costs between Los Angeles, California, and Salina, Utah. This simplied the calculations of transportation costs greatly. Transportation costs from Los Angeles, California, to San Francisco, California, or from Salina, Utah, to Salt Lake City, Utah, would not be considered in this model.

Ten different livestock classes, presented in Table 2, are considered to produce seven livestock products.

Similarly, the ten feed grain and pasture classes, utilized in this study, are presented in Table 3.

Feeds were converted to livestock products by a method developed by Grimshaw (1972). This method was roughly as follows: Each type of feed was capable of providing a certain amount of metabolizable energy (M.E.) measured in Megacalories (Mcal). Each feed also provided a certain percentage of digestable protein (%DP). The various types of livestock require minimum amounts of metabolizable energy and digestable protein each day in order to produce or gain weight. Information of how much M.E. and DP were provided from each feed combined with the convenience of knowing the %DP and M.E. requirements of the various classes of livestock, made it possible to model the conversion of feeds into livestock products. The LP model balanced the ration for each class of livestock to meet these requirements, and livestock products were then transferred to meet final demands.

The least cost LP as utilized in this study is summarized in the following section.

Table 2. 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
*Cow/calf	
*Backgrounders	
Sheep	Lamb
Horses	

*The cow/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.

Table 3. 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 Improved Pasture
9. Private Range
10. Public Grazing

The Objective Function and the Restraints

The problem is as follows:

Minimize

(1) $\sum_{ik}\sum A_{ik} B_{ik} + \sum_{ijk}\sum\sum C_{ijk} D_{ijk} + \sum_{jk}\sum E_{jk} F_{jk} + \sum_{ikg}\sum\sum R_{ikg} S_{ikg} + \sum_{jkg}\sum\sum Y_{jkg} Z_{jkg}$

Subject to

(2) $V_{ik} = A_{ik} + \sum_{gk} R_{igk} = \sum_{kg} R_{ikg}$ for all i and k

(3) $T_{jk} = E_{jk} + \sum_{gk} Y_{jgk} - \sum_{kg} Y_{jkg}$ for all j and i

(4) $\sum_{ik}\sum K_{ijk} V_{ik} = \sum_{jk}\sum L_{jk} E_{jk}$

(5) $\sum_{ik}\sum M_{ijk} V_{ik} = \sum_{jk}\sum N_{jk} E_{jk}$

(6) $A_{ik}, C_{ijk}, E_{jk}, R_{ikg}, Y_{jkg} \geq 0$

where

A_{ik} = the quantity of the ith feed produced in region K.

B_{ik} = the per unit cost of producing the ith feed in region K.

C_{ijk} = the quantity of the ith feed fed to the jth class of livestock in region K.

D_{ijk} = the per unit cost of feeding the ith feed to the jth class of livestock in region K.

E_{jk} = the quantity of the jth livestock product produced in region K.

F_{jk} = the nonfeed costs of producing one unit of the jth livestock product in region K.

R_{ikg} = the quantity of the ith feed shipped from region k to region g

S_{ikg} = the per unit cost of transporting the ith feed from region k to region g

Y_{jkg} = the quantity of the jth livestock produced shipped from region k to region g.

Z_{jkg} = the per unit cost of transporting the jth livestock product from region k to region g.

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

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

K_{ijk} = the metabolizable energy supplied per unit of the ith feed when fed to the jth class of livestock in region k.

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

M_{ijk} = the digestable protein supplied by the ith feed when fed to the jth class of livestock in region k.

N_{jk} = the digestable protein required per unit of product by the jth class of livestock in region k.

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

*i = 1,2,3,4,5,6,7,8,9,10	j = 1,2,3,...,10
where	where
1 - barley	1 - beef
2 - wheat	2 - hogs
3 - corn	3 - broilers
4 - oats	4 - turkeys
5 - milo	5 - layers (eggs)
6 - hay	6 - milk cows (milk)
7 - Private improved pasture	7 - cow/calf
8 - Private range	8 - backgrounders
9 - Public range	9 - sheep
10 - Protein supplement	10 - horses

*The reader is referred to tables 1, 2, and 3.

$k_g = 1,2,3,\ldots,10$

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

11 - Region XI

12 - Region XII

13 - Region XIII

In words, the objective of the model is 1) to minimize the cost of producing feed, livestock production costs both feed and nonfeed, and transportation costs. This objective is met subject to the constraints in equations 2-6. Equation (2) states that the available feed in each region is equal to production of that particular feed in that region plus inshipments into the region minus shipments of the feed out of the region. Equation (3) states that the demand for a livestock product in a region must equal the amount of that product produced in the region plus inshipments of the product into the region from other regions minus the amount of the product shipped out of the region to other regions. Equation (4) requires that the metabolizable energy

consumed by livestock in each region must equal the M.E. requirement for each livestock class. Equation (5) requires that the digestable protein consumed by livestock in each region must equal the digestable protein requirement for each livestock class. Equation (6) requires that all quantities of feed and livestock, produced and shipped, must be zero or positive (non-negative).

A tabular illustration of the linear programming matrix for one region is contained in Figure 2.

Assumptions

Assumptions of the model were as follows:

(1) The year 1978 is the base year, and it, therefore, was a "normal" year.

(2) Only the feed grains included in the model were considered.

(3) Only the livestock classes within the model were considered to be competing for the available feed.

(4) Only the livestock feed economy was considered.

(5) Consumption of wheat by livestock was limited to 20 percent of production (Nef, 1979).

(6) 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 1978 production (Nef, 1979).

(7) Hay, private improved pasture, private range, and public range were not considered transferable and were excluded

Activities Restraints	Production of Feed	Feed Transfer	Feed Conversion	Production of Livestock Products	Livestock Products Transfer	Consumption of Livestock Products
Objective function	+c	+c		+c	+c	
Feed production account	+1	-1				
Feed available account		+1	-1			
Mcal/M.E.			+d	-d		
%DP			+d	-d		
Feed ration			+1	-1		
Livestock products production account				+1	-1	
Livestock products available account					+1	-1
				b		b

c - cost of activity; d - data coefficient; b - bound
Mcal/M.E.- megacalories of metabolizable energy; %DP - percentage of digestible protein

Figure 2. Condensed tabular illustration of linear programming matrix for one region.

from the transportation model.

(8) The standard units of livestock used to determine M.E. and %DP requirements for conversion of feed to livestock products for range operations were as follows:

(a) For sheep, a lactating ewe with one lamb was considered.

(b) For cow/calf a lactating cow and her calf were considered.

(c) For horses, a two year old was considered as the basis of calculation.

(9) Protein supplement was not produced in the model but was assumed available in each region at the average price in that region. Also no transportation costs for protein supplement were considered.

(10) Private range and public range were assumed to meet the minimum protein and energy requirements for sheep, cow/calf, and horses.

(11) The cow/calf activity used 70 percent of the beef calf crop and 40 percent of the dairy calf crop. A 400 pound calf was produced in this activity as input to the backgrounding activity.

(12) The sheep activity produced a 100 pound lamb, and it was assumed that at this point the lamb was marketable for immediate slaughter.

(13) No revenue side was considered for horses, but their feed requirement was included in the model.

(14) The backgrounding activity added 250 pounds to a calf and thus yielded a 650 pound animal. This was the input for the beef activity.

(15) The beef activity added 400 pounds to a backgrounder generating a 1050 pound beef animal. Since only 62 percent of beef consumed in 1978 was fed beef, final demand for fed beef in the model was limited to 62 percent of beef consumed.

(16) Only milk (no other dairy products) was output from the milk cow activity, and annual per capita consumption was set at 560 pounds (Sorensen, 1978).

(17) Hay is fed only to cattle, sheep, and horses. The feeding of hay was limited to 560 pounds per animal for the beef activity. This allowed for 2.86 pounds per day gain over a 140 day feeding period. A lower limit on the amount of hay feed cow/calf operations was established from the Oklahoma Budget Generator (1976). Dairy cattle, horses, and sheep were limited to 4.5, 1.8, and 0.8 tons annual consumption of hay respectively.

(18) Public grazing was limited to cow/calf operations, range sheep operations, and horses. The AUM figures were actual BLM (1978) and USFS Statistics (1978) for the year 1978. Since only approximately 70 percent of the calves in cow/calf operations actually go into beef production, only 70 percent of the actual AUMs utilized on public land were allowed in the model. Sheep AUMs were calculated by taking the actual lamb crop for 1978 and dividing this by the actual inventory as of Jan. 1, 1978. This percentage was then multiplied by .8 since it was estimated that only 80 percent of the lamb crop would be slaughtered, and the

20 percent kept as replacements.* Horse AUMs were utilized in the Model at 100 percent of the actual level sold.

(19) Private range was utilized by cow/calf operations, range sheep operations, and horses in the same proportions as these three classes of livestock utilized public grazing.

(20) Private improved pasture was limited to dairy, cow calf, sheep, backgrounding, and horse activities. It was calculated for the base run that 73 percent of available pasture would be allowed to be utilized by cow/calf, 2 percent backgrounders, and 10.5 percent dairy (Nef, 1979). Sheep were estimated to use approximately 10 percent, and horses 4 percent (USDA, ERS, 1974).

(21) Exports and imports to and from rest of world were included in the model at prices received and paid. No transportation costs were considered from the region to the point of arrival or departure (FOB coastal regions).

Data Collection

Data for this study were collected mainly by the secondary sources. This section contains much of the information concerning the data used. The appendices contain additional information. Appendix A contained the results of two LP simulations or variations from the base year optimal solution. They were called Simulation III and Simulation IV. These simulations attempted to predict the long range effects of

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*An example of this method of calculation would be as follows: Utah's inventory of sheep on January 1, 1978 was 491,000. The lamb crop in 1978 was 377,000 or .76782 lambs per sheep in the beginning inventory. Because only 80 percent of lambs produced were slaughtered multiplying .76782 by .8 would give the percentage of AUMs fed to sheep that actually produced slaughter lambs.

reductions in available public grazing AUMs. Appendix B has information pertaining to calculation of transportation costs, upper and lower bounds for feed and livestock production, and the actual number of AUMs sold on public land in 1978.

Transportation costs for feed grains and livestock were calculated by using a weigh bill study by Dietrich (1970). These figures were then updated using a transportation cost index to 1977 (U.S. Senate Committe on the Judiciary, 1978). This figure was then updated to 1978 using the Consumer Price index.

The formulas were

$$Y = .090628326 + .00049126609X \qquad \text{(feed grains)}$$

$$\text{and } Y = .85082823 + .0010969456X \qquad \text{(livestock carcasses)}$$

where Y = transportation cost in dollars per hundred weight

X = mileage between regions

The carcass weight was converted to liveweight equivalent since production was in liveweight. For example, if carcass weight equaled 1000 pounds of fed beef, this figure would be divided by .583 to reach the live weight equivalent of 1715 pounds. Transportation costs for eggs were derived from Witt (1970) and updated using the above mentioned indices. Calves and backgrounders were shipped at a flat rate of 24 cents per hundred weight (USDA; 1977 updated to 1978).

Production of feed grains was actual production in tons by state (USDA, 1979). Production of livestock products was obtained from various USDA publications i.e., Livestock and Meat Statistics (USDA 1978) was used to find the production of fed beef, hogs, calves, backgrounders, and sheep. Poultry Production Disposition and Income 1977-1978 (USDA, 1979) was utilized to locate broiler, turkey, and egg

production figures. Milk Production (USDA, 1980) gave whole milk production and milk cow numbers. Livestock - Feed Relationships (USDA, 1974) provided information on horse numbers. Exports and imports were determined from Foreign Agriculture Circular (USDA, 1979 and 1980).

Final demand for livestock products was derived by using the national per capita consumption for each livestock product and the current population each region. Demand for beef, pork, chicken, turkey, and lamb was further adjusted to its live weight equivalent.

Production of feed grains was limited to an upper bound equal to the regions actual 1978 production. Production of livestock products was limited by an upper and lower bound. These bounds were established by actual 1978 production levels with the allowable deviations upward and downward being the upper and lower bound. The calculation of these deviations was stated in the assumptions of the model.

Factors utilized to convert feed and pasture into livestock products are shown in Tables 4, 5, and 6. The feed conversion process required calculation of the Mcal M.E. and the % DP. M.E. is defined as the actual energy that contributes to the maintainence and bodily functions of an animal. %DP is the percentage of a feed that an animal can digest as actual protein. The M.E. and %DP for each feed when fed to each livestock class are presented in Table 4.

Private improved pasture varied in %DP. The M.E. and %DP for private improved pasture are presented in Table 5. The protein requirements for each unit of each livestock product were also calculated and are listed in Table 6.

Table 4. Nutrients furnished by one ton of feed in Mcal M.E. or %DP when fed to various classes of livestock.*

Class of livestock	Variables	Barley	Wheat	Corn	Oats	Milo	Alfalfa hay	Protein supplement
Beef	Mcal M.E.	2,423	2,598	2,566	2,219	2,423	1,683	2,509
Cow/calf Backgrounders	% DP	8.7	10.0	6.5	8.8	6.3	11.4	37.3
Hogs	Mcal M.E.	2,609	3,099	2,971	2,420	2,896	--	2,718
	% DP	8.2	9.9	7.0	9.9	7.9	--	39.4
Broilers	Mcal M.E.	2,400	2,800	3,100	2,300	3,000	--	2,200
	% DP	11.6	10.8	8.8	11.8	11.1	--	43.8
Turkeys	Mcal M.E.	2,400	2,800	3,100	2,300	3,000	--	2,200
	% DP	11.6	10.8	8.8	11.8	11.1	--	43.8
Layers	Mcal M.E.	2,400	2,800	3,100	2,300	3,000	--	2,200
	% DP	11.6	10.8	8.8	11.8	11.1	--	43.8
M. cows	Mcal M.E.	2,423	2,598	2,566	2,219	2,423	1,683	2,509
	% DP	8.7	8.5	6.5	8.8	11.4	11.4	37.3
Sheep	Mcal M.E.	3,445	3.527	2,891	2,464	3,445	2,155	3,727
	% DP	10.3	11.2	4.8	10.3	9.05	12.3	37.9
Horses	Mcal M.E.	3,282	2,673	2,964	3,036	3,120	2,509	3,273
	% DP	11.4	14.4	5.6	10.5	8.8	11.6	35.7

*Source Sorensen (1978) calculated from NRC Tables (National Academy of Sciences, 1975, 1978)

Table 5. Nutrients furnished by one animal unit month (AUM) of improved pasture in Mcal M.E. or %DP when fed to milk cows, calves, backgrounders, sheep and horses.

Region		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
	Mcal M.E.	600	600	600	600	600	600	600	600	600	600	600	600	600
	% DP	4.25	4.25	4.51	3.77	3.77	3.77	3.77	3.77	3.77	3.77	3.77	4.4	4.7

*Source: Nef (1979) and also calculated by the author using NRC tables (National Academy of Sciences, 1975 and 1978).

Table 6. Nutrient requirements for livestock classes per unit of livestock product

Region	Variable*	Beef	Hogs	Broilers	Turkeys	Layers	Milk Cows	Cow/ Calf	Backgrounders	Sheep	Horses
I	Mcal/M.E.	3,442	4,738	3,582	3,962	6,122	938	8,957	1,812	21960	4745
	% DP	7.1	13.0	18.0	20.1	15.0	14.0	5.63	8.0	6.7	13.0
II	Mcal/M.E.	3,442	4,744	3,562	3,988	6,055	984	8,957	1,812	21960	4745
	% DP	7.1	13.0	18.0	20.1	15.0	14.0	5.63	8.0	6.7	13.0
III	Mcal/M.E.	3,442	4,746	3,602	3,971	6,105	904	8.957	1,812	21960	4745
	% DP	7.1	13.0	18.0	20.1	15.0	14.0	5.63	8.0	6.7	13.0
IV	Mcal/M.E.	3,442	4,754	3,579	3,963	6,249	1070	8,957	1,812	21960	4745
	% DP	7.1	13.0	18.0	20.1	15.0	14.0	5.63	8.0	6.7	13.0
V	Mcal/M.E.	3,442	4,756	3,562	3,965	6,452	1034	8,957	1,812	21960	4745
	%DP	7.1	13.0	18.0	20.1	15.0	14.0	5.63	8.0	6.7	13.0
VI	Mcal/M.E.	3,442	4,748	3,562	3,981	6,296	999	8,957	1,812	21960	4745
	% DP	7.1	13.0	18.0	20.1	15.0	14.0	5.63	8.0	6.7	13.0
VII	Mcal/M.E.	3,442	4,748	3,562	3,981	6,296	999	8,957	1,812	21960	4745
	%DP	7.1	13.0	18.0	20.1	15.0	14.0	5.63	8.0	6.7	13.0
VIII	Mcal/M.E.	3,442	4,748	3,562	3,981	6,296	999	8,957	1,812	21960	4745
	%DP	7.1	13.0	18.0	20.1	15.0	14.0	5.63	8.0	6.7	13.0
IX	Mcal/M.E.	3,442	4,748	3,562	3,981	6,296	999	8,957	1,812	21960	4745
	%DP	7.1	13.0	18.0	20.1	15.0	14.0	5.63	8.0	6.7	13.0
X	Mcal/M.E.	3,442	4,748	3,562	3,981	6,296	999	8,957	1,812	21960	4745
	%DP	7.1	13.0	18.0	20.1	15.0	14.0	5.63	8.0	6.7	13.0
XI	Mcal/M.E.	3,442	4,748	3,562	3,981	6,296	999	8,957	1,812	21960	4745
	%DP	7.1	13.0	18.0	20.1	15.0	14.0	5.63	8.0	6.7	13.0
XII	Mcal/M.E.	3,442	4,748	3,562	3,981	6,296	999	8,957	1,812	21960	4745
	%DP	7.1	13.0	18.0	20.1	15.0	14.0	5.63	8.0	6.7	13.0
XIII	Mcal/M.E.	3,442	4,748	3,562	3,981	6,296	999	8,957	1,812	21960	4745
	%DP	7.1	13.0	18.0	20.1	15.0	14.0	5.63	8.0	6.7	13.0

*Mcal/M.E means megacalories of metabolizeable energy.

% DP means percentage of digestible protein.

Source: Calculated from NRC tables (National Academy of Sciences, 1971a, 1971b, 1973, 1976, 1975, 1978).

The units of livestock products were defined at 1000 pounds of live weight fed beef, pork, broilers, turkeys, lambs and 100 dozen eggs. All feeds were in tons with the exception of the pasture categories which were in AUMs. An AUM was defined as the amount of forage a 1000 pound cow would eat in one month. Traditionally, this has also been considered the amount of forage five sheep will eat during a one month period. The amount of AUMs available on each type of pasture was calculated by using government publications (USDA, Forest Service, 1978), (DOI, BLM; 1978), and (Nef, 1979).

The costs of feed were taken from Agricultural Prices (USDA, 1978) and Livestock and Meat Statistics (USDA, 1978). These costs are presented in Table 7. The costs of grazing on public land were assumed to be the actual grazing fees paid or $1.89/AUM on BLM land in 1978 and $2.00/AUM on Forest Service land in 1978. A weighted average of these two prices was calculated by the following method:

If for example: Utah

had 563,140 AUMs sold on BLM land for cattle at $1.89/AUM

and 471,277 AUMs sold on Forest Service land for cattle at $2.00/AUM

Total 1,034,426

563,149/1,034,426 = 54 percent

471,277/1,034,426 = 46 percent

The weighted average is then calculated as follows:

.54 x $1.89 = $1.02

.46 x $2.00 = .92

$1.94/AUM = weighted average price per AUM on public land in Utah for 1978.

Table 7. Feed prices (1978).

Region	$/ton							$/AUM			
									Public Pasture		
	Barley	Wheat	Corn	Oats	Milo	Hay	Protein Supplement	Private Pasture*	Cattle	Sheep	Horses
I	77.07	113.32	94.63	100.00	--	54.50	291.00	5.04	2.00	2.00	2.00
II	79.15	114.98	94.63	87.50	--	58.50	261.00	5.22	1.93	1.99	1.95
III	97.90	108.32	98.20	100.00	88.00	59.00	278.40	7.29	1.96	1.97	2.00
IV	81.24	102.65	83.92	90.63	--	46.00	289.00	6.93	1.93	1.96	1.96
V	91.65	111.65	--	--	--	55.50	274.00	6.84	1.91	1.93	1.90
VI	83.32	99.65	94.63	100.00	--	58.00	271.60	6.75	1.94	1.94	1.98
VII	99.98	97.65	89.28	--	93.60	64.50	300.00	6.75	1.97	1.99	1.96
VIII	81.24	94.99	82.13	--	79.20	57.50	297.00	6.03	1.94	1.90	1.92
IX	97.90	91.65	74.99	75.00	63.00	56.50	236.00	6.84	1.97	1.97	1.98
X	97.90	91.65	80.35	84.38	--	45.00	243.00	7.02	1.94	1.93	1.97
XI	70.82	91.99	80.35	71.88	--	56.00	250.80	7.56	1.94	1.92	1.97
XII	72.49	94.32	72.85	71.25	67.00	43.80	234.20	5.60	--	--	--
XIII	74.98	102.32	75.34	76.88	62.60	56.94	235.80	6.13	--	--	--

*Fees for private improved pasture and private range are assumed to be equal.

Source: USDA, 1978, Agricultural Prices (1978); Andrus and Bergland (1977); Firm Enterprise Data System (USDA, 1977).

Private grazing fees were taken from studies at Oklahoma State University (USDA, 1979).

Non-feed costs for cow/calf operations, sheep operations, pork, milk, and eggs were taken from national studies conducted by the USDA. Fed beef and backgrounding non-feed costs were taken from various state experiment station bulletins and also from Nef (1979). These non-feed costs are presented in Table 8.

The AUMs on private and public lands were calculated from U.S. Senate Subcommittee on Agriculture and Forestry (1974), Nef (1979), DOI, BLM (1978), and (USDA, USFS, 1972 and 1978).

Simulated Reduction in Available Public Grazing

Five different optimal solutions were considered in this study: (1) the base year run, (2) a 25 percent reduction of public AUMs with an allowed 65 percent spillover onto private range called Simulation I, (3) a 50 percent reduction in grazing on public land with an allowed 65 spillover on private range called Simulation II, (4) a 25 percent reduction in grazing on public land with a 15 allowable spillover on private range called Simulation III, and (5) a 50 percent reduction in grazing on public land with an allowable spillover of 15 percent called Simulation IV.*

The effect of changes in allowed public grazing permits will affect the objective function and allow for the reallocation of present resources through the calculation of the linear program. Although it

*The short run effects of reductions in public grazing will be discussed in the text of this thesis (Simulations I and II). The long run effects (Simulations III and IV) represent a deepening of the short run effects with little change in the overall pattern. For these Simulations (III and IV) the reader is referred to Appendix A. All four simulations for Region VI (Utah) are presented within the text.

Table 8. Non feed costs of livestock production 1978. (per livestock unit)

Region	Fed Beef	Pork	Broilers	Turkeys	Eggs	Milk	Cow/Calf	Backgrounders	Sheep	Horses
I	55.24	110.59	98.60	108.00	152.71	42.77	161.67	34.02	245.97	168.12
II	46.75	110.59	98.60	108.00	152.71	42.77	130.20	30.13	245.97	168.12
III	57.62	100.44	98.60	98.40	158.64	37.91	168.57	35.46	297.11	168.12
IV	57.14	106.87	98.60	108.00	150.88	47.59	150.42	35.11	251.79	168.12
V	42.34	103.03	98.60	108.00	153.85	41.94	108.57	26.06	275.61	168.12
VI	56.79	105.62	98.60	108.00	149.04	50.00	155.90	34.95	251.79	168.12
VII	62.34	100.44	98.60	108.00	156.01	39.78	159.01	38.23	297.11	168.12
VIII	56.99	98.85	98.60	108.00	152.79	45.75	163.79	37.54	216.56	168.12
IX	52.84	96.04	98.60	108.00	148.14	50.15	154.60	32.51	284.98	168.12
X	51.44	103.77	98.60	108.00	148.85	49.39	150.52	31.73	219.99	168.12
XI	50.71	102.62	98.60	108.00	149.37	48.93	141.08	31.34	217.32	168.12
XII	48.67	91.26	97.09	95.69	146.34	50.22	156.44	32.19	234.32	168.12
XIII	57.10	92.56	97.31	79.50	.4299	47.38	180.46	35.68	329.71	168.12

$/1000 pounds live weight fed beef, hogs, broilers, turkeys, milk and sheep; $/1000 dozen eggs, $/head cow/calf, horses & backgrounders.

Source: Menzie et al. (1973); Jones and Wiegman (1979); Livestock and Meat Situation (1978); Gee (1969); Inuei and Jones (1971); Vass, et al. (1976); USDA ESCS (1972); Blackham (1978); Benson and Witzig (1977); Gustafson, Gilliam, and Boykin (1978); Christensen, Davis, and Richard (1973);Grimshaw (1979); Nef (1979); Henson, et al. (1976); Michalson and Noteboom (1966); McArthur and McKendrik (1974)p Committee on Agriculture, Nutrition and Forestry (1979); Committee on Agriculture and Forestry (1976).

was an assumption of this model that reductions would be across-the-board, it was believed that this was the most efficient method to see the overall effects of such changes. The magnitude of these changes was determined somewhat arbitrarily. It was believed, however, that a 25 percent reduction would be somewhat of an intermediate level. A larger, more substantial reduction of 50 percent was also considered. This reduction, it was believed, would show costs, and profits would increase (decrease) in a linear or exponential fashion. This larger reduction would also demonstrate a more profound effect on the general farm economy.

The amount of available AUMs on public land was calculated for each region by the method previously stated. These AUMs are listed in Table 9. Figure 3 shows the percentage of the land area of the 11 western states owned and controlled by the federal government.

After a reduction in grazing has taken place, it was assumed that private range and private improved pasture would not be a perfect substitute for the public range that was reduced. This has been the experience of Nielsen in studies of reductions of public grazing in Utah (1980). Based on this work it was assumed that in the short run approximately 65 percent of an initial reduction in public grazing could "spill-over" on private range.

During the base year, private range, private improved pasture, and public range were allowed to be fed to their optimum allowable (available) levels. From this point, if 65 percent of the reduction, in grazing exceeded the original upper bound on private range, then the original upper bound was held constant. For example, if a region had 500,000 AUMs available for cow/calf operations on public land and

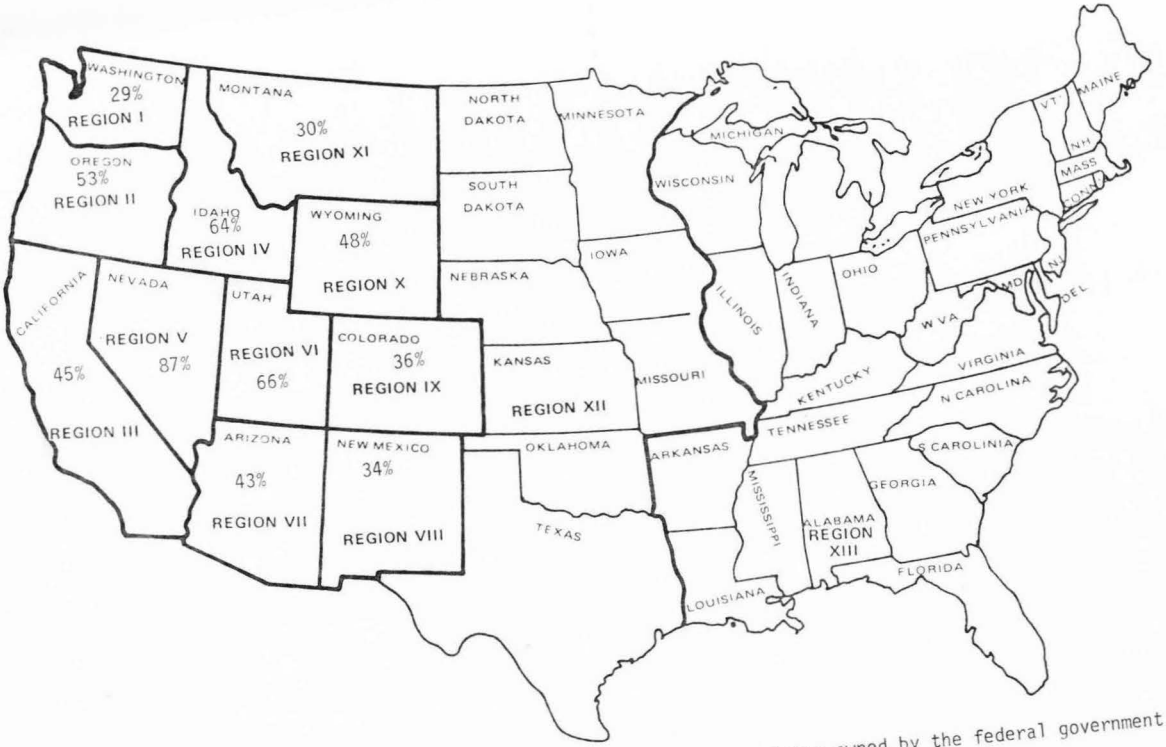

Figure 3: Percentages of the land area of the 11 western states owned by the federal government.

Table 9: Actual public AUMs utilized 1978.

Region	Cattle			Sheep			Horses		
	BLM	FS	Total (Amount Allowed in the model)	BLM	FS	Total (Amount Allowed in the model)	BLM	FS	Total
I		103794	103794 (68504)	-	4914	4914 (3170)	-	3216	3216
II	868706	525734	1394440 (920330)	3842	41064	44906 (25235)	3422	3638	7060
III	209365	454084	663449 (437876)	24900	57744	82644 (41152)	223	7637	7860
IV	954303	622938	1577241 (1040980)	141575	284582	426157 (298399)	5647	11533	17180
V	1598857	300839	1899696 (1253802)	141531	79077	220608 (136235)	9592	1246	10838
VI	563149	471277	1034426 (682724)	267336	256596	523932 (321829)	1931	9691	11622
VII	504625	1439289	1943914 (1282981)	5434	36818	42252 (16438)	5849	11610	17459
VIII	1211666	857577	2068243 (1365698)	133013	20564	153577 (69500)	21895	8777	30672
IX	326178	879791	1205969 (795940)	77708	229098	306806 (129995)	3426	17026	20452
X	851647	629832	1480779 (977315)	313642	197877	511519 (238455)	9328	21523	30851
XI	860824	609795	1470619 (970609)	57418	24912	92330 (43371)	4003	12347	16350

Source: BLM (1978) and USDA Forest Service (1978).

750,000 AUMs available on private range during the base year, and it was assumed that only the base year AUMs were available, then a 50 percent reduction in public AUMs would lead to a reduction of 250,000 AUMs on public land. If only 65 percent of this reduction was allowed on private range then the calculation was

250,000 x .65 = 162,500

Adding this figure to the original utilization on private range gave

162,500 + 600,000 = 762,500

but since this figure was greater than 750,000 (the amount of private range available) the lower figure (750,000) was used as the upper bound because the amount of forage on private range was assumed given for the base year with no possibility for higher production in the short run.

For the long run it was assumed that higher opportunity cost of grazing livestock on private ground vs. public would reduce the utilization of private range from 65 percent of any reduction to approximately 15 percent.

This same principle was applied to private improved pasture. During the base year run, livestock activities were allowed to utilize improved pasture to the allowable upper bound. In subsequent runs only an additional 10 percent was allowed to be utilized to the point of original availability. If the base run fed only 100,000 AUMs of improved pasture but 200,000 were available, then in subsequent runs the upper bound would be

200,000 x .1 = 20,000

100,000 + 20,000 = 120,000

Thus 120,000 AUMs would be the upper bound of private improved pasture for cow/calf operations in this particular region.

The procedure was used in order to reflect opportunity costs of feeding range livestock on improved pasture and also to recognize the necessary supplementation of these animals on improved pasture. These factors led to the assumption that only a small percentage of approximately 10 percent of available improved pasture would be available immediately to take up "slack" in the event of reductions in public grazing.

CHAPTER IV

RESULTS AND ANALYSIS

This chapter contains results of the LP "solutions." These results represent "optimal" solutions. These "optimal" solutions may or may not correspond with the "real" world and some of the numbers may differ from the actual production and utilization figures of the given base year.

The results and analyses are presented beginning with the base year optimal solution. Next, variations of the base year optimal solution will be presented. In all cases, each of the 13 regions are evaluated. Main emphasis was placed on the base year with the subsequent variations stating the deviations from the base year results. The results and analyses for Utah are treated for the base year and its variations in a separate section in this chapter to establish more clearly the effects this study projects on the state of Utah.

Care should be exercised in the interpretation of these results. It may be especially important to bear in mind that this study minimizes the costs of production and consumption over the entire United States. If each region were analyzed separately, different optimal solutions could be found. This would indicate that the results of the optimal solutions of regions taken separately may differ from the overall optimal solution.

The total costs and net profits for the base year solution and the subsequent solutions are presented in Table 10.

Table 10. Total costs and net profits.

Solution	Millions of Dollars Total Costs	Net Profits*
Base Year	39,741	24,956
Simulation I	39,782	24,917
Simulation II	39,831	24,867
Simulation III	39,786	24,912
Simulation IV	39,839	24,859

*Net Profits = Total Revenues - Total Costs

Base Year Solution

The year 1978 was used as the base year of this study. In the optimal solution total costs of producing and marketing feed grains, and livestock products were in excess of $39.7 billion. Net profits earned by farmers and ranchers in the base year solution was approximately $24.9 billion. This profit figure is most likely overstated because labor costs were assumed to be accrued at the minimum wage.

The optimal and actual production of feed and livestock products are represented in tables 11 and 15 respectively. Table 12 states the utilization of AUMs by the different classes of livestock on the three categories of pasture. The upper bound given is the actual number of AUMs available on the different categories of pasture. Actual use is the amount of the available AUMs utilized in the base year run. Table 13 depicts the actual and "shadow" prices for different livestock

Table 11. Actual and optimal production of feed - Base year 1978

Region		Tons					
		Barley	Wheat	Corn	Oats	Milo	Hay
I	Optimal	592,800	0	0	0	-	2,000,325
	Actual	592,800	803,880	220,220	29,760	-	2,582,000
II	Optimal	222,000	0	34,580	0	-	1,398,071
	Actual	222,000	311,550	34,580	67,200	-	2,607,000
III	Optimal	696,652	56,569	991,368	0	367,780	6,955,000
	Actual	1,094,400	274,950	991,368	81,408	367,780	6,955,000
IV	Optimal	505,510	0	95,004	0	-	3,495,596
	Actual	1,339,200	448,380	95,004	50,176	-	4,708,000
V	Optimal	0	0	-	-	-	963,000
	Actual	28,800	9,240	-	-	-	963,000
VI	Optimal	176,064	11,181	0	0	-	1,027,637
	Actual	176,064	33,594	40,320	9,216	-	1,886,000
VII	Optimal	0	57,960	161,000	-	104,656	384,500
	Actual	56,640	57,960	161,000	-	159,432	1,382,000
VIII	Optimal	34,200	27,989	211,680	-	343,896	524,814
	Actual	34,200	33,972	211,680	-	343,896	1,054,000
IX	Optimal	0	175,269	2,217,600	28,160	260,400	2,090,535
	Actual	368,640	343,608	2,217,600	28,160	260,400	3,013,000
X	Optimal	0	38,454	77,112	0	-	2,050,000
	Actual	198,072	45,636	77,112	43,904	-	2,050,000
XI	Optimal	1,353,000	163,294	10,080	0	-	1,924,317
	Actual	1,353,000	876,300	10,080	21,280	-	4,576,000
XII	Optimal	1,843,205	0	22,945,800	167	18,506,300	53,257,800
	Actual	4,634,930	6,377,730	98,869,700	6,077,360	18,506,300	58,095,000
XIII	Optimal	629,448	0	35,979,000	0	1,317,650	45,448,900
	Actual	629,448	1,165,330	95,363,100	3,211,650	1,317,650	52,393,000

Table 12. Upper bounds and optimal utilization of pasture AUMs base year 1978

	Region	Improved Pasture					Private Range			Public Range		
		Dairy	Backgrounders	Cow/Calf	Sheep	Horses	Cow/Calf	Sheep	Horses	Cow/Calf	Sheep	Horses
I	Optimal	0	44369	1076163	106543	88738	759977	7504	11631	68504	3170	3216
	UP BND	232936	44369	1076163	143125	88738	759977	7504	11631	68504	3170	3216
II	Optimal	0	57296	1389722	160989	114593	1168655	10051	17886	920330	25235	7060
	UP BND	300806	57296	1389722	160989	114593	1168655	10051	17886	920330	25235	7060
III	Optimal	0	167804	4070088	417779	335608	1901684	276574	34715	437876	41152	7860
	UP BND	880971	167804	4070088	417779	335608	1901684	276574	34715	437876	41152	7860
IV	Optimal	0	51444	1247783	180109	102889	571296	191400	11389	1040980	298399	17180
	UP BND	270083	51444	1247783	180109	102889	571296	191400	11389	1040980	298399	17180
V	Optimal	0	8262	0	0	16524	866064	72829	15111	1253802	136235	10838
	UP BND	43376	8262	200395	25511	16524	887627	102650	15111	1253802	136235	10838
VI	Optimal	0	26972	0	82840	53945	496047	333249	13911	682724	321829	11622
	UP BND	141605	26972	654216	82840	53945	560051	333249	13911	682724	321829	11622
VII	Optimal	0	7300	0	14200	14600	478437	60110	51502	1282981	16438	17495
	UP BND	38325	7300	177062	14200	14600	3263179	60110	51502	1282981	16438	17495
VIII	Optimal	0	25650	0	58038	51300	3610634	271654	66699	1365698	69500	30672
	UP BND	134663	25650	662141	58038	51300	3961901	271654	66699	1365698	69500	30672
IX	Optimal	0	104175	0	220697	208350	1955963	354166	37995	795940	129995	20452
	UP BND	546919	104175	2526764	220697	208350	1955963	354166	37995	795940	129995	20452
X	Optimal	0	31973	0	74212	63946	2547710	648755	53751	977315	237445	30851
	UP BND	167859	31973	775507	74212	63946	2625203	648755	53751	977315	237445	30851
XI	Optimal	0	76661	1859418	201923	153322	4392960	184544	70063	970609	43371	16350
	UP BND	402471	76661	1859418	201923	153322	4392960	184544	70063	970609	43371	16350
XII	Optimal	0	4161600	75823600	4098843	7139329	40893400	4202300	3349170	-	-	-
	UP BND	2 348400	4161600	100940000	10443300	8323200	40893400	4202300	3349170	-	-	-
XIII	Optimal	0	1201429	67527500	1062288	9197150	25012900	1394942	871225	-	-	-
	UP BND	24142500	4598580	11154000	14725800	9197150	25012900	1394942	871225	-	-	-

Table 13. Actual and Shadow Prices of Livestock Feed - Base Year 1978.

Region		Barley	Wheat	Corn	Oats	Milo	Hay
				$/Ton			
I	Actual	77.07	113.32	94.63	100.00	-	54.50
	Shadow	86.47	102.82	91.77	77.19	-	54.50
II	Actual	79.15	114.98	94.63	87.50	-	58.50
	Shadow	89.54	105.89	94.82	82.83	-	58.50
III	Actual	97.90	108.32	98.20	100.00	88.00	59.00
	Shadow	97.90	108.32	100.38	100.00	102.47	65.55
IV	Actual	81.24	102.65	83.92	90.63	-	46.00
	Shadow	81.24	101.41	86.03	90.63	-	46.00
V	Actual	91.65	111.65	-	-	-	55.50
	Shadow	89.76	111.65	-	-	-	61.08
VI	Actual	83.32	99.65	94.63	100.00	-	58.00
	Shadow	87.99	99.65	94.63	100.00	-	58.00
VII	Actual	99.98	97.65	89.28	-	93.60	64.50
	Shadow	99.98	104.65	91.07	-	93.60	64.50
VIII	Actual	81.24	94.99	82.13	-	79.20	57.50
	Shadow	87.36	94.99	89.03	-	85.39	57.50
IX	Actual	97.90	91.65	74.99	75.00	63.00	56.50
	Shadow	97.90	91.65	84.56	75.32	84.20	56.50
X	Actual	97.90	91.65	80.35	84.38	-	45.00
	Shadow	97.90	91.65	86.33	84.38	-	51.68
XI	Actual	70.82	91.99	80.35	71.88	-	56.00
	Shadow	75.64	91.99	85.72	71.88	-	56.00
XII	Actual	72.49	94.32	72.85	71.25	67.00	43.84
	Shadow	72.49	94.32	72.85	71.25	74.94	43.84
XIII	Actual	74.98	102.32	75.34	76.88	62.60	56.94
	Shadow	80.57	102.32	75.34	76.88	84.44	56.94

feeds where shadow price is defined as the marginal cost of one more unit or the amount willing to be paid for one more unit of the commodity. Table 14 depicts the actual and shadow prices of the different categories of pasture.

Livestock product production in base year 1978 is presented in Table 15 where both optimal and actual production are presented. The "shadow" prices of these different livestock products is delineated in Table 16. Again a "shadow" price is the marginal cost of one more unit or the amount buyers would be willing to pay for one more unit at the margin.

Region I (Washington)

Region I produced only barley and hay as feeds. Barley was produced at its upper bound and hay at 77 percent of its upper bound where the upper bounds are actual 1978 production. All barley produced in the state was used locally (not exported outside of the state).

Production of livestock products was as follows: fed beef was produced at its lower bound as were hogs, broilers, turkeys, eggs, milk, and calves (cow/calf). Backgrounders were produced at an intermediate level, and sheep were produced at their upper bound.

Utilization of livestock products was centered within the state with fed beef, pork, broilers, and sheep utilized locally only. Eggs were used locally and shipped to Montana. Milk was the largest export item with substantial shipments to Nevada, Oregon, Montana, and a small amount to Arizona. Inputs to the fed beef category viz. cow/calf operations and backgrounders had all production going into local beef enterprises. The least cost feeds for each class of livestock are presented in Table 17.

Table 14. Actual and shadow prices of pasture AUMs fed to different livestock classes

Region		Improved Pasture					Private Range			Public Range		
		Dairy	Backgrounders	Cow/Calf	Sheep	Horses	Cow/Calf	Sheep	Horses	Cow/Calf	Sheep	Horses
I	Actual	5.04	5.04	5.04	5.04	5.04	5.04	5.04	5.04	2.00	2.00	2.00
	Shadow	5.04	19.43	18.52	5.04	14.60	23.38	6.92	9.13	23.93	6.92	9.13
II	Actual	5.22	5.22	5.22	5.22	5.22	5.22	5.22	5.22	1.93	1.93	1.93
	Shadow	5.22	20.86	6.95	17.31	15.03	8.92	23.78	10.80	9.51	23.78	10.06
III	Actual	7.29	7.29	7.29	7.29	7.29	7.29	7.29	7.29	1.96	1.96	1.96
	Shadow	7.29	23.37	22.06	19.01	18.39	27.90	26.00	12.08	28.86	26.00	12.08
IV	Actual	6.93	6.93	6.93	6.93	6.93	6.93	6.93	6.93	1.93	1.93	1.93
	Shadow	6.93	16.40	15.15	14.22	14.84	19.25	19.53	9.32	20.15	19.53	9.32
V	Actual	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	1.91	1.91	1.91
	Shadow	6.84	21.78	6.84	6.84	17.45	6.84	6.84	11.40	7.73	6.84	11.40
VI	Actual	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	1.94	1.94	1.94
	Shadow	6.75	13.91	6.75	17.01	16.79	6.75	23.37	10.92	7.62	23.36	10.92
VII	Actual	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	1.97	1.97	1.97
	Shadow	6.75	17.68	5.16	18.10	18.55	6.75	24.86	12.13	7.61	24.86	12.13
VIII	Actual	6.03	6.03	6.03	6.03	6.03	6.03	6.03	6.03	1.94	1.94	1.94
	Shadow	6.03	19.94	4.51	16.28	17.23	6.03	22.68	11.08	6.77	22.68	11.08
IX	Actual	6.84	6.84	6.84	6.84	6.84	6.84	6.84	6.84	1.97	1.97	1.97
	Shadow	6.84	18.73	6.84	16.28	15.77	6.87	22.36	10.38	7.74	22.36	10.38
X	Actual	7.02	7.02	7.02	7.02	7.02	7.02	7.02	7.02	1.94	1.94	1.94
	Shadow	7.02	18.46	5.37	16.00	15.00	7.02	21.98	9.75	7.93	20.98	9.75
XI	Actual	7.56	7.56	7.56	7.56	7.56	7.56	7.56	7.56	1.94	1.94	1.94
	Shadow	7.56	13.50	17.37	14.62	15.98	22.05	20.09	10.44	23.06	20.09	10.44
XII	Actual	5.60	5.60	5.60	5.60	5.60	5.60	5.60	5.60	-	-	-
	Shadow	5.60	15.63	5.60	5.60	5.60	11.39	7.69	5.60	-	-	-
XIII	Actual	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13	-	-	-
	Shadow	0	6.13	6.13	6.13	12.50	12.78	8.18	8.99	-	-	-

Table 15. Optimal and actual livestock and livestock product production[a]--base year 1978

Region		Fed Beef	Pork	Broilers	Turkeys	Eggs	Milk	Calves	Backgrounders	Sheep	Horses[b]
I	optimal	353261	15443	50220	0	78784	2591599	269389	269389	3676	37000
	actual	406000	19255	61939	0	84833	2669000	295091		3358	
II	optimal	152268	27115	89606		38966	1058390	401153	147258	20004	44000
	actual	175000	33810	70511	21069	41958	1090000	432540		24443	
III	optimal	1282700	42903	655819	24567	572648	12426100	814609	452627	65554	77000
	actual	1415000	58770	573700	256096	645204	11859011	872920		74629	
IV	optimal	453420	16372	500	307432	16429	1578784	409736	1268120	39795	51000
	actual	495000	19800	0	0	17232	1633000	534743		38264	
V	optimal	34955	1786	500	0	184	359081	180000	672900	8711	20000
	actual	38160	2160	0	0	192	4604	170940		7260	
VI	optimal	115496	8040	500	49548	25529	911518	200637	40100	31120	31000
	actual	131440	12960	0	63948	28958	940000	224000		28550	
VII	optimal	579828	34616	500	0	9410	467104	150516	10852	17250	53000
	actual	633000	41857	0	0	9833	467104	230468		21210	
VIII	optimal	308692	19284	500	0	24523	467104	422618	38133	16504	55000
	actual	337000	23318	0	0	25625	467104	478207		14350	
IX	optimal	2248780	126285	500	79256	41242	925715	452325	154874	67282	68000
	actual	2455000	106543	0	82563	40291	872000	627980		69998	
X	optimal	116515	9549	500	0	1395	359081	467441	626914	54658	51000
	actual	127200	8056	0	0	1458	467104	443914		49689	
XI	optimal	108088	75153	500	0	15391	359081	911112	176782	24367	88000
	actual	118000	79068	0	0	16083	467104	1054320		21756	
XII	optimal	18205000	11421700	1312620	739253	740696	22516200	11451000	19312800	299405	829000
	actual	18305972	10324198	1091122	934581	815745	24305004	12874941		253733	
XIII	optimal	1531280	8534630	13612300	1506642	3345000	77697300	8521103	1480900	91307	1596000
	actual	2012195	7956955	12265343	1213380	3611411	76041025	9849883		89517	

[a]Thousands of pounds liveweight of fed beef, pork, broilers, turkeys and sheep; thousands of dozens eggs, thousands pounds of milk; head of calves and backgrounders.

[b]This is the actual horse population for each region. No deviation in production was allowed.

Table 16. Shadow prices[a] of livestock and livestock products--base year 1978

Region		Fed Beef	Pork	Broilers	Turkeys	Eggs	Milk	Calves	Backgrounders	Sheep
I	Actual	474.00	484.00	308.00	467.00	506.00	106.00	276.30	330.20	624.00
	Shadow	446.36	468.18	307.52	413.59	449.67	76.67	74.38	330.20	1036.21
II	Actual	476.00	463.00	310.00	467.00	545.00	108.00	270.70	323.10	614.00
	Shadow	451.64	446.36	318.83	424.29	499.68	97.98	270.70	323.10	610.50
IIII	Actual	488.00	483.00	283.00	436.00	508.00	102.00	260.70	334.10	600.00
	Shadow	440.61	472.16	287.13	392.50	406.45	102.00	0	334.10	517.58
IV	Actual	499.00	440.00	260.00	372.00	500.00	99.50	323.90	335.40	608.00
	Shadow	468.30	424.10	263.83	0	472.72	78.98	180.30	335.40	704.41
V	Actual	484.00	491.00	260.00	490.00	521.00	104.00	301.50	334.80	579.99
	Shadow	462.74	479.28	266.85	0	469.29	104.00	346.54	334.80	955.83
VI	Actual	476.00	453.00	260.00	490.00	482.00	103.00	291.50	332.80	595.00
	Shadow	443.07	443.96	268.28	426.70	432.33	86.43	289.36	332.80	598.85
VII	Actual	508.00	504.00	260.00	436.00	483.00	111.00	303.10	336.70	623.00
	Shadow	450.33	496.24	264.56	0	420.29	117.21	293.34	336.70	547.69
VIII	Actual	529.00	479.00	260.00	466.00	590.00	115.00	299.90	351.00	679.00
	Shadow	482.85	476.23	267.50	0	572.46	117.31	299.90	351.00	737.34
IX	Actual	510.00	465.00	260.00	460.00	530.00	112.00	310.70	334.80	633.00
	Shadow	476.48	477.59	281.71	417.03	530.00	112.28	310.70	334.80	633.00
X	Actual	547.00	448.00	260.00	460.00	540.00	105.00	343.50	377.00	679.00
	Shadow	516.11	451.97	277.08	0	534.69	105.00	346.82	377.00	752.05
XI	Actual	515.00	448.00	260.00	430.00	570.00	107.00	337.90	370.50	671.00
	Shadow	501.02	448.00	272.91	0	563.59	107.00	165.17	370.50	789.09
XII	Actual	499.20	469.40	280.00	403.10	503.40	100.80	288.90	339.10	664.40
	Shadow	499.20	469.40	305.23	379.23	492.20	83.95	240.61	339.10	1071.95
XIII	Actual	426.10	464.60	257.90	433.10	576.90	104.80	286.00	314.60	608.10
	Shadow	424.21	473.53	257.90	433.10	522.82	104.80	191.82	314.60	921.00

a Thousands of pounds liveweight of fed beef, pork, broilers, turkeys and sheep; thousands of dozens eggs, thousands pounds of milk; head of calves and backgrounders.

Table 17. Feeds fed to each class of livestock in Region I - base year 1978.

Livestock Class	Tons							AUMs		
	Barley	Wheat	Corn	Oats	Milo	Hay	Protein Supplement	Improved Pasture	Private Range	Public Range
Fed Beef	357517					207760				
Hogs		21406					2514			
Broilers					50131		13407			
Layers (Eggs)					146249		19804			
Milk Cows (Milk)						792000	154956			
Cow/Calf						680845		1076163	759977	68504
Backgrounders						274220		44369		
Sheep								106544	7504	3170
Horses						45502	2024	88738	11631	3216

Table 18 presents the percentages of utilization of the 3 categories of pasture by the different classes of grazing livestock in Region I for the base year optimal solution.

Table 18. Percentages of available pasture* fed to the different classes of livestock in Region I. Base Year 1978.

Livestock Class	Improved Pasture (Percent)	Private Range (Percent)	Public Range (Percent)
Milk Cows	0	N/A**	N/A
Backgrounders	100	N/A	N/A
Cow/Calf	100	100	100
Sheep	74	100	100
Horses	100	100	100

*This represents the percentages of each portion of the pasture categories alloted to each type of livestock that was actually utilized. Example: Sheep utilized all AUMs sold for sheep grazing in Washington in 1978 or 100 percent. Sheep also utilized 100 percent of the AUMs available for sheep on private range. Only 74 percent of AUMs that could have been utilized for sheep on private improved pasture were actually used. The reader is referred to the assumptions of the model in Chapter II.

**Not Applicable.

Washington could expand barley and sheep production profitably. As shown by the "shadow" prices for sheep, Washington has the greatest comparative advantage of any region to expand sheep production.

Region II (Oregon)

Barley, corn, and hay were the only feeds produced in Region II. Again barley was produced at its upper bound. Corn was also produced at its upper bound. Hay was utilized at only 54 percent of its actual 1978 production. All feed grown within the state was fed to local

feeding operations.

Livestock products were all produced at the lower bound with the exception of broilers which were produced at their upper bound. Most livestock products were also utilized only within the state. This was the case with fed beef, pork, broilers, turkeys and milk. Eggs were used locally, and the surplus transported abroad. Sheep were also utilized locally, and the surplus was shipped to Region I and Region XIII. Backgrounders were put into local feeding activities only. Calves were used locally, and the surplus was transported to Region IV and Region V. Table 19 depicts the percentage of each category of pasture available for the different classes of grazing livestock that was actually utilized by the different grazing livestock classes in Region II for the base year optimal solution.

Table 20 presents the types of feed and their amounts fed to the different classes of livestock in Region II.

Table 19. Percentages of available pasture fed to the different classes of livestock in Region II base year 1978.

Livestock Classes	Improved Pasture (Percent)	Private Range (Percent)	Public Range (Percent)
Milk Cows	0	N/A	N/A
Backgrounders	100	N/A	N/A
Cow/calf	100	100	N/A
Sheep	100	100	100
Horses	100	100	100

Table 20. Feeds fed to each class of livestock in Region II - base year 1978.

	Tons							AUMs		
Livestock Class	Barley	Wheat	Corn	Oats	Milo	Hay	Protein Supplement	Improved Pasture	Private Range	Public Range
Fed Beef	119004		34580			87360				
Hogs		37585					4413			
Broilers					89447		23922			
Turkeys					21837		8166			
Layers (Eggs)					72333		9795			
Milk Cows (Milk)	57208					418500	59713			
Cow/calf						708590		1389722	1168655	920330
Backgrounders						274220		57296		
Sheep	87020							160989	10051	25235
Horses	6580							114593	17886	7060

The conclusions that can be drawn from the base year solution for Region II are that in the feed sector, barley and corn could be expanded. In the livestock sector only broilers could be expanded profitably. All other feed and livestock activities are currently producing at or above their optimum levels.

Region III (California)

Region III produced a somewhat wider variety of feeds. Hay, corn, and milo were all produced at their upper bounds or actual 1978 production levels. Barley was produced at 64 percent of the actual 1978 production figure, and wheat at only 23 percent. All feed produced within the state were fed locally with no feed being exported to any of the other regions.

Production of livestock products was at the lower bound for most products. This was the case for fed beef, pork, turkey, eggs, calves, and sheep. Milk was produced at 97 percent of its upper bound, and broilers were produced at their upper bound. These livestock products were utilized exclusively, for the most part, within the region. The only exceptions were eggs which had their surplus shipped to Regions I, II, V, VI, and VII and milk that showed a small surplus which was shipped to Region VII. Table 21 represents the types of feed and their quantities fed to the various classes of livestock in Region III. Table 22 represents the percentage of available pasture in the three pasture categories utilized by the different grazing livestock classes in Region III for the base year optimal solution.

Table 21. Feeds fed to each class of livestock in Region III base year 1978.

Livestock Class	Tons							AUMs		
	Barley	Wheat	Corn	Oats	Milo	Hay	Protein Supplement	Improved Pasture	Private Range	Public Range
Fed Beef			1186183			814800				
Hogs		56569					6995			
Broilers					658310		176060			
Turkeys					266032		99483			
Layers (Eggs)					1060253		143576			
Milk Cows (Milk)	1256018					3807000	710519			
Cow/Calf						1841788		4070088	1901684	437876
Backgrounders						427497		167804		
Sheep	252352							417779	276574	41152
Horses						63915	985	335608	34715	7860

Table 22. Percentages of available pasture fed to the different classes of livestock in Region III base year 1978.

Livestock Class	Improved Pasture (percent)	Private Range (percent)	Public Range (percent)
Milk Cows	0	N/A	N/A
Backgrounders	100	N/A	N/A
Cow/calf	100	100	100
Sheep	100	100	100
Horses	100	100	100

The base year solution would indicate that it is possible to expand profitably corn and hay production in Region III. The only livestock classes that should be expanded are broilers and milk. All other categories of feed and livestock products were producing at or above their optimum levels.

Region IV (Idaho)

Region IV produced barley, corn, and hay as feeds. Of these only corn was produced at its 1978 production level. Barley was produced at 38 percent of actual 1978 production and hay at 73 percent. The barley was used only within the state. Corn was used locally, and the surplus was shipped to Region V.

Fed beef is produced at its lower bound as are pork, turkeys, eggs, milk and calves. Turkeys were not produced. Sheep and broilers were produced at their upper bounds.

Idaho exported much of its livestock products. Fed beef was consumed locally, and surpluses were shipped to Regions I, II, V, and

VI. Milk was utilized locally with the surplus milk being transported to Regions VII, VIII, and IX. Backgrounders in surplus were shipped to Regions III, VI, VII, and VIII. Sheep were also used locally with any surplus being shipped to Region XIII. Pork, broilers, and eggs were consumed totally within the boundaries of the state. Table 23 depicts the percentages of available pasture in the three categories of pasture fed to the different grazing livestock classes in Region IV for the base year optimal solution.

Table 24 indicates the amount and types of feed fed to the livestock classes in Region IV.

Table 23. Percentages of available pasture fed to the different classes of livestock in Region IV base year 1978.

Livestock Class	Improved Pasture (percent)	Private Range (percent)	Public Range (percent)
Milk Cows	0	N/A	N/A
Backgrounders	100	N/A	N/A
Cow/Calf	100	100	100
Sheep	100	100	100
Horses	100	100	100

The indication of the base year optimal solution is that corn production could be expanded profitably. Livestock products that could be expanded profitably were broilers and sheep. All other feed and livestock categories were operating at or above their optimum levels.

Table 24. Feeds fed to each class of livestock in Region IV base year 1978.

Livestock Class	Tons							AUMs		
	Barley	Wheat	Corn	Oats	Milo	Hay	Protein Supplement	Improved Pasture	Private Range	Public Range
Fed Beef	396721		61338			262640				
Hogs		22722					2668			
Broilers					496		133			
Layers (Eggs)					30163		4085			
Milk Cows (Milk)	108789					625500	94544			
Cow/Calf						1017308		1247783	571296	1040980
Backgrounders						1346979		51444		
Sheep						141893		180109	191400	298399
Horses						65277	3119	102889	11389	17180

Region V (Nevada)

Hay was the only feed produced in Nevada, and it was at its upper bound. All other feeds were imported.

Fed beef was produced at its lower bound as were eggs and pork. Turkeys were not produced, and milk was produced at 77 percent of its upper bound. Broilers, cow/calf operations, and sheep were produced at their upper bounds. All livestock products were utilized locally only with the exceptions of backgrounders and sheep. These two classes were both utilized locally and had their surpluses shipped to Region III. Table 25 presents the percentages of pasture in the 3 pasture categories that were utilized by the different classes of grazing livestock in Region V for the base year run. Table 26 presents the types and amounts of feed fed to the various classes of livestock in Region V for the base year optimal solution.

Table 25. Percentage of available pasture fed to the different classes of livestock in Region V base year 1978.

Livestock Class	Improved Pasture (percent)	Private Range (percent)	Public Range (percent)
Milk cows	0	N/A	N/A
Backgrounders	100	N/A	N/A
Cow/Calf	0	98	100
Sheep	0	71	100
Horses	100	100	100

Table 26. Feeds fed to each class of livestock in Region V base year 1978.

Livestock Class	Tons							AUMs		
	Barley	Wheat	Corn	Oats	Milo	Hay	Protein Supplement	Improved Pasture	Private Range	Public Range
Fed Beef			33666			20160				
Hogs		2479					291			
Broilers					496		132			
Layer (Eggs)					338		46			
Milk Cows (Milk)						180000	20086			
Cow/Calf						13286			886064	1253802
Backgrounders						721520		8262		
Sheep									72829	136325
Horses						28034	1583	16524	15111	10838

The conclusions of the base year optimal solution for Region V were that broilers, cow/calf operations, and range sheep operations could be expanded profitably. Hay production could also be expanded. All other categories of feed and livestock production are at or exceed their optimal levels.

Region VII (Arizona)

Region VII produced wheat and corn at their upper limits or actual 1978 production. Milo was produced at 66 percent of 1978 production, and hay was only 28 percent of its actual 1978 production level. Wheat was utilized only locally. All corn produced in Region VII was shipped to Region III. No corn was fed within the state.

Fed beef, pork, eggs, calves, and sheep were produced at their lower bounds. Turkeys were not produced. Broilers and milk were produced at their upper bounds. Pork, broilers, milk, and backgrounders were utilized only locally. All other livestock products were utilized locally and any surpluses shipped to other regions, i.e., fed beef to Region III, eggs to Region VIII, calves to Region XII, and sheep to Region III. Table 27 depicts the types of feeds and amounts fed to the different classes of livestock in Region VII during the base year. Table 28 presents the percentages of available pasture in the 3 pasture categories utilized by the different grazing livestock classes in Region VII for the base year run.

Table 27. Feeds fed to each class of livestock in Region VII base year 1978.

Livestock Class	Tons							AUMs		
	Barley	Wheat	Corn	Oats	Milo	Hay	Protein Supplement	Improved Pasture	Private Range	Public Range
Fed Beef			712516			99427				
Hogs		48043					5641			
Broilers					496		133			
Layers (Eggs)					17277		2340			
Milk Cows (Milk)	24938	9917				180000	28099			
Cow/Calf						16107			478437	1282981
Backgrounders						9082		7300		
Sheep					86883			14200	60110	16438
Horses						79883	4798	14600	13911	17459

Table 28. Percentages of available pasture fed to the different classes of livestock in Region VII base year 1978.

Livestock Class	Improved Pasture (percent)	Private Range (percent)	Public Range (percent)
Milk Cows	0	N/A	N/A
Backgrounders	100	N/A	N/A
Cow/calf	0	15	100
Sheep	100	100	100
Horses	100	100	100

Wheat, broiler, and milk production could be expanded. All other activities in Region VII are producing at or above their optimum levels.

Region VIII (New Mexico)

Barley, Corn, and Milo are produced at their actual 1978 levels in Region VIII. Wheat is produced at 82 percent of its upper bound, and hay was produced at 50 percent of 1978 production. These feeds were all fed locally only with the exception of milo which had its surplus transported to Region III.

Beef, hogs, and eggs were produced at their lower bounds. Turkeys were not produced. Calves are produced at 84 percent of their upper bound. Broilers, milk, and sheep were produced at their upper bounds.

Pork, broilers, eggs, milk, and backgrounders were all utilized only within the boundaries of the state. Fed beef was consumed locally with the surplus amount being shipped to Region III. Calves and sheep were also utilized locally with surpluses being transported to Region XII and Region XIII respectively. Table 29 presents the percentage of

pasture in the three pasture categories that was utilized by the different classes of grazing in Region VIII for the base year run.

Table 29. Percentages of available pasture fed to the different classes of livestock in Region VIII base year 1978.

Livestock Class	Improved Pasture (percent)	Private Range (percent)	Public Range (percent)
Milk Cows	0	N/A	N/A
Backgrounders	100	N/A	N/A
Cow/Calf	0	91	100
Sheep	100	100	100
Horses	100	100	100

Table 30 presents the types and amounts of feed fed to the various classes of livestock in Region VIII for the base year optimal solution.

Barley, corn, milo, broilers, milk and sheep could be expanded in Region VIII. All other categories of feed and livestock production are at or exceed their optimum levels.

Region IX (Colorado)

Corn, oats, and milo were produced at their actual 1978 production levels for the base year optimal solution in Region IX. Wheat was produced at 51 percent of its upper bound, and hay was produced at 69 percent of the actual 1978 figure.

All feed produced within the region (corn, oats, milo, wheat and hay) was utilized only within the region. No feed was transported outside of the region.

Table 30 Feeds fed to each class of livestock in Region VIII base year 1978.

Livestock Class	Tons							AUMs		
	Barley	Wheat	Corn	Oats	Milo	Hay	Protein Supplement	Improved Pasture	Private Range	Public Range
Fed Beef			276891			209160				
Hogs		26764					3143			
Broilers					496		132			
Layers (Eggs)					45024		6097			
Milk Cows (Milk)	34220	1226				180000	28155			
Cow/Calf						31577			3610634	1365698
Backgrounders						31912		25650		
Sheep					14593			58038	271654	69500
Horses						72165	3999	51300	66699	30672

Only fed beef and eggs were produced at the lower bound. Milk was produced at 77 percent of its upper bound. All other livestock classes (calves, sheep, broilers, hogs and turkeys) were produced at their upper bounds. Utilization of livestock products was as follows: Fed beef was used locally with the surplus being shipped to Regions VI and XIII. Excess beef in Region IX was also exported abroad. Pork, broilers, eggs, milk and backgrounders were utilized locally only. The other livestock products were used locally but also showed surpluses which were transported elsewhere. They were turkeys which were shipped to Regions VII, VIII, and X. Calves were shipped to Region XII. Sheep were transported to Region XIII. Table 31 represents the percentages of available pasture in the three pasture categories utilized by the different grazing livestock classes in Region IX for the base year optimal solution. Table 32 depicts the types and

Table 31: Percentages of available pasture fed to the different classes of livestock in Region IX base year 1978.

Livestock Class	Improved Pasture (percent)	Private Range (percent)	Public Range (percent)
Milk Cows	0	N/A	N/A
Backgrounders	100	N/A	N/A
Cow/calf	0	100	100
Sheep	100	100	100
Horses	100	100	100

amounts of feed fed to the livestock classes in Region IX.

Table 32. Feeds fed to each class of livestock in Region IX base year 1978.

Livestock Class	Tons							AUMs		
	Barley	Wheat	Corn	Oats	Milo	Hay	Supplement	Improved Pasture	Private Range	Public Range
Fed Beef			2763567			385614				
Hogs		175269					20581			
Broilers					496		132			
Turkeys					82684		30920			
Layers (Eggs)					75721		10254			
Milk Cows (Milk)	65686			28160		324000	57380			
Cow/Calf						1180960			1955963	795940
Backgrounders						129606		104175		
Sheep	144907				101499			220697	354166	129995
Horses						70355	2503	208350	37995	20452

The base year run indicates that corn, oats, milo, broilers, hogs, turkeys, sheep, and calf production could all be expanded. All other feed and livestock activities were produced at or above their optimum levels.

Region X (Wyoming)

Hay and corn were produced at their actual 1978 production levels while wheat for feed was produced at 84 percent of its upper bound. These feeds were utilized locally only with the exception of wheat which was utilized locally with the surplus being shipped to Region IV.

Fed beef and eggs were the only livestock products produced at their lower bounds. Milk was produced at 77 percent of its upper bound. Pork, broilers, calves, and sheep were all produced at their upper bounds. Hog, broilers, turkeys, eggs, and calves were utilized only within the region. Backgrounders and milk were utilized locally and had their surpluses transported to Region IX. Fed beef was consumed locally with surplus going to Region III. Sheep were also utilized within the region, and the surplus is transported to Region XIII. Table 33 presents the types of feeds and their quantities fed to the various classes of livestock in Region X. Table 34 presents the percentages of available pasture in the three pasture categories fed to the different grazing livestock classes in Region X for the base year optimal solution.

Table 33. Feeds fed to each class of livestock in Region X base year 1978.

	Tons							AUMs		
Livestock Class	Barley	Wheat	Corn	Oats	Milo	Hay	Protein Supplement	Improved Pasture	Private Range	Public Range
Fed Beef			112216			67200				
Hogs		13253					1556			
Broilers					496		133			
Turkeys					584		218			
Layers (Eggs)					2561		347			
Milk Cows (Milk)						180000	20086			
Cow/Calf						916815			2547710	977315
Backgrounders						663518		31973		
Sheep						157764		74212	648755	237455
Horses						64593	3420	63946	53751	30851

Table 34. Percentages of available pasture fed to the different classes of livestock in Region X base year 1978.

Livestock Class	Improved Pasture (percent)	Private Range (percent)	Public Range (percent)
Milk Cows	0	N/A	N/A
Backgrounders	100	N/A	N/A
Cow/Calf	0	97	100
Sheep	100	100	100
Horses	100	100	100

The results of this analysis indicate that corn, hay, hogs, broilers, turkeys, cow/calf operations, and range sheep operations could be expanded profitably. The other production activities are already producing at or above the optimal level.

Region XI (Montana)

Barley and corn are produced at their actual 1978 levels. Hay was at 42 percent of actual 1978 production. Wheat for feed was fed at 19 percent of its upper bound. Corn was utilized only within the region. Barley was utilized locally with its surplus being shipped to Regions I, II, and III. Wheat was used locally and transported to Regions I and II.

Fed beef, calves, and eggs were produced at their lower bounds. Turkeys were not produced. Hogs and milk were produced at intermediate levels of 84 percent and 77 percent of their upper bounds respectively. Broilers and sheep were produced at their upper bounds. Pork, broilers, eggs, and milk were all consumed only within the region. Fed beef

was utilized locally with the surplus transported to Region I. Surplus calves were transported to Region IV after local needs were met. Backgrounders were utilized locally with surplus shipped to Region I. Sheep were utilized within the region, and the surplus was transported to Region XIII. Table 35 depicts the percentages of each category of pasture available for the different classes of grazing livestock that was actually utilized by each class in Region XI for the base year optimal solution.

Table 35. Percentages of available pasture fed to the different classes of livestock in Region XI base year 1978.

Livestock Class	Improved Pasture (percent)	Private Range (percent)	Public Range (percent)
Milk Cows	0	N/A	N/A
Backgrounders	100	N/A	N/A
Cow/Calf	100	100	100
Sheep	100	100	100
Horses	100	100	100

Table 36 represents the types of feed and their amounts fed to the different classes of livestock.

This analysis indicates that in Region XI barley, corn, broilers, and sheep production could be expanded profitably.

Table 36. Feeds fed to each class of livestock in Region XI base year 1978.

	Tons							AUMs		
Livestock Class	Barley	Wheat	Corn	Oats	Milo	Hay	Protein Supplement	Improved Pasture	Private Range	Public Range
Fed Beef	153545									
Hogs		104303					12247			
Broilers			458				163			
Layers (Eggs)			9622		17832		4486			
Milk Cows (Milk)						180000	20086			
Cow/Calf						1548350		1859418	4392960	470609
Backgrounders						84091		76661		
Sheep	55755							201923	184544	43371
Horses						111876	5549	153322	70063	16350

Region XII (The Midwest)

Milo was the only feed produced at its 1978 level. Hay was produced at 92 percent of the 1978 level. A minute amount of oats were produced. Barley and corn were produced at 40 percent and 23 percent of their 1978 levels respectively. All of these feeds were utilized within the region, and their surpluses transported elsewhere. The transportation of these surpluses was as follows: Barley was shipped to Region VII, IX, and exported abroad. Corn was shipped to Regions II, VI, VII, VIII, IX, and exported abroad. Milo was transported to Regions I, II, III, IV, V, VI, X, XI, and was exported abroad.

Turkeys, eggs, milk, and calves were produced at their lower bounds. Fed beef and hogs were produced at 90 percent and 98 percent of their upper bounds respectively. Broiler and sheep were produced at their upper bounds. Region XII was a major exporter. After demand was satisfied locally, all livestock classes (products) showed surpluses that were shipped elsewhere with the exceptions of broilers and calves which were utilized within the region only. Surplus fed beef was transported to Region XIII. Pork was exported to all regions except Region XI. Turkeys were shipped to Regions I, XI, XIII and exported abroad. Eggs were shipped to Regions IX and X. Milk was transported to Region XIII. Backgrounders went to Regions VIII and IX. Sheep were transported to Region XIII. Table 37 presents the types and amounts of feed fed to the different classes of livestock for the base year run. Table 38 presents the percentages of each category of pasture available for the different classes of grazing

Table 37. Feeds fed to each class of livestock in Region XII base year 1978.

	Tons							AUMs	
Livestock Class	Barley	Wheat	Corn	Oats	Milo	Hay	Protein Supplement	Improved Pasture	Private Range
Fed Beef			18886100			8437240			
Hogs			2590818		13154100		3129956		
Broilers					1309192		350133		
Turkeys					766387		286590		
Layers (Eggs)					1403495		190057		
Milk Cows (Milk)	1606366					9823500	1461581		
Cow/Calf						15687600		75823600	40893400
Backgrounders						19309500		4161600	
Sheep								4098843	4202300
Horses								7139029	3349170

livestock that were actually utilized by each class in Region XII for the base year optimal solution.

Table 38. Percentage of available pasture fed to the different classes of livestock in Region XII base year 1978.

Livestock Class	Improved Pasture (percent)	Private Range (percent)
Milk Cows	0	N/A
Backgrounders	100	N/A
Cow/calf	75	100
Sheep	40	100
Horses	86	100

In Region XII milo, broiler, turkey, eggs, milk, and sheep production could be expanded profitably. All other livestock and feed production activities are already equal to or exceed their optimum levels.

Region XIII (The eastern U.S.)

Barley and milo were the only two feeds produced at their actual 1978 production levels for the base year run. Corn was produced at 38 percent of actual 1978 production, and hay at 87 percent of its 1978 level. All of these feeds were utilized locally only.

Fed beef, eggs, and calves were produced at their lower bounds. Broilers, turkeys, and milk were produced at 99 percent, 96 percent, and 98 percent of their upper bounds respectively. Sheep and hogs were produced at their upper bounds. Fed beef, pork, turkeys, milk,

backgrounders, and sheep were utilized only within the region. Eggs were consumed locally with surpluses shipped to Region IX. Surplus calves were transported to Region XII for fattening. Region XIII was a large exporter of broilers which were transported to every region within the contingent United States and also abroad. Table 39 depicts the percentage of pasture in the 3 pasture categories that was utilized by the different classes of grazing livestock in Region XIII for the base year run. Table 40 specifies the types of feed and

Table 39. Percentage of available pasture fed to the different classes of livestock in Region XIII base year 1978.

Livestock Class	Improved Pasture (percent)	Private Range (percent)
Milk Cows	0	N/A
Backgrounders	100	N/A
Cow/calf	61	100
Sheep	7	100
Horses	100	100

their amounts fed to the various livestock classes in Region XIII for the base year optimal solution.

These results indicate that Region XIII could profitably expand its barley, milo, sheep, and hogs production. All other activities are near or exceed their optimum levels.

Table 40. Feeds fed to each class of livestock in Region XIII base year 1978.

Livestock Class	Tons							AUMs	
	Barley	Wheat	Corn	Oats	Milo	Hay	Protein Supplement	Improved Pasture	Private Range
Fed Beef			1881818			262579			
Hogs			11310600				257594		
Broilers			12482200				4451024		
Turkeys			1444598				679811		
Layers (Eggs)			4823256		1317650		1216772		
Milk Cows (Milk)	629448		4036481			33030000	5128227		
Cow/Calf						10129100		67527500	25012900
Backgrounders						1166093		1201429	
Sheep								1062288	1394942
Horses						861054		9197150	871225

Summary

Some of these results lead to conclusions about the state of the livestock industry in 1978. The strength of the sheep industry and its potential for expansion is shown quite clearly with only Region III and Region VII not being able to expand the sheep industry profitably. The beef industry appears to be operating above optimum levels.

The importance of public range is shown by its 100 percent utilization in every grazing livestock category in the 11 western states. It is shown to be the cheapest source of feed available. Private range is utilized at or near its maximum in all livestock categories in all regions with the exception of Region VII where only 15 percent of private range allowed for cow/calf operations was utilized. These findings indicate a heavy dependence on public range in the 11 western states to sustain the livestock industry. Private range alone will not sustain livestock numbers in the west at present levels if only range land is considered.

Private improved pasture was utilized to its upper bound in 5 of the 11 western states for cow/calf operations. Nine of the 11 western states utilized private improved pasture to its upper bound for sheep. All regions fed private improved pasture to horses near or at their upper bounds. This indicates that sheep are more dependent on grazing than cattle and would possibly feel reductions in grazing more strongly and sooner than cattle. Also expansion of the sheep industry could lead to reductions in cattle numbers as sheep "crowd out" cattle on grazing lands.

In general, barley and hay are the cheapest substitutes for grazing in the 11 western states. The choice of either barley or hay

depends upon which state (Region) one is discussing. Region II and XI, for instance, use barley as a substitue while Region V uses hay as its substitute for grazing.

It appears that the livestock industry in the 11 western states has approached its capacity to sustain itself on grazing with small amounts of supplementation. Further expansions would involve more costly feeds or replacements of one form of livestock with another.

Simulation I

This was the first variation of the base year optimal solution. With this reduction in grazing, costs increased by $40.4 million and profits decreased $38.9 million.

Table 41 indicates the new optimal production of feeds in the different regions. Table 42 presents the new shadow prices for feeds in the 13 regions. Table 43 depicts the optimal utilization of grazing by the different classes of grazing livestock and Table 44 gives the shadow prices of the pasture categories as fed to the different classes of grazing livestock. Table 45 presents new optimal production levels of livestock products. Table 46 presents shadow prices for livestock and livestock products associated with the grazing reduction. Particular notice should be given to the new production and shadow prices of cow/calf and range sheep operations since these are the livestock categories most directly affected by reductions in public grazing.

Region I

Feed production remained the same with the exception of hay production which increased by 7748 tons, or approximately 1 percent.

Table 41. Optimal production of feed - Simulation I.

Region	Tons					
	Barley	Wheat	Corn	Oats	Milo	Hay
I	592800	0	0	0	0	2008074
II	222000	0	34580	0	0	1467260
III	779173	59569	991368	0	367780	6955000
IV	505510	0	95004	0	0	3662410
V	0	0	0	0	0	963000
VI	176064	11181	0	0	0	1052277
VII	0	57960	161000	0	105747	385137
VIII	34200	27989	211680	0	343896	525934
IX	0	175269	2217600	28160	260400	2091282
X	0	38454	77112	0	0	2050000
XI	1353000	163294	10080	0	0	1924914
XII	1851837	0	22999000	167	18506300	53385600
XIII	629448	0	35979000	0	1317650	45448900

Table 42. Shadow prices of livestock feed - Simulation I.

Region	$/Ton					
	Barley	Wheat	Corn	Oats	Milo	Hay
I	86.47	102.82	91.77	79.19	-	54.50
II	89.54	105.89	94.82	82.83	-	58.50
III	97.90	108.32	100.38	100.00	102.47	65.55
IV	81.24	101.41	86.03	90.63	-	46.00
V	89.76	111.65	-	-	-	61.08
VI	87.99	99.65	94.63	100.00	-	58.00
VII	99.98	104.34	91.07	-	93.60	64.50
VIII	87.36	94.99	89.03	-	85.39	57.50
IX	97.90	91.65	84.56	75.32	84.20	56.50
X	97.90	91.65	86.33	84.38	-	51.78
XI	75.64	91.99	85.72	71.88	-	56.00
XII	72.49	94.32	72.85	71.25	74.94	43.84
XIII	80.57	102.32	75.34	76.88	84.44	56.94

Table 43. Upper bounds and optimal utilization of pasture AUMs--Simulation I

	Region	Improved Pasture					Private Range			Public Range		
		Dairy	Backgrounders	Cow/Calf	Sheep	Horses	Cow/Calf	Sheep	Horses	Cow/Calf	Sheep	Horses
I	UP BND	232936	44369	1076163	143125	88738	759977	7504	11631	51378	2378	2412
	Optimal	0	44369	1076163	107623	88738	759977	7504	11631	51378	2378	2412
II	UP BND	300806	57296	1389722	160989	114593	1168655	10051	17886	690248	18926	5295
	Optimal	0	57296	1389722	160989	114593	1168655	10051	17886	690248	18926	5295
III	UP BND	880971	167804	4070088	417779	335608	1901684	276574	34715	328407	30864	5895
	Optimal	0	167804	2070088	417779	335608	1901684	276574	34715	328407	30864	5895
IV	UP BND	270083	51444	1247783	180109	102889	571296	191400	11389	780735	223800	12885
	Optimal	0	51444	1247783	180109	102889	571296	191400	11389	780735	223800	12885
V	UP BND	43376	8262	20040	25511	16524	887627	94967	15111	940352	102176	8129
	Optimal	0	8262	20040	16378	16524	887627	94967	15111	940352	102176	8129
VI	UP BND	141605	26972	65422	82840	53945	560051	333249	13911	512043	241372	8717
	Optimal	0	26972	65422	82840	53945	560051	333249	13911	512043	241372	8717
VII	UP BND	38325	7300	17706	14200	14600	686921	60110	51502	962236	12329	13094
	Optimal	0	7300	17706	14200	14600	686921	60110	51502	962236	12329	13094
VIII	UP BND	134663	25650	62214	58038	51300	3767560	271654	66699	1024274	52125	23004
	Optimal	0	25650	62214	58038	51300	3767560	271654	66699	1024274	52125	23004
IX	UP BND	546919	104175	252676	220697	208350	1955963	354166	37995	596955	97496	15339
	Optimal	0	104175	252676	220697	208350	1955963	354166	37995	596955	97496	15339
X	UP BND	167859	31973	77551	74212	63946	2625203	648755	53751	732986	178091	23138
	Optimal	0	31973	77551	74212	63946	2625203	648755	53751	732986	178091	23138
XI	UP BND	402471	76661	1859418	201923	153322	4392960	184544	70063	727957	32528	12263
	Optimal	0	76661	1859418	201923	153322	4392960	184544	70063	727957	32528	12263
XII	UP BND	21848400	4161600	100940000	10443300	7139029	40893400	4202300	3349170	-	-	-
	Optimal	0	4161600	76258900	4098843	8323200	40893400	420[illegible]300	3349170	-	-	-
XIII	UP BND	24142500	4598580	111540000	14725800	9197150	25012900	1394942	871225	-	-	-
	Optimal	0	1201429	67527500	1062288	9197150	25012900	1394942	871225	-	-	-

Table 44. Shadow prices of pasture AUMs fed to the different livestock classes--Simulation I

	Improved Pasture					Private Range			Public Range		
Region	Dairy	Backgrounders	Cow/Calf	Sheep	Horses	Cow/Calf	Sheep	Horses	Cow/Calf	Sheep	Horses
I	0	19.43	18.52	5.04	14.60	23.38	6.92	9.13	23.93	6.92	9.13
II	5.22	20.86	19.92	17.31	15.03	25.13	23.78	10.80	25.72	23.78	10.06
III	0	23.37	22.06	19.01	18.39	27.90	26.00	12.08	28.86	26.00	12.08
IV	6.93	16.40	15.15	14.22	14.84	19.25	19.53	9.32	20.15	19.53	9.32
V	0	21.78	20.55	6.84	17.45	25.99	9.40	11.40	26.88	9.40	11.40
VI	6.75	13.91	19.46	17.01	16.79	24.63	23.37	10.92	25.50	23.36	10.92
VII	0	17.68	21.41	18.10	18.65	27.07	24.86	12.12	25.93	24.86	12.12
VIII	6.03	19.94	7.84	16.28	17.23	10.07	22.68	11.08	10.81	22.68	11.08
IX	0	18.72	8.48	16.28	15.77	10.91	22.36	10.38	11.79	22.36	10.38
X	7.02	18.46	8.82	16.00	15.00	11.34	21.98	9.75	12.26	20.98	9.75
XI	0	13.50	17.37	14.62	15.98	22.05	20.09	10.44	23.06	20.09	10.44
XII	0	15.63	5.60	5.60	5.60	11.39	7.69	5.69	-	-	-
XIII	6.13	6.13	6.13	6.13	12.50	12.78	8.18	8.99	-	-	-

Table 45. Optimum livestock and livestock product production--Simulation I

Region	Fed Beef	Pork	Broilers	Turkeys	Eggs	Milk	Calves	Backgrounders	Sheep	Horses
I	353261	15443	50220	0	78784	2591599	269589	269389	3767	37000
II	152268	27115	89606	21069	38966	1058390	394866	147258	20004	44000
III	1282700	42903	655819	256096	572748	12426100	814609	407050	65554	77000
IV	453420	16372	500	0	16429	1578784	409736	1318775	39795	51000
V	34955	1786	500	0	184	359081	160000	657206	8711	20000
VI	115496	8048	500	49548	25529	911518	200637	40099	31120	31000
VII	57928	34616	500	0	9410	467104	150516	10853	17250	53000
VIII	308692	19284	500	0	24523	467104	411337	38113	16504	55000
IX	2248780	126285	500	79257	41242	925715	452590	154874	67282	68000
X	116515	9549	500	0	1395	359081	458666	602456	54658	51000
XI	108088	75153	500	0	15391	359081	911112	176782	24367	88000
XII	78205000	11421700	1312620	739253	740696	22516200	11497100	19347900	299405	829000
XIII	1531280	8534630	13612300	1506642	3345000	77697300	8521103	1480901	91307	1596000

Thousands of pounds liveweight of fed beef, pork, broilers, turkeys, and sheep; thousands of dozen eggs, thousand pounds of milk; head of calves and backgrounders.

Table 46. Shadow prices of livestock and livestock products--Simulation I

Region	Fed Beef	Pork	Broilers	Turkeys	Eggs	Milk	Calves	Backgrounders	Sheep
I	446.36	468.18	307.52	413.59	449.67	76.67	122.67	330.20	1036.21
II	451.64	446.36	318.83	424.29	499.68	92.98	125.44	323.10	610.50
III	440.61	472.16	287.13	392.50	406.45	102.00	36.16	334.10	517.58
IV	468.30	424.10	263.83	0	472.72	78.98	228.59	335.40	704.41
V	462.74	479.28	266.85	0	469.29	104.00	166.14	334.80	894.45
VI	443.07	443.96	268.28	426.70	432.33	86.43	124.10	332.80	598.85
VII	450.33	491.24	264.56	0	420.29	117.21	89.21	336.70	547.69
VIII	482.85	476.23	276.50	0	572.46	117.31	299.90	351.00	737.34
IX	476.48	476.59	281.71	417.03	530.00	112.28	310.70	334.80	633.00
X	516.11	451.97	277.08	0	534.69	105.00	343.50	377.00	752.05
XI	501.02	448.00	272.91	0	563.59	107.00	213.46	370.50	789.09
XII	499.20	469.40	305.23	379.23	492.20	83.95	288.90	339.10	1071.95
XIII	424.21	473.53	257.90	433.10	522.82	104.80	240.11	314.60	921.00

Prices are $/1000 lbs liveweight for fed beef, pork, broilers, turkeys, and sheep; $/100 dozen eggs; $/1000 lbs of milk; $/head for calves and backgrounders.

Cow/calf operations fed an additional 6370 tons or about a 1 percent increase. Horses were fed an additional 118 tons of hay which was only a slight increase. Horses also had a slight increase in the amount of protein supplement fed to them.

Region I experienced relatively small effects due to this reduction. Production remained the same but costs went up. This small impact results from a lesser dependence on public grazing for feed relative to other regions.

Region II

All feed production remained constant in Region II with the exception of hay production which increased by 5 percent. Barley in-shipments increased by 4 percent with the entire increase coming from Region XI.

The amount of barley fed to sheep increased by 31,487 tons or 55 percent. The amount of barley fed to horses also increased by 123 tons or 2 percent. Hay fed to cow/calf operations increased by 69,072 tons or 10 percent.

The number of calves produced decreased by two percent or by 6,287 calves which would equal a loss in revenues of $1,701,890 at 1978 prices. The transportation of calves to other regions now shifts from Region V in favor or Region IV with an increase of 28 percent in calves transported to Region IV and a decrease of 31 percent shipped to Region V.

The shadow price of public range utilized in cow/calf operations increased 70 percent and remained constant from the base year for sheep and horses. This indicates a more inelastic demand for range

grazing for cattle than sheep and less ability to substitute other types of feeds.

The effects on Region II demonstrate a more profound effect than was shown by Region I suggesting that Region II would be more vulnerable to reductions in public grazing than Region I.

Region III

There were few changes in feed production in Region III. There was a decrease in export of barley in favor of local use. There was also a decrease in milo importation. An additional 48,793 tons of hay were utilized by cow/calf operations or an increase of 3 percent. Hay to horses increased 287 tons or less than 1 percent. Hay to backgrounders decreased by 49,070 tons or 11 percent. Protein supplement to horses increased 2 percent or 17 tons.

The production of livestock and livestock products remained constant with only the production of backgrounders decreasing by 45,577 head or 10 percent. This decrease is due to an increase in shipments of calves to Region V amounting to 45,577 head or 13 percent. The shadow prices of public grazing increased by 6 percent for horses; the shadow prices for cow/calf and sheep operations remained the same.

This grazing reduction results in Region III shipping more calves out of the region to be fattened. However, this result would not have as great an effect on Region III as it might have on other regions. Although feed prices are high, the market is close, and this keeps Region III competitive and relatively unhurt by this reduction.

Region IV

The only change in feed production in Region IV was an increase in hay production of 202,814 tons or 6 percent. There was no change in the transportation of feed to or from Region IV.

An additional 115,973 tons of hay were fed to cow/calf operations for an increase of 11 percent over the base year. Backgrounders utilized an additional 54,538 tons of hay for an increase of 4 percent, and horses increased their consumptions of hay by 1 percent for 627 tons. Horses also were fed an additional 39 tons of protein supplement for an increase of 1 percent. Hay to sheep increased 31,674 tons or 22 percent.

There was an increase in backgrounder production of 50,656 head or 4 percent. There was an increase in shipments of backgrounders to Region III of 61,260 head or 56 percent. At the same time shipments of backgrounders to Region VIII decreased by 10,604 head or 18 percent.

There were no changes in the shadow prices of public grazing. However, the shadow price of calves increased by 27 percent indicating that Region IV is somewhat more competitive (or other regions are less competitive) now in cow/calf production than previous to the reduction. This suggests that Region IV is less affected by reductions than its neighboring regions and will remain more competitive in a situation of reduced public grazing relative to some of the other regions.

Region V

There were no changes in feed production or shipments of feed in or out of the region from the base year. Hay fed to cow/calf operations increased by 16,489 tons or 124 percent. Hay to horses

increased by 396 tons or 1 percent. Protein supplement to horses increased by 25 tons or 2 percent. In results of this run, 20,040 AUMs of private improved pasture were fed to cow/calf operations where none were fed during the base year run.

The number of calves decreased by 20,000 head which resulted in a loss in revenues of $6,030,000 for cow/calf operations. Backgrounder production was only off 2 percent from the base year, and sheep production remained constant. The number of calves utilized within the state (input into backgrounding activities) decreased by 12 percent or 20,000 head.

The shadow price of calves decreased by 52 percent and the shadow price of sheep decreased by 7 percent. The shadow price of public grazing for cow/calf operations increased by 248 percent, 37 percent for sheep, and remained constant for horses.

Region V again demonstrated dependence on public grazing to remain competitive especially in cow/calf operations. The high cost and limited local availability of alternative feeds made Region V very vulnerable to such reductions in public grazing. If a reduction of this nature took place, Region V would lose the comparative advantage it experienced in the base year in calf production.

Region VII

Milo production increased by 1 percent in Region VII. Hay production increased by 637 tons or less than 1 percent. These increases were used only within the region. There was an increase in importion of corn from Region XII of 28,672 tons or 4 percent. This 28,672 tons of corn was used as a substitute for grazing and was

fed in cow/calf operations. Additional cow/calf operations were fed 17,706 AUMs of private improved pasture, and private range was utilized by cow/calf operations to its upper bound. Horses were fed an additional 638 tons of hay or an increase of 1 percent. Horses were fed an additional 638 tons of hay or an increase of 1 percent. Horses consumed 39 more tons of protein supplement for an increase of 1 percent. Sheep consumed an additional 1091 tons of milo for an increase of 1 percent.

All livestock products and livestock production remained constant from the base year and transportation of livestock products and livestock into and out of the region remained the same as the base year.

The shadow price of calves decreased by 70 percent while sheep prices remained constant. The shadow price of public grazing fed in cow/calf operations increased by 267 percent and remained constant for sheep and horses.

Region VII would lose any comparative advantage it currently has in calf production if such a grazing reduction took place. The region was already at its lower bound for calf production for the base year; therefore, no further reductions could take place. Sheep production remained strong.

Region VIII

Hay production increased by 1120 tons for a slight increase of about 1 percent.

Less milo was shipped to Region III and more was utilized locally. Other feed production activities were unchanged.

Milo served as a substitute for public grazing for sheep. Sheep consumed an additional 4614 tons for an increase of 32 percent. Horses utilized 1120 more tons of hay approximately a 2 percent increase and 69 more tons of protein supplement for an increase of 2 percent. Cow/calf operations utilized 58,038 AUMs of private improved pasture and 100 percent of private range alloted them.

Calf production was reduced by 3 percent or 11,281 head. This represented a reduction in revenue of $3,383,172 for calves alone and led to lower exports of calves to Region XII.

Shadow prices of livestock products remained the same. The shadow price for public grazing for cow/calf operations increased by 60 percent and remained constant for sheep and horses.

Region VIII is impacted most severely by this type of reduction but not as much as some of the other regions. The cattle industry was the hardest hit by the grazing reduction.

Region IX

Hay production is the only feed activity that did not remain constant, and it increased by only 747 tons. Transportation of feeds in and out of the region remained the same except for an additional 8630 tons of barley transported into the region from Region XII or an increase of 4 percent.

Barley fed to sheep increased by 6 percent. Hay fed to horses increased by 747 tons or 1 percent. Protein supplement fed to horses increased by 2 percent. Cow/calf operations utilized 252,676 AUMs of private improved pasture, and private range was utilized at 100 percent of the allotment for cow/calf operations.

The number of calves produced decreased by only 264 head so the loss in revenue through calves was negligible. The number of backgrounders from Region X decreased by 24,457 head or 5 percent while the number of backgrounders transported into the region from Region XII increased by the same amount (24,457 head) or 2 percent. The shadow price of livestock remained constant. The shadow price of public grazing for cow/calf operations increased by 55 percent and remained constant for sheep and horses.

Region IX is not as severely affected by this grazing reduction as some of the other western regions. It is evident in this analysis, however, that as the price of grazing goes up or AUMs are in shorter supply, a feeding region such as Region IX may begin to look to regions such as Region XII, where reductions in public grazing aren't so critical, to buy feeds and backgrounders.

Region IX would not seem to be in position of gaining from these reductions, primarily because it has sufficient alternative feeds and competitive prices.

Region X

There were no changes in feed production or transportation of feed in or out of Region X during this simulation. More hay was fed to sheep and less to backgrounders. That is, 26,208 tons of additional hay were fed to sheep for an increase of 17 percent while backgrounders were fed 26,333 tons less or a decrease of 4 percent. Horses consumed an additional 1,127 tons of hay for a 2 percent increase and an additional 70 tons of protein supplement for an increase of 2 percent.

Cow/calf operations consumed 77,551 AUMs of private improved pasture and 100 percent of the private range alloted to them.

The number of calves produced decreased by 8,775 head which would translate into a loss in revenue of $3,014,213 for calves. Backgrounders production declined by 24,458 head or 4 percent. Region X exported 24,458 fewer head of backgrounders to Region IX for a decline of 5 percent in its backgrounder exports to Region IX. The decline in calf production was absorbed locally by reductions in number of calves going into feeding activities.

The shadow price for calves declined approximatley 1 percent while prices for sheep remained constant. The shadow price of public grazing increased by 35 percent for cow/calf operations, by 5 percent for sheep, and remained constant for horses.

This type of grazing reduction would find Region X producing fewer cattle in favor of feeding the optimum level of sheep. Sheep have a stronger market and would be more profitable. The effects upon the livestock industry as a whole would be a shift from cattle to sheep.

Region XI

Hay was the only feed that changed its level of production. It increased by only 597 tons. As barley became a substitute for grazing, there was a shift in the export of barley from Region III in favor of local use.

The amount of barley fed to cow/calf operations increased by 75,109 tons or 44 percent. Barley fed to sheep increased by 2,880 tons or 5 percent. Hay fed to horses increased by 598 tons or 1 percent.

Horses also consumed an additional 37 tons of protein supplement for an increase of 1 percent.

There were no changes in livestock or livestock product production in Region XI. Also there were no changes in the transportation of livestock and livestock product into or out of the region.

The shadow price of calves increased 29 percent while other livestock product shadow prices remained constant. Shadow prices of public grazing remained the same as the base year for all categories of grazing livestock.

Region XI has the advantage of barley as a low cost alternative to grazing. Reductions in public grazing in the neighboring western regions could enhance Region XI's ability to market cattle because it can support the same number of livestock by feeding barley to displace losses in public grazing for approximately the same price.

Region XII

Region XII increased its production of barley, corn, and hay by 8632, 53,200, and 127,800 tons respectively. All of these increases represent increased production of less than 1 percent. Exports of barley to Region IX and corn to Region VI and VII increased while all other feed and feed transportation activities remained constant.

Hay fed to cow/calf operations increased by 90,100 tons or 1 percent. The amount of protein supplement fed to hogs increased by 108 tons. Private improved pasture fed to cow/calf operations

increased by 435,300 AUMs or 14 percent.

Calf production increased by 45,100 head which represented an increase in revenues of $13,318,290. Backgrounders increased by 35,100 head. The effect of this grazing reduction was more backgrounders are shipped to Regions VIII and IX and fewer would be shipped into the region from Region VIII. The increased calf production was all utilized locally. All shadow prices remained constant with the exception of calves which increased by 17 percent.

Region XII produced more feed for livestock which, in turn, were used in the region. There was a lower importation of livestock from other regions because it was cheaper to raise more cattle in Region XII than to buy them. The western sheep industry remains in a good competitive position with Region XII despite the reduction in public grazing.

Region XIII

Region XIII was not impacted significantly from the grazing reduction. The only noticeable change was in the shadow price of calves which increased by 25 percent. This indicates that reductions in public grazing made calf production more competitive with the other regions.

Summary

This analysis shows potential gainers and losers from such a grazing reduction. Those regions without alternative feed are impacted most severely. Those regions with abundant supplies of alternative feeds gain from the grazing reduction because production

in the vulnerable regions becomes less competitive. Regions XI and XII seem to be in the "best" position at present to withstand grazing reduction. Region XIII, a high demand area, was least affected because of its large imports from Region XII, a region not adversely affected by the reduction. Regions such as II, V, VI, VIII and X were impacted most severely by reductions in public grazing.

Simulation II

The results of this solution followed closely those of Simulation I. The same patterns were followed almost without exception. The magnitude of the changes was generally greater, as would be expected, however.

The sheep industry remains strong in most regions while it becomes increasingly costly to maintain present levels of cattle in several of the western regions. The other livestock and livestock product activities remained constant. This may again show weakness in the analysis because no substitution was allowed.

Hay, corn, and barley have again been shown to be the cheapest and most readily available alternative to pasture and range grazing.

The following analysis will be a comparison between the base year optimal solution and the optimal solution calculated for a 50 percent reduction in public grazing with 65 percent of that reduction being allowed on private range. This will demonstrate the patterns which might develop in the livestock and feed industries if a rather drastic reduction in public grazing were to take place.

Table 47 will present the new optimal production of feed for livestock. Table 48 will give the new shadow price for feed for

livestock. Table 49 will define the new upper bounds for the 3 pasture categories and also state the new optimum utilization of that pasture by the different types of livestock. Table 50 presents the new shadow prices for pasture fed to the different classes of livestock. Table 51 will give the new optimum production of livestock products, and Table 52 will give the new shadow prices for livestock and livestock products.

Region I

The production of hay was the only feed activity to change. It increased by 15,498 tons of 1 percent. This increase was feed to cow/calf operations and horses which consumed an additional 15,264 tons and 235 tons respectively. There were no changes in the transportation of feed to or from Region I.

The only other changes in feed consumption, besides those already mentioned, were in protein supplement to horses and private improved pasture fed to sheep. Horses utilized an additional 15 tons or an increase of 1 percent, and sheep were fed an additional 2178 AUMs of private improved pasture.

All productions of livestock and livestock products remained constant from the base year. Imports and exports from the region also remained constant.

The shadow prices for public range remained the same for cow/calf operations, sheep, and horses. The shadow price of calves increased by 60 percent. This indicates that Region I would become somewhat more competitive in calf production, relative to the other western

Table 47. Optimal production of feed - Simulation II.

Region	Tons					
	Barley	Wheat	Corn	Oats	Milo	Hay
I	592800	0	0	0	0	2015823
II	222000	0	34580	0	0	1569910
III	861692	59569	991368	0	367780	6955000
IV	505510	0	95004	0	0	3911510
V	0	0	0	0	0	963000
VI	176064	11181	0	0	0	1128762
VII	0	57960	161000	0	106838	385775
VIII	34200	27989	211680	0	343896	527054
IX	0	175269	2217600	28160	260400	2092029
X	0	38454	77112	0	0	2050000
XI	1353000	163294	10080	0	0	1925511
XII	1865708	0	23142500	0	18506300	53490100
XIII	629448	0	35979000	0	1317650	45448900

Table 48: Shadow prices of livestock feed - Simulation II.

Region	$/Ton					
	Barley	Wheat	Corn	Oats	Milo	Hay
I	86.47	102.82	91.77	79.19	-	54.50
II	89.54	105.89	94.82	82.83	-	58.50
III	97.90	108.33	100.38	100.00	102.47	65.84
IV	81.24	101.41	86.03	90.63	-	46.00
V	89.76	111.65	-	-	-	61.37
VI	87.99	99.65	94.63	100.00	-	58.00
VII	99.98	104.65	91.07	-	93.60	64.50
VIII	87.36	94.99	89.03	-	85.39	57.50
IX	97.90	91.65	84.56	75.32	84.20	56.50
X	97.90	91.65	86.33	84.38	-	51.68
XI	75.64	91.99	85.72	71.88	-	56.00
XII	72.49	94.32	72.85	71.25	74.94	43.84
XIII	80.57	102.32	75.34	76.88	84.44	56.94

Table 49. Upper bounds and optimal utilization of pasture AUMS--Simulation II

		Improved Pasture					Private Range			Public Range		
	Region	Dairy	Cow/Calf	Backgrounders	Sheep	Horses	Cow/Calf	Sheep	Horses	Cow/Calf	Sheep	Horses
I	UP BND	232936	1076163	44369	143125	88738	759977	7504	11631	34252	1585	1608
	Optimal	0	1076163	44369	108722	88738	759977	7504	11631	34252	1585	1608
II	UP BND	300806	1389722	57296	160989	114593	1168655	10051	17886	460165	12618	3530
	Optimal	0	1389722	57296	160989	114593	1168655	10051	17886	460165	12618	3530
III	UP BND	880971	4070088	167804	417779	335608	1901684	276574	34715	218938	20576	3930
	Optimal	0	4070088	167804	417779	335608	1901684	276574	34715	218938	20576	3930
IV	UP BND	270083	1247783	51444	180109	102889	571296	191400	11389	520490	149200	8590
	Optimal	0	1247783	51444	180109	102889	571296	191400	11389	520490	149200	8590
V	UP BND	43376	20040	8262	25511	16524	887627	102650	15111	626901	68118	5419
	Optimal	0	20040	8262	25511	16524	887627	102650	15111	626901	68118	5419
VI	UP BND	141605	65422	26972	82840	53945	560051	333249	13911	341362	160915	5811
	Optimal	0	65422	26972	82840	53945	560051	333249	13911	341362	160915	5811
VII	UP BND	38325	17706	7300	14200	14600	895406	60110	51502	641491	8219	8730
	Optimal	0	17706	7300	14200	14600	895406	60110	51502	641491	8219	8730
VIII	UP BND	134663	62214	25650	58038	51300	3961901	271654	66699	682849	34750	15336
	Optimal	0	62214	25650	58038	51300	3961901	271654	66699	682849	34750	15336
IX	UP BND	546919	252676	104175	220697	208350	1955963	354166	37995	397970	64998	10226
	Optimal	0	252676	104175	220697	208350	1955963	354166	37995	397970	64998	10226
X	UP BND	167859	77551	31973	74212	63946	2625203	648755	53751	488658	118728	15426
	Optimal	0	77551	31973	74212	63946	2625203	648755	53751	488658	118728	15426
XI	UP BND	402471	1859418	76661	201923	153322	4392960	184544	70063	485305	21686	8175
	Optimal	0	1859418	76661	201923	153322	4392960	184544	70063	485305	21686	8175
XII	UP BND	21848400	100940000	4161600	10443300	8323200	40893400	4202300	3349170	-	-	-
	Optimal	0	76657400	4161600	4098843	713900	40893400	4202300	3349170	-	-	-
XIII	UP BND	24142500	111540000	1201429	14725800	9197150	25012900	1394942	871225	-	-	-
	Optimal	0	67527500	4598580	1062288	9197150	25012900	1394942	871225	-	-	-

Table 50. Shadow prices of pasture AUMs fed to different livestock classes--Simulation II

	Improved Pasture					Private Range			Public Range		
Region	Dairy	Backgrounders	Cow/Calf	Sheep	Horses	Cow/Calf	Sheep	Horses	Cow/Calf	Sheep	Horses
I	0	19.43	18.52	5.04	14.60	23.38	6.92	9.13	23.93	6.92	9.13
II	5.22	20.86	19.92	17.31	15.03	25.13	23.78	10.80	25.72	23.78	10.06
III	0	23.47	22.16	19.01	18.44	28.03	26.00	12.13	28.99	26.00	12.13
IV	6.93	16.40	15.15	14.22	14.84	19.25	19.53	9.32	20.15	19.53	9.32
V	0	21.88	20.65	16.41	17.51	26.12	22.54	11.44	27.00	9.40	11.44
VI	6.75	13.91	19.46	17.01	16.79	24.63	23.37	10.92	25.50	23.36	10.92
VII	0	17.68	21.41	18.10	18.65	27.07	24.86	12.13	25.93	24.86	12.13
VIII	6.03	19.94	7.84	16.28	17.23	10.07	22.68	11.08	10.81	22.68	11.08
IX	0	18.73	18.54	16.28	15.77	23.48	22.37	10.38	24.30	22.36	10.38
X	7.02	18.46	8.82	16.00	15.00	11.34	21.98	9.75	12.26	20.98	9.75
XI	0	13.50	17.37	14.62	15.98	22.05	20.09	10.44	23.06	20.09	10.44
XII	0	15.63	5.60	5.60	5.60	11.39	7.69	5.60	-	-	-
XIII	6.13	6.13	6.13	6.13	12.50	12.78	8.18	8.99	-	-	-

Table 51. Optimal livestock and livestock product production--Simulation II

Region	Fed Beef	Pork	Broilers	Turkeys	Eggs	Milk	Calves	Backgrounders	Sheep	Horses
I	353261	15443	50220	0	78784	2591599	269389	269389	3676	37000
II	152268	27115	89606	21069	38966	1058390	394866	147258	20004	44000
III	1282700	42903	655819	256096	572748	12426100	814609	447510	65554	77000
IV	453420	16372	500	0	16429	1578784	409736	1412421	39795	51000
V	34955	1786	500	0	184	359081	160000	527099	7889	20000
VI	115496	8040	500	49548	25529	911518	200637	40099	31120	31000
VII	579828	34616	500	0	9410	467104	150516	10853	17250	53000
VIII	308692	19264	500	0	24523	467104	399021	38133	16504	55000
IX	2248780	126285	500	79257	41242	925715	443179	154874	68104	68000
X	116515	9549	500	0	1395	359081	438208	577999	54658	51000
XI	108088	75153	500	0	15391	359081	911112	176782	24367	88000
XII	18205000	11421700	1312620	739253	740696	22516200	11539300	19368300	299405	829000
XIII	1531280	8534630	13612300	1506642	3345000	77697300	8521103	1480901	91307	1596000

Thousands of pounds liveweight of fed beef, pork, broilers, turkeys, and sheep; thousands of dozen eggs; thousand pounds of milk; head of calves and backgrounders.

Table 52. Shadow prices of livestock and livestock products--Simulation II

Region	Fed Beef	Pork	Broilers	Turkeys	Eggs	Milk	Calves	Backgrounders	Sheep
I	446.36	468.18	307.52	413.59	449.67	76.67	122.67	330.20	1036.21
II	451.64	446.36	318.83	424.29	499.68	92.98	125.44	323.10	610.50
III	440.61	472.16	287.13	392.50	406.45	102.00	34.33	334.10	517.58
IV	468.30	424.10	263.83	0	472.72	78.98	228.59	335.40	704.41
V	462.74	479.28	266.85	0	469.29	104.00	164.30	334.80	579.00
VI	443.07	443.96	268.28	426.70	432.33	86.43	124.10	332.80	598.85
VII	450.33	491.24	264.56	0	420.29	117.21	89.21	336.70	547.69
VIII	482.85	476.23	267.50	0	572.46	117.31	299.90	351.00	737.34
IX	476.48	476.59	281.71	417.03	530.00	112.28	160.53	334.80	633.00
X	516.11	451.97	277.08	0	534.69	105.00	343.50	377.00	752.05
XI	501.02	448.00	272.91	0	563.59	107.00	213.46	370.50	789.09
XII	499.20	469.40	305.23	379.23	492.20	83.95	288.90	339.10	1071.95
XXIII	424.21	473.53	257.90	433.10	522.82	104.80	240.11	314.60	921.00

Prices are $/1000 lbs liveweight for fed beef, pork, broilers, turkeys, and sheep; $/1000 dozen eggs; $/1000 lbs of milk; $/head for calves and backgrounders.

regions, if this reduction took place. All other livestock shadow prices remained constant.

Region I would be able to withstand this reduction without great losses. This is again attributed to the region's small dependence on public grazing for feed. Indeed, Region I would find its position in the cattle industry more favorable as surrounding regions were forced to cut back cattle production.

Region II

Region II increased hay production by 12 percent or 171,839 tons. There was an increase in the importation of barley from Region XI of 3,598 tons or 8 percent.

The increase in hay production was fed to cow/calf operations to compensate for the loss of public grazing. At the same time, sheep and horses were fed more barley as a substitute for grazing.

The most significant change was in calf production with a decrease in production of 6287 head or 2 percent. This would represent a loss in revenues of $1,701,891 to ranchers and farmers in the region. With this drop in production, calf growers in Region II would stop shipments to Region V completely while increasing shipments to Region IV by 126,620 head or 201 percent. All other livestock activities remained the same as the base year.

The shadow price of private improved pasture fed to cow/calf operations increased a dramatic 749 percent over the base year. This was also true of private and public range fed to cow/calf operations which saw their shadow prices increase by 438 percent and 214 percent respectively. The shadow prices of the three pasture categories fed

to sheep and horses remained constant. The shadow price of calves was the only livestock or livestock product to change, and it decreased by 54%.

Region II shows a high degree of sensitivity to changes in public grazing. All comparative advantages in cattle production held in the base year is lost under this reduction. The sheep industry again remains strong. The indication would be that the cattle industry would be forced to decline under this type of reduction.

Region III

Barley production increased by a large 23 percent of 165,240 tons. This increase was used entirely within the region. Barley shipments from Region XI were cut by 159,569 tons or 20 percent. This would indicate that barley production in Region III would become much more competitive as the cheaper source of feed, grazing, becomes more scarce. The net increase in the utilization of barley in the Region would be 5671 tons. This increase would be fed almost entirely to sheep operations. Milo importation for Region XII also increased to 9230 tons.

One variation from Simulation I is that Region III would now find it cheaper to feed more corn to cow/calf operations rather than more hay. This is because hay production has reached its actual 1978 level, and corn represents the next cheapest alternative feed. The increase in corn fed, 70,655 tons, comes entirely from Region XII. As stated previously, hay is produced at its 1978 level, and there is an increase in hay fed to cow/calf operations and horses of less than 1 percent in both cases. Horses are fed an additional 35 tons of

protein supplement for a 4 percent increase.

The number of backgrounders produced in the region decreased by 5117 head or 1 percent because fattening them became cheaper by shipping them to Region V.

Shadow prices for private improved pasture rose 1 percent for cow/calf operations and horses but remained constant for sheep. The shadow prices for private range also increased by 1 percent for cow/calf operations and horses but remained constant for sheep.

These shadow prices rose less dramatically on public range with the price for cow/calf operations and horses increasing less than 1 percent and sheep remaining constant. The only change in shadow price for the livestock sector was an increase of 17 percent for calves. This would indicate a small increase in the ability of Region III to compete with the surrounding regions if such a reduction were to take place.

Region III would feel the effect of this reduction quite heavily. It does have the advantage of producing a fairly large amount of feed substitues such as hay and barley. This is the only factor that would improve Region III's position relative to the surrounding regions' position if such a reduction were to take place. The feed would be available but would cost considerably more than if present grazing levels were maintained.

Region IV

Hay production in Region IV increased by 451,913 tons or 13 percent. This represents a dramatic increase over the base year optimal solution and would indicate that hay is the main substitute

for grazing in Region IV. All other feed activities remained constant.

Hay fed to cow/calf operations increased by 231,947 tons or 23 percent. Horses were fed an additional 1255 tons of hay and an additional 78 tons of protein supplement for increases of 2 percent and 3 percent respectively. Backgrounders were fed 155,362 tons of hay more than the base year for an increase of 12 percent. Sheep consumed 63,349 tons more of hay for an increase of 45 percent.

Region IV showed a comparative advantage in producing backgrounders. As Regions V and X decreased production, Region IV increased its production by 144,302 head or 11 percent. With this increase, there was a shift in shipment of backgrounders out of the region with less going to Region VIII and more being transported to Region III.

Shadow prices for all three pasture categories remained constant from the base year for cow/calf operations, sheep, and horses.

The shadow price for calves increased by 15 percent while other livestock activity prices remained constant. This would indicate a substantial improvement in the calf market over the base year.

Region IV would benefit from the losses of other regions if such a reduction in grazing took place. Although costs would increase in the region, the relative increase would be less than other regions in the West. Region IV would then begin to "crowd-out" other regions like Region V in the backgrounder market for exports to Region III. Region IV again has shown an ability to meet the new feed requirements presented by a reduction in public grazing. An abundant and relatively cheap hay crop would seem to be the reason for this. This analysis may indicate the weakness in the assumption of an across-the-board reduction in public grazing because it may not hold true if all

regions do not have equal reductions.

Region V

There was no change in the production of feeds for Region V over the base year. All three pasture categories are now fed at their upper limits for cow/calf operations, sheep, and horses.

Less hay is fed to backgrounders in favor of more hay to cow/calf operations. Hay fed to cow/calf operations increased by 156,173 tons or 1175 percent. Horses consumed an additional 792 tons of hay and an additional 49 tons of protein supplement for increases of 3 percent in both cases.

The production of calves dropped by 20,000 head for a loss in revenues of $6,030,000. Backgrounder production also declined by 145,790 head or 22 percent. Sheep production was off 822,000 pounds from the base year for a loss in revenue of $475,938. Backgrounders and sheep transported to Region III both declined while other livestock production and transportation activities remained constant from the base year.

Shadow prices for public range increased 331 percent for cow/calf operations, 318 percent for sheep, and less than 1 percent for horses. Shadow prices for calves and sheep decreased by 53 percent and 39 percent respectively.

Region V would find it cheaper to reduce herd sizes rather than buy feed for their cattle and sheep. The feeder industry would reduce the greatest number in favor of feeding the cow/calf operations. Region V is, without doubt, the region most vulnerable to reductions in public grazing. There is little or no alternative feed (with the

exception of hay) grown within the state, and reductions in the main feed source, grazing, proves devastating.

Region VII

Region VII increased its milo production by 65,483 tons or 62 percent. Hay production went up by 1275 tons or less than 1 percent from the base year. Pasture is now fed to its upper bound in all 3 categories. The shipment of corn into the region from Region XII increased by 61,484 tons or 9 percent. All other feed and feed transportation activities remained constant.

Almost the entire increase in imported corn from Region XII is fed to cow/calf operations. This makes corn an attractive substitute for grazing if this type of grazing reduction were to take place.

All livestock production and transportation activities remained constant from the base year solution.

The shadow prices for public range increased by 276 percent for cow/calf operations and remained constant for sheep and horses. The shadow prices for calves decreased 34 percent and remained constant for sheep.

The production of calves would become increasingly noncompetitive with other regions if such a reduction took place. The base year solution already placed calf production at its lowest possible level, and a reduction in public grazing would accentuate the already weak position of the cattle market. As in the base year optimal solution, less sheep should be raised because they can be raised cheaper in other regions. Region VII is already overproducing livestock. This cut would make herd reductions look even more attractive.

Region VIII

Region VIII would produce an additional 2242 tons of hay for an increase of less than 1 percent. The amount of milo imported from Region III decreased in favor of local utilization. Pasture was now fed to cow/calf operations, sheep, and horses at its upper bound in all three categories.

The amount of hay fed to horses increased by 2240 tons or 3 percent. Horses were also fed an additional 138 tons of protein supplement for an increase of 3 percent. Sheep were fed an additional 9229 tons of milo for an increase of 63 percent.

Ranchers and farmers would find it more profitable to produce less calves and import more backgrounders from Region XII. There would be 23,697 fewer head of calves produced. This would represent a loss in revenue of $7,076,740. The increase in importation of backgrounders from Region XII would be 6606 head or 3 percent.

Shadow prices for public grazing increased 60 percent for cow/calf operations and remained constant for sheep and horses. Shadow prices for all livestock products remained constant from the base year.

Region VIII displays again that herd reductions would be the "best" alternative if reductions in public grazing of this magnitude were to take place. Cattle operations again seem the most vulnerable to these reductions compared to sheep market which remains strong. Unlike some of the other western regions, Region VIII still is fairly competitive with Region XII in calf production. This is most likely due to larger amounts of private range being available.

Region IX

Hay production increased by 1494 tons, an increase of less than 1 percent. Barley imported from Region XII increased by 22,503 tons or an increase of 11 percent. At the same time, corn shipped from Region XII increased by 25,309 tons for an increase of 5 percent. Pasture for cow/calf operations, sheep, and horses is now fed to its upper bound in all 3 pasture categories.

Sheep were fed the entire increase in barley importation from Region XII. Cow/calf operations were fed the entire corn importation increase from Region XII. Hay fed to horses increased by 1494 tons for an increase of 2 percent. Horses also consumed 93 more tons of protein supplement than in the base year. This was an increase of 4 percent.

Sheep production increases by 822,000 pounds or 1 percent. This increase was shipped to Region XIII to replace the amount of decrease in sheep transportation from Region VI to Region XIII.

Calf production decreased by 9147 head for a decrease in revenues of $2,841,913. This reduction is reflected in a decrease of 4 percent in calves transported to Region XII from Region IX.

The shadow prices for public range increased by 215 percent and remained constant for sheep and horses from the base year. The shadow price for calves decreased by 52 percent while the price for sheep remained constant.

Region IX would find corn and milo the cheapest substitutes for grazing for cow/calf operations and sheep operations respectively. Region IX produces a relatively large quantity of alternative feeds; however, it still will find reductions in herd size the best

alternative for cow/calf operations if this reduction was to take place. The sheep industry maintains its strong position.

Region X

There was no change in feed production or feed transportation from the base year optimal solution for Region X. Pasture, however, is now fed to its upper bound in all three pasture categories to cow/calf operations, sheep, and horses.

Horses are fed an additional 2253 tons of hay and an additional 139 tons of protein supplement for increases of 3 percent and 4 percent respectively. Because hay was already at its upper bound for the base year, less hay was fed to backgrounders and from this decrease came the increase in the amount of hay fed to horses. This was accomplished by reducing backgrounders production by 48,915 head of 8 percent. This reduction was due, in large part, to a reduction in the number of calves produced in the region, 29,233 head or 6 percent. This would represent a loss in revenues to farmers and ranchers of $10,041,536. Sheep were fed an additional 50,411 tons of hay for an increase of 32 percent.

Shadow prices for public grazing increased by 55 percent for cow/calf operations and were constant for sheep and horses. The shadow price for calves decreased by 1 percent and remained constant for sheep.

Region X is already at its actual 1978 level for hay production. If this reduction takes place, alternative feed would be imported from outside the region. This additional cost would make Region X less competitive in calf and backgrounder production and would require

reduction in herd sizes.

Region XI

Region XI would increase its hay production by only 1194 tons or less than 1 percent. The amount of barley shipped to Region III would decrease by 159,579 tons or 20 percent and would instead by utilized within the region.

Barley fed to cow/calf operations would increase by 150,218 tons or 87 percent. Barley fed to sheep would increase by 5760 tons or 10 percent making barley the least expensive substitute for grazing for both cow/calf and sheep operations. Horses were fed an additional 1195 tons of hay and an additional 14 tons of protein supplement for increases of 1 percent and less than 1 percent respectively.

Livestock production and transportation remained constant for all activities within the region from the base year.

Shadow prices for all three pasture categories fed to cow/calf operations, sheep, and horses remained constant from the base year. The shadow price for calves increased by 29 percent while the price for lambs remained constant.

Region XI would see itself become more competitive in calf production with the other regions if this reduction took place. This is due to its costs not going up as much as the surrounding regions and also to a relatively large production of relatively cheap alternative feed, barley. Again the sheep industry maintains its position as is the case with almost all of the western regions.

Region XII

Barley production would increase by 22,503 tons, corn production by 196,700 tons, and hay production by 232,300 tons. These represent increases of approximately 1 percent for these three feed categories. Private improved pasture fed to cow/calf operations increased by 833,800 AUMs or 1 percent. Barley shipments to Region IX increased. Corn shipments increased to Regions III, VI, VII, IX, and also the utilization of corn grown within the region increased. Milo shipments to Region III also increased.

Hay fed to cow/calf operations increased by 172,500 tons or 1 percent. Hay consumed by backgrounders increased by 597,700 tons or less than 1 percent. Protein supplement fed to hogs increased by 217 tons for only a slight percentage increase.

The number of calves produced in Region XII increased by 88,300 head for an increase in revenue of $25,509,870. The number of backgrounders produced increased by 55,500 head. The increase in calf production utilized within the region increased while shipments of backgrounders to Region VIII also increased.

The shadow prices for pasture cow/calf operations, sheep, and horses remained constant. The shadow prices of calves increased by 14 percent. All other prices for livestock and livestock products remained constant.

Region XII is the great gainer from this reduction. While the western regions lose ground or barely hold their own, Region XII is pulling ahead in calf production. The western 11 regions would produce 88,264 less calves and bear a loss of $27.7 million in revenues from only the loss in calf production while Region XII would raise an

additional 88,300 head of calves and only gain $25.5 million in added revenues from calf production. This would be due to the generally lower price paid for calves in Region XII relative to the 11 western regions. This, together with the increase in feed production, would be highly advantageous to Region XII.

Region XIII

Region XIII experienced almost no change in its feed and livestock sectors with this reduction. Only the shadow price of calves increased by 20 percent. This indicates, as did Simulation I, that Region XIII will become increasingly more competitive as it becomes more expensive to raise calves in the western states.

Summary

The 50 percent reduction in public grazing proved to be only an extension of the 25 percent reduction. In some areas, however, the greater reduction in public grazing requires new sources of more costly feed when the cheapest alternatives (i.e., hay or barley) are exhausted within the region.

Again those regions with the least amount of locally grown alternative feeds and the greatest amounts of public grazing were the most vulnerable to the reduction. This was especially true of Region V. On the other hand, those regions with relatively large amounts of locally grown feed alternatives and relatively small amounts of public grazing suffered the least and actually made gains. Region XII is the best example of this. The final simulations will attempt to show the long range effects of this reduction.

Analysis of Effects on Utah

Base Year

For the base year solution barley was produced at its upper bound or actual 1978 level. Wheat for feed and hay were produced at 33 percent and 54 percent of actual 1978 production levels respectively. All of the feed produced within the region was utilized locally.

Fed beef, pork, turkeys, eggs, milk and calves were all produced at their lowest allowable limits. Fed beef, pork, and broilers were all consumed within the region. Turkeys were utilized locally with surpluses shipped to Regions IV and X. The entire crop of backgrounders was transported to Region III. Sheep were consumed locally with the surplus shipped to Regions III and XIII.

Table 53 shows the percentage of allowable AUMs in each pasture category actually utilized by the different classes of grazing livestock. Table 54 presents the utilization of feeds in production of livestock in Utah.

Table 53. Percentages of available pasture fed to the different classes of livestock in Region VI base year 1978

Livestock Class	AUMs		
	Improved Pasture (percent)	Private Range (percent)	Public Range (percent)
Milk Cows	0	N/A	N/A
Backgrounders	100	N/A	N/A
Cow/calf	0	89	100
Sheep	100	100	100
Horses	100	100	100

Table 54. Optimum levels of feed fed to each class of livestock in Region VI--Base year 1978

		Tons							AUMs		
Livestock Products	Amount Produced[a]	Barley	Wheat	Corn	Oats	Milo	Hay	Protein Supplement	Improved Pasture	Private Range	Public Range
Beef	115496	87772		26499			69440				
Pork	8048		11181					1313			
Broilers	500					496		133			
Turkeys	49548					51600		19296			
Eggs	25529					48737		6600			
Milk	911518	79924					342000	56343			
Calves	200637						542500			496047	682724
Backgrounders	60528						33556				
Sheep	31120	8368							82840	333249	321829
Horses	31000						40140	200	53945	13911	11622

[a]Thousand pounds liveweight of fed beef, pork, broilers, turkeys and sheep; thousand dozen eggs; thousand lbs of milk; head of calves; backgrounders, and horses.

The indication of the base year analysis is that barley, sheep, and broilers are the only three activities that could be expanded. All other feed and livestock activities are currently at or exceed their optimum levels.

Simulation I

Hay production increased by 24,640 tons or 2 percent. All other feed production and transportation activities remained constant except the importation of corn from Region XII. This increase by 20,179 tons or 76 percent. This additional corn was utilized by fed beef. By utilizing corn, less barley was consumed by fed beef, and this extra barley was, in turn, fed to sheep. This indicates that barley was the cheapest alternative to grazing for sheep in Utah. The increase in hay was fed to cow/calf operations and horses. Cow/calf operations utilized an additional 24,215 tons and horses an additional 424 tons for increases of 4 percent and 1 percent respectively. Horses also consumed an additional 27 tons of protein supplement for an increase of 1 percent. The amount of private improved pasture fed to cow/calf operations increased by 20,040 AUMs and was 100 percent utilization of available pasture in all 3 pasture categories. This shows that the pasture categories are the first to be utilized by cow/calf operations, sheep operations, and horses. As soon as the upper bounds for pasture were met, other more expensive feeds were sought in order to feed the inventory of livestock. In Utah's case hay was the next cheapest alternative for cow/calf operations, barley for sheep, and hay supplemented with protein supplement for horses.

Production of livestock and livestock products remained constant from the base year. The shadow price of calves, however, dropped a

dramatic 43 percent indicating a substantial erosion in Utah's competitive position in the market. Because calves were already produced at the lowest available limit in the base year, this analysis indicated that if the lower restraint were relaxed, the number of calves produced would decrease even more. Sheep were able to maintain a good position in the market, however. There was a decrease of 10 percent in shipments of calves to Region X. This decrease, however, was offset by an increase in the number of calves shipped to Region IV.

Increased costs of this reduction for Utah farmers and ranchers were approximately as follows:

Increased costs

24,640 tons of hay @ $58.00 a ton = $1,429,120

20,179 tons of corn @ $72.85 a ton plus $20.33 transportation per ton = $1,880,279

65,442 AUMs of private improved pasture @ $6.75 per AUM = $441,734

27 tons of protein supplment @ $271.60 per ton = $7333.20

63,999 AUMs of private range @ $6.75 per AUM = $431,993.

Reductions in Costs

163,181 AUMs of public range for cow/calf @ $1.94 = $316,571

80,457 AUMs of public range for sheep @ $1.94 = $156,087

2,906 AUMs of public range for horses @ $1.94 = $5,638

	441,734	
	1,429,120	
	1,880,279	316,571
	7,333	156,087
	431,993	5,638
=	$ 4,190,459	= $478,296

Net changes in costs

$4,190,459 - $478,296 = $3,712,163

Utah farmers and ranchers could, therefore, expect to pay an additional $3,712,163 in feed costs if this reduction took place. In 1978 there were 1988 permittees on BLM land and 1,786 on Forest Service land in Utah. Some of these certainly overlap with one permittee holding permits on both BLM and Forest Service land. This overlap is estimated to be approximately 70 percent. If this is the case, approximately 2382 operators grazed livestock on public range in Utah in 1978 (Godfrey, 1980). If this figure is accurate, the average increase in cost to each permit holder would be $1558. Because livestock inventories were not reduced, it was possible to subtract this figure from the 1978 average net income of $5222 (Utah Ag. Statistics, 1979). This figure would then equal $3664 or a decrease of approximately 30 percent for an "average" farmer or rancher. This might be considerably less than 30 percent for operators with a small dependence on public grazing and more for operators with a greater dependence. This calculation would offer only an approximation of the actual loss in net income with a constant livestock inventory.

Simulation II

Hay production increased by 101,125 tons or 10 percent over the base year. Private improved pasture AUMs fed to cow/calf operations increased 65,422. Private range fed to cow/calf operations went up by 64,004 AUMs. Corn imported from Region XII increased by 40,358 tons or 152 percent.

Beef were fed less barley and more corn. This excess barley was then fed to sheep. Hay was the best alternative for grazing for cow/calf operations with an additional 100,276 tons of hay for an increase of 18 percent. Horses were fed more hay and protein supplement to make for the loss in public grazing. They consumed an additional 850 tons of hay and 53 more tons of protein supplement.

As Region V began to produce and ship less lamb to Region III, the market was opened for a shift of 822,000 pounds to be shipped to Region III from Region VI. The number of calves shipped to Region X from Region VI increased by 19,682 head or 14 percent. At the same time, shipments of calves from Region VI to Region IV decreased by the same number.

Calculating the loss in income to farmers and ranchers currently grazing livestock on public land would be as follows:

Increased Costs

101,125 tons of hay @ $58.00 per ton = $5,865,250

65,422 AUMs of improved pasture fed to cow/calf operations @ $6.75 per AUM = $441,599

64,004 AUMs of private range fed to cow/calf operations @ $6.75 per AUM = $432,027

40,358 tons of corn @ $72.85 per ton plus $20.33 transportation per ton = $3,760,558

53 tons of protein supplement @ $271.60 per ton = $14,395

Reductions in Costs

341,362 AUMs of public range fed to cow/calf operations @ $1.94 per AUM - $662,242

160,915 AUMs of public range fed to sheep operations @ $1.94 per AUM = $312,175

5811 AUMs of public range fed to horses @ $1.94 per AUM = $11,273

$5,865,250	$662,242
441,599	312,175
432,027	11,273
3,760,558	
14,395	$985,690
$10,513,829	

Net change in costs

$10,513,829 - $985,690 = $9,528,139

Change in average net income

$9,528,139 ÷ 2382 = $4000

Average Net Income

$5222 - $4000 = $1222

This would represent a loss in net income of 77 percent for the average rancher or farmer grazing livestock on public land in Utah.

Simulation III

As with the other regions, the changes in Simulation I from the base year hold true for this simulation. The following analyses will delineate the changes in Simulation III from the base year run.

Hay production increased by 41,753 tons or 4 percent. This entire increase was fed to cow/calf operations. Cow/calf operations were also fed an additional 25,601 AUMs of private range over the base year and 65,422 AUMs more of private improved pasture. Importation of corn was constant from Simulation I.

There was a shift in the exportation of lamb of 433,000 pounds from Region XIII to Region III. This indicates that Region V is giving up its market to Utah as Region V becomes unable to compete effectively due to the reduction in public grazing.

Taking into account only the changes in feed costs the following was calculated:

Increased costs

41,753 tons of hay @ $58.00 per ton = $2,421,674

20,179 tons of corn @ $72.85 per ton plus $20.33 transportation per ton = $1,880,279

25,601 AUMs of private range @ $6.75 per AUM = $172,807

65,422 AUMs of private improve pasture @ $6.75 per AUM = $441,993

27 tons of protein supplement @ $271.60 per ton = $7333

Reductions in costs

163,181 AUMs of public range for cow/calf @ $1.94 per AUM = $316,571

80,457 AUMs of public range for sheep @ $1.94 per AUM = $156,087

2,906 AUMs of public range for horses @ $1.94 per AUM = $5638

$2,421,674	$316,571
1,880,279	156,087
7,333	5,638
172,807	
441,993	$478,296
$4,924,086	

Net changes in costs

$4,924,086 - $478,296 = $4,445,790

The average change in net income would be $4,445,790 ÷ 2382 = $1866 or the new average net income would equal $5222 - $1866 = $3356.

This would represent a reduction in net income for the average permit holding farmer or rancher of approximately 36 percent over the base year.

Simulation IV

The production of hay increased by 106,830 tons over the base year or approximately 10 percent. Importations of corn from Region XII and all other feed activities were the same as Simulation II.

Livestock and livestock product production remained constant from the base year. All simulations including Simulation IV, showed a weakening in the shadow price of calves. If the lower bound were relaxed, cattle numbers would likely decrease.

Lamb shipments to Region III increased by 1,213,000 pounds over the base year. This increase coincides with a decrease of the same amount shipped from Region VI to Region XIII and is made possible by the reduction in the number of sheep produced in Region V.

The loss in net income for farmers and ranchers grazing on public land would be calculated as follows:

Increased costs

106,830 tons of hay @ $58.00 per ton = $6,196,140

40,358 tons of corn @ $72.85 per ton plus $20.33 transportation per ton = $3,760,558

65,422 AUMs of private improved pasture fed to cow/calf operations @ $6.75 per AUM = $441,599

51,203 AUMs of private range fed to cow/calf operations @ $6.75 per AUM = $345,620

Reductions in costs

341,362 AUMs of public range fed to cow/calf operations @ $1.94 per AUM = $662,242

160,915 AUMs of public range fed to sheep operations @ $1.94 per AUM = $312,175

5,811 AUMs of public range fed to horses @ $1.94 per AUM = $11,273

$6,196,140	$662,242
3,760,558	312,175
441,599	11,273
51,203	
345,620	
$10,795,120	$985,690

Net change in costs

$10,795,120 - $985,690 = $9,809,430

Change in average net income

$9,809,430 ÷ 2382 = $4118

Average net income

$5222 - $4118 = $1104

This would represent a loss in average net income of approximately 79 percent for farmers and ranchers grazing livestock on public land as compared with the base year with livestock inventories remaining constant.

Summary

The livestock market in Utah would be affected greatly by these types of reduction. There is an exponential relationship between the percentage of reduction in public grazing and the percentage loss in average net farm income for farmers and ranchers presently utilizing

public grazing to feed their livestock.

If the market maintained its 1978 level for the same industry, it would perhaps be advantageous to begin to raise more sheep in the state and less cattle because the market was much stronger for sheep than cattle and less vulnerable to reductions in available grazing. In fact, the analysis shows a comparative advantage in sheep production over Region V for the California market as public grazing reductions become larger and longer.

The indication is that the alternative left to farmers and ranchers utilizing public grazing is to either reduce their cattle herds or suffer substantial reductions in net income. Utah, along with most of the western regions, is at present unable to produce enough cheap alternative feed if these reductions took place. It is forced to import feed from the Midwest in order to meet demand.

There is virtually no affect upon the other livestock producing activities outside of cow/calf and sheep operations when these reductions are analyzed. This again may not accurately reflect the ability of the consuming public to substitute other livestock products for beef as the cost of producing beef increases.

Chapter V

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The base year solution was very close to actual livestock production patterns for 1978. Region XII was the largest producer of livestock and livestock products. The production of sheep was profitable in nearly all regions. Regions with large quantities of public grazing, such as Regions V and VI, were very competitive in the market for calves. Production of all livestock products in addition to calves, backgrounders, and lambs remained constant from the base year throughout the later simulations. This would indicate that without allowing substitution, only the grazing livestock industry would be affected by grazing reductions with very small reverberations through the rest of the livestock industry.

The base year simulation reconfirmed that most regions did have a comparative advantage in producing livestock products for their own region as long as feed was available within the region.

In Regions I, II, III, IV, V and VI beef was produced profitably only to the extent of their own intraregional demand. Region III was the only region among western regions importing beef. This import came from Regions IX, X, and XI. All regions produced as much fed beef as feed supplies would permit to meet local demands with the exception of Region III. Region XII supplied Region XIII with all the beef demanded beyond local production. All of the regions that did not export beef found it most profitable to sell either

calves or backgrounders precluding the fed beef stage.

Hogs were produced only to the extent of meeting local demand in all regions except Region XII which exported pork to all regions, but Region XI.

The broiler industry showed the possibility for expansion for local use in all of the western regions except Regions I, II and III. Region XIII was the largest producer of broilers, transporting large numbers to all other regions.

Turkeys were raised only for local consumption in most regions. Utah produced at its lowest allowable limit and exported its surplus to Regions I, II, III, IV and V. Region IX also produced turkeys at the lowest allowable limit and exported its surplus to Regions II, VII, VIII and X. Region XII exports its surplus to Regions I, XI, and XIII. Regions IV, V, VII, VIII, and XI found it cheaper to import turkey from other regions. Only Region X could profitably expand its turkey industry to meet local needs.

Eggs were found to be at their optimal level or above for all regions. Again local demand was met first with surplus being shipped elsewhere.

Regions VII, VIII, and IX found it profitable to import milk from other regions. Region VII showed a large deficit in milk and Region IV was the largest milk exporter.

The subsequent reduction simulations showed that the cattle industry in most regions of the West would suffer substantial losses. Only those regions with relatively large amounts of locally grown alternative feeds will remain competitive. Hay, barley, and corn were found to be the lowest cost alternative feeds. Regions such as

Nevada and Utah where large amounts of public grazing are utilized (relative to other feeds) would suffer the most. Region XII is in the best position to pick up the market for cattle from the West if these reductions took place. This would be an incentive for ranchers and farmers in the Midwest to favor reductions in public grazing and continued control of large sections of western land by the federal government. Region XIII or the East was virtually unaffected by these reductions because the vast majority of its imported livestock products come from Region XII, a region with little or no public grazing.

The reduction in profits was shown to increase in an exponential fashion, decreasing by $39 million for the first cut of 25 percent and by an additional $50 million for a 50 percent reduction in public grazing. There would be a total loss of $89 million in profits for a 50 percent reduction in public grazing with a 65 percent allowance on private range. This illustrates the high costs associated with utilization of more expensive feeds as reductions in public grazing become larger.

In conclusion, the question is, do the American people believe that they would gain more utility from these reductions in grazing than would be lost to the farmers and ranchers currently grazing their livestock on public land. The Kaldor criterion states that if gainers can compensate losers from a given action, then the action should be taken. If this is the case, then some type of compensation may be called for or at least a tax reduction of some sort to compensate the losses that farmers and ranchers using public land must bear. This could possibly be implemented through the lobbying efforts by the cattlemen and wool growers associations.

Recommendations

The scope of this problem is much too large to be covered in this study. The author would recommend some type of study to be undertaken to measure the actual loss in utility to the general public of holding grazing on public land at its current level. Is the public willing to bear the cost of the reductions because it is in the name of the public that the reductions are being made? Should farmers and ranchers receive compensation when their grazing on public land is reduced?

There is also a great weakness in many of the AUM totals for private land. It would be very helpful to future work in this area if some type of documented information of forage production was given for private land as well as public.

Perhaps some type of quadratic programming technique could allow for substitution between livestock products. This would be helpful in gaining a closer estimation of the effect of reductions in public grazing on other livestock products besides cattle and sheep.

Studies using this type of model on a smaller scale could also be undertaken. The effects on different regions of a state could be examined. This model could also be used to examine changes in production or availability of other types of feed besides grazing.

Different types of sensitivity analysis could be used with this model to determine optimum levels of usage of the different types of pasture and feeds. This could be accomplished by modifying the bounds on feed production by smaller amounts than those done in this study and then interpreting the results to pinpoint the levels of production and usage that would be most desirable.

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APPENDICES

Simulation III

As stated previously, this simulation attempted to predict the long range effects of reductions in public grazing. The changes reflected a shift in production of livestock products from regions with little alternative feeds to those with relatively large amounts of alternative feeds. Extreme cases are provided by Region V where the largest dependence on public grazing was found, and Region XII whiched gained from the grazing reduction. No change was observed in the production of livestock and livestock products other than in the grazing livestock industry, i.e., cattle and sheep, a result which may be dictated by the inflexibilities of the model. It should be noted that lower bounds for livestock production held in the base year were common for this solution. This weakens this analysis because long range adjustments in production levels of livestock and livestock products were not allowed. The author hoped, however, that the general trend would be recognizable and that conclusions could be drawn on that basis.

Table 55 presents optimal feed productions for the 13 regions. Virtually no change was observed in the shadow prices for feeds when compared with the base year or Simulation I as presented earlier in Tables 13 and 42. Table 56 lists new upper bounds and optimum utilization of pasture AUMs for the different regions. Table 57 lists new shadow prices for the three categories of grazing when utilized by the different types of grazing livestock. Table 58 presents the new optimum production of livestock and livestock products for this simulation, and Table 59 depicts their new shadow prices. All changes

from the base year observed in the results of Simulation I were also observed in this simulation.

Regions I and II were essentially identical with Simulation I. Region III had more lamb (433,000 pounds more than the base year) shipped from Region VI and less (an identical 433,000 pounds) shipped from Region V.

Region IV showed an increased hay production of 199,132 tons or 6 percent over the base year. This was a decrease in hay production from Simulation I of 3682 tons or less than 1 percent. This decrease was attributed to the reduction in backgrounder numbers of 3,420 head from Simulation I. This is, however, 47,236 head more than the base year solution. This indicated an increased advantage for backgrounder production in the early stages that would disappear in the long run.

The sheep industry in Region V was heavily impaired. Formerly this region showed a strong sheep market, but with this reduction in grazing, production shifted to Region VI. Sheep production decreased by 433,000 pounds from the base year or 5 percent. This represented a loss in revenue of $250,707 for sheep producers. Calf production, along with all other livestock and livestock product activities, remained constant.

Region VII changed only marginally when compared with Simulation I. Corn continued to serve as a primary substitute for grazing, and an additional 46,874 tons were transported from Region XII to meet the demand. This represents an increase of 75,546 tons over the base year or 11 percent.

Region VIII experienced a decline in its calf production. The total decline in production from the base year was 20,132 head for a

Table 55. Optimal production of feed - Simulation III

Region	Barley	Wheat	Corn	Oats	Milo	Hay
	Tons					
I	592800	-	-	-	-	2008074
II	222000	-	34580	-	-	1467260
III	779173	59569	991368	-	367780	6955000
IV	550510	-	95004	-	-	3658728
V	-	-	-	-	-	963000
VI	176064	11181	-	-	-	1069390
VII	-	57960	161000	-	105747	385137
VIII	34200	27989	211680	-	343896	525934
IX	-	175269	2217600	28160	260400	2091282
X	-	38454	77112	-	-	2050000
XI	1353000	163294	10080	-	-	1924914
XII	1854594	-	23045900	167	18506300	53413300
XIII	629448	-	35979000	-	1317650	45448900

Table 56. Upper bounds and optimal utilization of pasture AUMs--Simulation III

	Region	Improved Pasture					Private Range			Public Range		
		Dairy	Backgrounders	Cow/Calf	Sheep	Horses	Cow/Calf	Sheep	Horses	Cow/Calf	Sheep	Horses
I	UP BND	232936	44369	1076163	143125	88738	759977	7504	11631	51378	2378	2412
	Optimal	0	44369	1076163	107623	88738	759977	7504	11631	51378	2378	2412
II	UP BND	300806	57296	1389722	160989	114593	1168655	10051	17886	690248	18926	5295
	Optimal	0	57296	1389722	160989	114593	1168655	10051	17886	690248	18926	5295
III	UP BND	880971	167804	4070088	417779	335608	1901684	276574	34715	328407	30864	5895
	Optimal	0	167804	4070088	417779	335608	1901684	276574	34715	328407	30864	5895
IV	UP BND	270083	51444	1247783	180109	102889	571296	191400	11389	780735	223800	12885
	Optimal	0	51444	1247783	180109	102889	571296	191400	11389	780735	223800	12885
V	UP BND	43376	8262	20040	25511	16524	887627	77938	15111	940352	102176	8129
	Optimal	0	8262	20040	16378	16524	887627	77938	15111	940352	102176	8129
VI	UP BND	141605	26972	65422	82840	53945	521648	333249	13911	512043	241372	8717
	Optimal	0	26972	65422	82840	53945	521648	333249	13911	512043	241372	8717
VII	UP BND	38325	7300	17706	14200	14600	526549	60110	51502	962236	12329	13094
	Optimal	0	7300	17706	14200	14600	526549	60110	51502	962236	12329	13094
VIII	UP BND	134663	25650	62214	58038	51300	3661848	271654	66699	1024274	52125	23004
	Optimal	0	25650	62214	58038	51300	3661858	271654	66699	1024274	52125	23004
IX	UP BND	546919	104175	252676	220697	208350	1955963	354166	37995	596955	97496	15339
	Optimal	0	104175	252676	220697	208350	1955963	354166	37995	596955	97496	15339
X	UP BND	167859	31973	77551	74212	63946	2584358	648755	53751	732986	178091	23138
	Optimal	0	31973	77551	74212	63946	2584358	648755	53751	732986	178091	23138
XI	UP BND	402471	76661	1859418	201923	153322	4392960	184544	70063	727957	32528	12263
	Optimal	0	76661	1859418	201923	153322	4392960	184544	70063	927957	32528	12263
XII	UP BND	21848400	4161600	100940000	10443300	7139029	40893400	4202300	3349170	-	-	-
	Optimal	0	4161600	76258900	4098843	8323200	40893400	4202300	-	-	-	-
XIII	UP BND	24142500	4598580	111540000	14725800	9197150	25012900	1394942	871225	-	-	-
	Optimal	0	1201429	67527500	1062288	9197150	25012900	1394942	871225	-	-	-

Table 57. Shadow prices of pasture AUMs fed to the different livestock classes--Simulation III

	$/AUM										
	Improved Pasture					Private Range			Public Range		
Region	Dairy	Backgrounders	Cow/Calf	Sheep	Horses	Cow/Calf	Sheep	Horses	Cow/Calf	Sheep	Horses
I	0	19.43	18.52	5.04	14.60	23.38	6.92	9.13	23.93	6.92	9.13
II	5.22	20.86	19.92	17.31	15.03	25.13	23.78	10.80	25.72	23.78	10.06
III	0	23.37	22.06	19.01	18.39	27.90	26.00	12.08	28.86	26.00	12.08
IV	6.93	16.40	15.15	14.22	14.84	19.25	19.53	9.32	20.15	19.53	9.32
V	0	21.78	20.55	16.41	17.45	25.99	22.54	11.40	26.88	22.54	11.40
VI	6.75	13.91	19.47	17.01	16.79	24.63	23.37	10.92	25.50	23.36	10.92
VII	0	17.68	21.41	18.10	18.65	27.07	24.86	12.13	25.93	24.86	12.13
VIII	6.03	19.94	7.84	16.28	17.23	10.07	22.68	11.08	10.81	22.68	11.08
IX	0	18.73	8.48	16.28	15.77	10.91	22.36	10.38	11.79	22.36	10.38
X	7.02	18.46	8.82	16.00	15.00	11.34	21.98	9.75	12.27	20.98	9.75
XI	0	13.50	17.37	14.62	15.98	22.05	20.09	10.44	23.06	20.09	10.44
XII	0	15.63	5.60	5.60	5.60	11.39	7.69	5.60	-	-	-
XIII	6.13	6.13	6.13	6.13	12.50	12.78	8.18	8.99	-	-	-

Table 58. Optimum livestock and livestock product production--Simulation III

Region	Fed Beef	Pork	Broilers	Turkeys	Eggs	Milk	Calves	Backgrounders	Sheep	Horses
I	353261	15443	50220	0	78784	2591599	269389	269389	3676	37000
II	152268	27115	89606	21069	38966	1058390	394866	147258	20004	44000
III	1282700	42903	655819	256096	572748	12426100	814609	407050	65554	77000
IV	453420	16372	500	0	16429	1578784	409736	1315355	39795	51000
V	34955	1786	500	0	184	359081	160000	657206	8278	20000
VI	115496	8048	500	49548	25529	911518	200637	40099	31120	31000
VII	57928	34616	500	0	9410	467104	150516	10853	17250	53000
VIII	308692	19284	500	0	24523	467104	402486	38133	16504	55000
IX	2248780	126285	500	79257	41242	925715	452590	154874	67715	68000
X	116515	9549	500	0	1395	359081	455246	602456	54658	51000
XI	108088	75153	500	0	15391	359081	911112	176782	24367	88000
XII	18205000	11421700	1312620	739253	740696	22516200	11509300	19351300	299405	829000
XIII	1531280	8534630	13612300	1506642	3345000	77697300	8521103	1480901	81307	1596000

1000 pounds liveweight for feed beef, pork, broilers, turkeys and sheep; 1000 dozen eggs; 1000 pounds of milk; head of calves, backgrounders, and horses.

Table 59. Shadow prices of livestock and livestock products--Simulation III allowance on private range

Region	Fed Beef	Pork	Broilers	Turkeys	Eggs	Milk	Calves	Backgrounders	Sheep	Horses
I	353261	15443	50220	0	78784	2591599	269389	269389	3676	37000
II	152268	27115	89606	21069	38966	1058390	394866	147258	20004	44000
III	1282700	42903	655819	256096	572748	12426100	814609	407050	65554	77000
IIV	453420	16372	500	0	16429	1578784	409736	1315355	39795	51000
V	34955	1786	500	0	184	359081	160000	657206	8278	20000
VI	115496	8048	500	49548	25529	911518	200637	40099	31120	31000
VII	57928	34616	500	0	9410	467104	150516	10853	17250	53000
VIII	308692	19284	500	0	24523	467104	402486	38133	16504	55000
IX	2248780	126285	500	79257	41242	925715	452590	154874	67715	68000
X	116515	9549	500	0	1395	359081	455246	602456	54658	51000
XI	108088	75153	500	0	15391	359081	911112	176782	24367	88000
XII	18205000	11421700	1312620	739253	740696	22516200	11509300	19351300	299405	829000
XIII	1531280	8534630	13612300	1506642	3345000	77697300	8521103	1480901	91307	1596000

1000 lbs liveweight for feed beef, pork, broilers, turkeys and sheep; 1000 dozen eggs; 1000 lbs of milk; head of calves, backgrounders, and horses.

total loss in revenue from calves of $6,037,587. As the number of cow/calf operations decreased, the number of backgrounders remained constant requiring more to be imported from Region XII. This trend seems to be constant and would indicate that Region VIII may have a comparative advantage in feeding.

Region IX's sheep production increased by 433,000 pounds over the base year. This increase was shipped to Region XIII in addition to the 57.3 million pounds originally shipped there for the base year run and Simulation I. This indicates that Region IX would "pick-up" on Region VI's market in Region XIII when Region VI found a closer market in Region III.

An additional 11,389 tons of barley were shipped from Region XII to Region IX compared with the base year for an increase of 5 percent. All other livestock and feed activities in Region IX remained constant with Simulation I.

Region X decreased its production of calves by 12,195 head compared with the base year. This represented a loss in revenue for cow/calf operations of $4,188,983. As the number of locally produced calves decreased, the number of calves imported from Region VI increased. All other feed and livestock activities remained constant with Simulation I.

Region XI showed long run effects from this grazing reduction. This region might even gain from the losses other regions must bear.

Region XII experienced increased production of barley, corn, and hay that were slightly higher than Simulation I. Additional barley was shipped to Region VI, additional corn to Region VII, and hay was fed in local cow/calf operations.

There was an additional 57,300 head of calves produced compared with the base year for an increase in revenues to cow/calf operations of $116,842,870. A total of 38,500 additional backgrounders were produced as compared with the base year. The number of calves imported from Region VIII decreased as the number raised locally increased.

Region VII, although not experiencing significant increase in production, in the long run began to displace the losses incurred by the western regions because of a reduction of this magnitude.

Region XIII experienced little change. As noted earlier, it began to import more sheep from Region IX and fewer from Region VI. Region XII is the most competitive producer of livestock products for the demand in Region XIII. This demand is in excess of what Region XIII produces itself. Therefore, reductions in public grazing will not affect Region XIII directly.

Summary

In the long run, the overall effect of this type of reduction would be to improve Region XII's position in the livestock and livestock products market. The western regions would remain somewhat stable from the initial reduction but would be incurring higher costs for feed. The sheep industry remains strong while the cattle industry has become increasingly costly. Region V displays the greatest vunerability and its position in the livestock market continued to slip. Other regions with relatively large amounts of alternative feeds such as Regions IX and IV experienced smaller long run effects in production as the production in other regions decline.

Simulation IV

The long run effect of a 50 percent reduction seems to be just a deepening of the short run effects. The cattle industry in the 11 western regions seems to have hit rock-bottom. All of the western regions with the exceptions of Regions VIII and X are at their lower bounds for calf production. Regions VIII and X did have to reduce their number of cow/calf operations and Region V had to reduce even more its sheep herds than in Simulation II. Therefore, close attention should again be paid to Region V, the largest net loser and Region XII, the largest net gainer. All changes associated with Simulation II still hold. Tables 60, 61, and 62 give the new optimum levels of feed production, pasture utilization, and livestock production respectively. The shadow prices for these three items are all virtually the same as the preceding section covering the 50 percent reduction in public grazing with 65 percent allowance on public land. For these shadow prices the reader is referred to tables 53, 55, and 57.

Regions I, II, and III experienced no changes from Simulation II in feed or livestock production. Region IV had only a slight reduction from Simulation II in its hay production which was associated with a small reduction in the numbers of livestock produced.

Region V reduced its sheep production by an additional 391,100 pounds over Simulation II, for a total reduction of 1,213,000 pounds from the base year for a total loss in revenues from sheep of $702,327 from the base year.

Table 60. Optimal production of feed - Simulation IV

Region	Barley	Wheat	Corn	Oats	Milo	Hay
	Tons					
I	592800	-	-	-	-	2015823
II	222000	-	34580	-	-	1569910
III	861692	59569	991368	-	367780	6955000
IV	505510	-	95004	-	-	3911132
V	-	-	-	-	-	963000
VI	176064	11181	-	-	-	1134467
VII	-	57960	161000	-	106838	385775
VIII	34200	27989	211680	-	343896	527053
IX	-	175269	2217600	28160	260400	2092029
X	-	38454	77112	-	-	2050000
XI	1353000	163294	10080	-	-	1925511
XII	1868201	-	23236200	167	18506300	53531900
XIII	629448	-	35979000	-	1317650	45448900

Table 61. Upper bounds and optimum usage of pasture by the different classes of livestock--Simulation IV

		Private Improved Pasture					Private Range			Public Range		
	Region	Dairy	Backgrounders	Cow/Calf	Sheep	Horses	Cow/Calf	Sheep	Horses	Cow/Calf	Sheep	Horses
I	UP BND	232936	44369	1076163	143125	88738	759977	7504	11631	34252	1585	1608
	Optimal	0	44369	1076163	108721	88738	759977	7594	11631	34252	1585	1608
II	UP BND	300806	57296	1389722	160989	114593	1168655	10051	17886	460165	12618	3530
	Optimal	-	57296	1389722	160989	144593	1168655	10051	17886	460165	12618	3530
III	UP BND	880971	167804	4070088	417779	335608	1901684	276574	34715	218938	20576	3930
	Optimal	-	167804	4070088	417779	335608	1901684	276574	34715	218938	20576	3930
IV	UP BND	270083	51444	1247783	180109	102889	571297	191400	11389	520490	149200	8590
	Optimal	-	51444	1247783	180109	102889	571296	191400	11389	520490	149200	8590
V	UP BND	43376	8262	20040	25511	16524	887627	93264	15111	626901	68118	5419
	Optimal	-	8262	20040	25511	16524	886627	93264	15111	626901	68118	5419
VI	UP BND	141605	26972	65422	82840	53945	547250	333249	13911	341362	160915	5811
	Optimal	-	26972	65422	82840	53945	547250	333249	13911	341362	160915	5811
VII	UP BND	38325	7300	17706	14200	14600	574661	60110	51502	641491	8219	8730
	Optimal	-	7300	17706	14200	14600	574661	60110	51502	641491	8219	8730
VIII	UP BND	134663	25650	62214	58038	51300	3713061	271654	66699	682849	34750	15336
	Optimal	-	25650	62214	58038	51300	3713061	271654	66699	682849	34750	15336
IX	UP BND	546919	104175	252676	220697	208350	1955963	354166	37995	397970	64998	10226
	Optimal	-	104175	252676	220697	208350	1955963	354166	37995	397970	64998	10226
X	UP BND	167859	31973	77551	74212	63946	2621008	648755	53751	488658	118728	15426
	Optimal	-	31973	77551	74212	63946	2621008	648755	53751	488658	118728	15426
XI	UP BND	402471	76661	1859418	201923	153322	4392960	184544	70063	485305	21686	8175
	Optimal	-	76661	1859418	201923	153322	4392960	184544	70063	485305	21686	8175
XII	UP BND	21848400	4161600	100940000	10443300	8323200	40893400	4202300	339170	-	-	-
	Optimal	-	4161600	76857500	4098843	7139029	40893400	4202300	-	-	-	-
XIII	UP BND	24142500	4598580	111540000	14725800	9197150	25012900	1394942	871225	-	-	-
	Optimal	-	1201429	67527500	1062288	9197150	25012900	1394942	871225	-	-	-

Table 62. Optimum production of livestock and livestock products--Simulation IV

Region	Fed beef	Pork	Broilers	Turkeys	Eggs	Milk	Calves	Backgrounders	Sheep	Horses
I	353261	15443	50220	-	78784	2591599	269389	269389	3676	37000
II	152268	27115	89606	21069	38966	1058390	394866	147258	20004	44000
III	1282700	42903	655819	256096	572748	12426100	814609	447510	65554	77000
IV	435420	16372	500	-	16429	1578784	409736	1412070	39795	51000
V	34955	1786	500	-	184	35908	160000	527099	7498	20000
VI	115496	8048	500	49548	25529	911518	200637	40099	31120	31000
VII	579828	34616	500	-	9410	467104	150516	10853	17250	53000
VIII	308692	19284	500	-	24523	467104	378185	38133	16504	55000
IX	2248780	126285	500	79257	41242	925715	443179	154874	68495	68000
X	116515	9549	500	560	1395	359081	437857	577999	54658	51000
XI	108088	75153	500	-	15391	359081	911112	176782	24367	88000
XII	18205000	11421700	1312620	739253	740696	22516200	11560400	19368700	299405	829000
XIII	1531280	8534630	13612300	1506642	3345000	77697300	8521103	1480901	91307	1596000

thousands of lbs liveweight of fed beef, pork, broilers, turkeys and sheep; thousands of lbs of milk; thousands of dozen eggs; head of calves, backgrounders, and horses.

Region VII increased its importation of corn from Region XII in order to meet the loss of grazing for cow/calf operations. This increase amounted to 12 percent or 93,747 tons over Simulation II for a total increase of 155,231 tons over the base year.

Region VIII reduced the amount of calves it produced, an additional 20,836 head for an added loss in revenue from calves of $6,248,717 over Simulation II. This would amount to a total loss from calf production of $13,325,456 from the base year.

Region IX continued to take more of the market for sheep in Region XIII away from Region VI as was demonstrated in Simulation II. Region VI found it more profitable to ship more sheep to Region III since the amount of sheep shipped from Region V to Region III declined. The increase was equal to Region V's decrease or 1,213,000 pounds of sheep shipped to Region XIII from Region IX over the base year. Because the amount of available grazing decreased, an increasing amount of barley was fed to sheep in Region IX which indicated barley to still be the cheapest alternative to grazing for sheep.

Region X produced 310 less head of calves than Simulation II for a loss in revenues from calves of $106,485. This represents a total loss for calf production from the base year of $10,148,021. The long range effect for reductions in grazing on cow/calf operations would, therefore, seem not to be much worse than in Simulation II.

Regions XI and XIII experienced no changes from those mentioned in Simulation II. Region XII saw its corn production and hay production increased by 93,700 tons and 41,800 tons respectively. These both represented increases of less than 1 percent from Simulation II.

The increase in corn production was transported to Region VII while the additional hay was fed to cow/calf operations and backgrounders. Cow/calf operations were also fed an additional 200,100 AUMs of private improved pasture.

The number of calves produced in Region XII over the base year was 66,200 head for an increase in revenues from calves of $31,605,660. Backgrounder numbers increased by 35,500 head over the base year. All other feed and livestock activities remained constant.

Summary

Region XII continues to gain from the reduction. One change over the previous 50 percent simulation is that Region XII now gains more than the 11 western regions loose. Barley, corn, and hay continue to be the cheapest alternatives to grazing for the country as a whole. The livestock industry in the west has, for this run, reached a new low. Production and prices are at their lowest while production in Region XII has reached its highest point.

Table 63. Allowable deviations in production of livestock products from 1978 totals.

Region	Deviation	Beef	Pork	Broilers	Turkeys	Eggs	Milk	Cow/Calf	Sheep
I	Increase	.2580	.2350	.2708	.1800	.0590	.0838	.0400	.0948
	Decrease	.1299	.1980	.1892	.2605	.0713	.0290	.0871	.1689
II	Increase	.2580	.2350	.2708	.1800	.0590	.0838	.0400	.1183
	Decrease	.1299	.1980	.1892	.2605	.0713	.0290	.0871	.1816
III	Increase	.1750	.2146	.1430	.2200	.1035	.0781	.0470	.0700
	Decrease	.0935	.2700	.0360	.2490	.1123	.0070	.0668	.1216
IV	Increase	.1046	.1853	-	.8800	.1079	.0616	.0530	.0499
	Decrease	.0840	.1730	-	.2360	.0430	.0332	.1160	.1204
V	Increase	.1046	.1853	-	.8800	.1079	.0616	.0530	.1999
	Decrease	.0840	.1730	-	.2360	.0430	.0332	.1160	.0804
VI	Increase	.3505	.3810	-	.3690	.1837	.0848	.0556	.0900
	Decrease	.1213	.3790	-	.2256	.1184	.0303	.1043	.1897
VII	Increase	.1046	.1853	-	.8800	.1079	.0616	.0530	.1700
	Decrease	.0840	.1730	-	.2360	.0430	.0332	.1160	.1867
VIII	Increase	.1046	.1853	-	.8800	.1079	.0616	.0530	.1501
	Decrease	.0840	.1730	-	.2360	.0430	.0332	.1160	.1625
IX	Increase	.1046	.1853	-	.8800	.1079	.0616	.0530	.1899
	Decrease	.0840	.1730	-	.2360	.0430	.0332	.1160	.0909
X	Increase	.1046	.1853	-	.8800	.1079	.0616	.0530	.1000
	Decrease	.0840	.1730	-	.2360	.0430	.0332	.1160	.1132
XI	Increase	.1046	.1853	-	.8800	.1079	.0616	.0530	.1200
	Decrease	.0840	.1730	-	.2360	.0430	.0332	.1160	.1801
XII	Increase	.1050	.1311	.2030	.2900	.0175	.0331	.0515	.1800
	Decrease	.0205	.1867	.0970	.2090	.0920	.0736	.1106	.1300
XIII	Increase	.3982	.0726	.1178	.2870	.0630	.0457	.0252	.0200
	Decrease	.2390	.1386	.0209	.1390	.0465	.0503	.1349	.0800

Taken from Nef (1979)

Table 64: Production bounds on production of livestock products.

Region	Bound	Fed Beef	Pork	Broilers	Turkeys	Eggs	Milk	Calves	Sheep
I	Upper	510748	19547	90539	560	89838	2892662	306895	3676
	Lower	353261	15443	50220	-	78784	2591599	269389	2791
II	Upper	220150	34480	89606	28989	44434	1181342	449842	27335
	Lower	152268	27115	54653	21069	38966	1058390	394866	20004
III	Upper	1804120	62545	655819	375067	711983	12785188	913947	79853
	Lower	1282700	42903	552269	256096	572748	11775987	814609	65554
IV	Upper	546777	19098	500	560	19091	1733593	563084	39795
	Lower	453420	16372	-	-	16429	1578784	409736	33657
V	Upper	42152	4019	500	560	213	467104	180000	8711
	Lower	34955	1786	-	-	184		160000	6676
VI	Upper	177510	17912	500	87593	34278	1019712	236454	31120
	Lower	115496	8048	-	49548	25529	911518	200637	23134
VII	Upper	699212	49704	500	560	10894	467104	242683	24816
	Lower	579828	34616	-	-	9410	-	150516	17250
VIII	Upper	372250	24808	500	560	28390	467104	503552	16504
	Lower	308692	19284	-	-	24523	-	328630	12018
IX	Upper	2711790	126285	500	113029	44638	925715	661262	83291
	Lower	2248780	95683	-	79257	38558	843050	443179	63635
X	Upper	140505	9449	500	560	1615	467104	467441	54658
	Lower	116515	7544	-	-	1395	-	394468	44064
XI	Upper	130343	88978	500	560	17818	467104	1110199	24367
	Lower	108088	69250	-	-	15391	-	911112	17838
XII	Upper	20228100	11677700	1312620	1205610	830021	25109496	13538020	299405
	Lower	17930700	8370770	984467	739253	740696	22516152	11450989	220748
XIII	Upper	2813460	8534630	13710200	15616200	3838930	79516074	10098063	91307
	Lower	1531280	6859610	11996400	10450600	3345000	72216138	8521103	82356

Bounds are 1000's of pounds liveweight for fed beef, pork, broilers, turkeys, and sheep; 1,000 dozen eggs, 1,000 pounds of milk; head of calves

Table 65: Mileage between regions used to calculate transportation costs.

Region	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
I	-	374	1170	607	594	882	1348	1354	1248	985	453	1533	1908
II	-	-	969	397	220	715	974	1144	1038	775	672	1413	1869
III	-	-	-	958	587	594	389	868	1059	986	1190	1595	2054
IV	-	-	-	-	371	299	814	771	647	417	399	1021	1482
V	-	-	-	-	-	435	754	1066	860	641	748	1287	1746
VI	-	-	-	-	-	-	510	534	467	423	623	1069	1528
VII	-	-	-	-	-	-	-	522	792	933	1133	1290	1713
VIII	-	-	-	-	-	-	-	-	356	586	1137	813	1249
IX	-	-	-	-	-	-	-	-	-	230	781	537	996
X	-	-	-	-	-	-	-	-	-	-	637	646	1105
XI	-	-	-	-	-	-	-	-	-	-	-	1050	1425
XII	-	-	-	-	-	-	-	-	-	-	-	-	459
XIII	-	-	-	-	-	-	-	-	-	-	-	-	-

Source: Rand McNally (1979)

Table 66. Liveweight equivalent co-efficients for livestock products

Livestock Product			
Fed Beef	Live weight	= carcass weight	÷ .583
Hogs	"	= " "	÷ .632
Broilers	"	= ready to cook	÷ .72
Turkeys	"	= " " "	÷ .8
Sheep	"	= carcass weight	÷ .535

Source: Nef (1979) and Reeder (1980)

Table 67. Estimated costs of shipping eggs

Region	$/1000 dozen												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
I	-	14.96	43.78	24.28	23.76	37.15	53.92	54.16	94.81	39.40	19.32	102.07	104.61
II	14.96	-	43.78	19.85	11.00	37.15	48.70	57.20	94.81	38.75	33.60	102.07	104.66
III	43.78	43.78	-	57.48	35.22	34.88	23.34	52.08	94.81	59.16	71.40	102.07	104.66
IV	24.28	19.85	57.48	-	18.55	17.50	40.70	38.55	32.35	20.85	19.95	71.47	103.74
V	23.76	11.00	35.22	18.55	-	24.50	37.70	53.30	43.00	32.05	37.40	90.09	122.22
VI	37.15	37.15	34.88	17.50	24.50	-	25.50	26.70	33.37	21.15	31.15	78.41	100.94
VII	53.92	48.70	23.34	40.70	37.70	25.50	-	26.10	39.60	46.65	56.65	90.30	119.91
VIII	54.16	57.20	52.08	38.55	53.30	26.70	26.10	-	17.80	29.30	56.85	56.91	87.43
IX	39.31	39.31	39.38	32.35	43.00	33.39	39.60	17.80	-	12.65	42.96	47.15	63.47
X	39.40	38.75	59.16	20.85	32.05	21.15	46.65	29.30	12.65	-	35.04	45.22	77.35
XI	19.32	33.60	71.40	19.95	37.40	31.15	56.65	56.85	42.96	35.04	-	73.50	99.75
XII	39.38	39.38	39.38	45.95	57.92	48.11	48.05	36.59	24.17	29.07	47.25	-	39.12
XIII	45.85	45.85	45.85	66.69	78.57	63.29	68.76	56.21	44.82	49.73	64.13	39.12	-

Costs were calculated by author using Witt (1970). U. S. Senate (1978) and Consumer Price Index

Table 68. Total AUMs sold by permit for cattle on public land 1978.

Region	BLM	Forest Service	Total
I	-	103794	103794
II	868706	525734	1394440
III	209365	454084	663449
IV	954303	622938	1577241
V	1598857	300839	1899696
VI	563149	471277	1034426
VII	504625	1439289	1943914
VIII	1211666	857577	2069243
IX	326178	879791	1205969
X	851647	629132	1480779
XI	860824	609795	1470619

Source: Department of the Interior (BLM, 1978) and USDA (F.S., 1978)

Table 69. Total AUMs sold by permit for sheep on public land 1978.

Region	BLM	Forest Service	Total
I	-	4914	4914
II	3842	41064	44906
III	24900	57744	82644
IV	141575	284582	426157
V	141531	79077	220608
VI	267336	256596	523932
VII	5434	36818	42252
VIII	133013	20564	153577
IX	77708	229098	306806
X	313642	197877	511519
XI	57418	24912	82330

Source: Department of the Interior (BLM, 1978)
USDA (F.S., 1978)

Table 70. Total AUMs sold by permit for horses on public land 1978

Region	BLM	Forest Service	Total
I	-	3216	3216
II	3422	3638	7060
III	223	7637	7860
I	5647	11533	17180
V	9592	1246	10838
VI	1931	9691	11622
VII	5849	11610	17459
VIII	21895	8777	30672
IX	3426	17026	20452
X	9328	21523	30851
XI	4003	12347	16350

Source: Department of the Interior (BLM, 1978) and USDA (F.S., 1978)