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Linear Programming Applied to Sheep Ranching in Utah

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LINEAR PROGRAMMING APPLIED TO SHEEP RANCHING IN UTAH

by

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A dissertation submitted in partial fulfillment
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of

DOCTOR OF PHILOSOPHY

in

Range Science

Approved:

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Thesis Director

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Major Professor

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Dean of Graduate Studies

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It is evident from the above that the entire project was a team effort, including many not mentioned here, and I definitely appreciate the opportunity I have had in participating on a team of this high calibre.

William Reed Flint

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Linear Programming Applied to

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by

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Major Professor: Dr. L. A. Stoddart
Department: Range Science

The study was initiated to determine how sheep ranches were physically and economically organized in 1964 and to select range and livestock management alternatives which would be profitable to sheep ranches. With data collected from the ranches three model ranches, representing the three most prominent strata, were constructed. These strata were determined by number of breeding ewes that were on the ranch and by the season of grazing on government land, i.e., winter, summer, or year around. After the building of these three ranches, each of them was linear programmed to find the profit maximizing combination of resources both before and following the addition of private and public capital. Capital was added in small increments, and the internal rate of return was calculated for each increment to determine the profitability of each investment. As an added tool, the capitalized value of the ranch resources was obtained showing the value of one more unit of each resource to the ranch concerned.

Forest Service permits were reduced in small increments through successive stages on the most typical ranch in order to observe the reduction in annual income for each permit reduction. Likewise, Forest Service

permits and irrigated pasture were increased from the base level in separate operations.

The three most prominent strata from which the modal ranches were built used government grazing land year around, and each represented a different size class: (1) 700 to 1,499 breeding ewes, stratum 1c, (2) 1,500 to 2,499 breeding ewes, stratum 2c, and (3) 2,500 to 5,499 breeding ewes, stratum 3c. The greatest number of ranches in Utah fell into the 2c class for which the modal ranch had 1,709 breeding ewes.

The rates of return to fixed investment for the modal ranches of the three prominent strata are 1.12 percent for 1c, 3.96 percent for 2c, and 2.88 percent for 3c.

Improvement practices on both private and government land increased annual return significantly for all linear programming models.

The range of the internal rate of return when private and public capital are used for improvement practices in all models shows that these investments are good; those considered ranged from 5.6 percent to 49 percent, and will compete favorably with other investments in our economy.

The optimal yearly level of investment for both private and public capital for all models ranged from $270.17 to $1,588.09.

Lambing on seeded ranges during May and June is economically better than lambing on unimproved ranges according to the linear programming results.

On one modal ranch Forest Service grazing permits were reduced from 643 AUM's to zero. This reduction caused the annual income to fall from $10,094.24 to $6,777.97. At the same time the capitalized value of the ranch dropped from $201,784.80 to $135,559.40. The

capitalized value of the permits remained at $99.50 through the first part of the permit reductions and then increased to $120.06 in the last part.

When Forest Service grazing permits are increased from 643 to an optimum of 913, the annual income increased from $10,089.24 to $11,443.57. When irrigated pasture is increased from 49 acres to an optimum amount of 178 acres, the capitalized value of the ranch increased from $201,784.80 to $228,871.60. The change in income caused by changing permits or other resource levels depends on the combination of any particular ranch's resources.

(194 pages)

CHAPTER I

INTRODUCTION

Because of pressures on the sheep industry such as low market prices, foreign competition, labor shortages, and government land grazing cuts, the "Wool Growers" along with other interested groups desired to know the economic status of the sheep rancher. Consequently, this study was initiated in order to determine Utah's position in relation to number of sheep ranchers, size of herds, amount of investment per ranch, and return to fixed resources.

It was hoped, along with gathering this factual information, that answers to some of the problems would be found. Therefore, knowing that some combinations of reseeded range, sprayed range, hay land, etc., are more profitable than others, linear programming was used to find these optimum combinations for typical ranches.

This chapter surveys the study area, general economic information pertaining to the study area, and the general approach used in building strata and obtaining the sample from the sheep ranchers.

Chapter II discusses the general economic principles used, and Chapters III and IV will cover analytical techniques and analyses of ranch data.

Description of the Study Area

Utah extends 345 miles from north to south and 275 miles from east to west. Mountain ranges, desert basins, broad tablelands, deep canyons, and irrigated valleys comprise Utah's varied topography. A series of

broken mountain ridges and plateaus extends roughly north to south through the center of the state, forming the boundary between the Colorado Plateau, east, and the Great Basin, west. This central highland strip begins in the Wasatch Range (a span of the Rockies) in the north, which rises to 12,008 feet at Mount Timpanogos, and continues southward in Wasatch Plateau, Parant Mountains, Tushar Mountains, Aquarius Plateau, and Markagunt and Paunsaugunt Plateaus, whose south edges form the scenic Pink Cliffs. In this section, drained by Bear River, north, and by Jordan, Sevier, and Virgin rivers, south, are the bulk of the state's population, 890,627 (1960 census), and all its large cities. In northeast Utah the Uinta Mountains (with an east-west axis) rise to 13,227 feet in Kings Peak, highest point in the state. South of the Uintas in east Utah lies the Colorado Plateau, carved by wind and water into such prominent features as the Taraputs Plateau, with its south escarpment, the Book Cliffs, the splendid gorges of the Colorado River and Green River, the domed Henry, La Sal, and Abajo mountains, and many remarkable natural bridges, multi-colored sandstone cliffs, and isolated buttes and mesas. In west Utah, which consists of the east part of the Great Basin, are Great Salt Lake Desert and the noted Great Salt Lake, largest inland body of salt water in the Western Hemisphere. This lake and Utah Lake and Sevier Lake to the south are remnants of prehistoric Lake Bonneville, whose receding waters left well-preserved terraces along the west base of the Wasatch Range where Ogden, Salt Lake City, Provo, and other cities now stand. West Utah, a drab region of extensive salt flats, desert plains and block mountains, has no drainage outlet to the sea. The state, with an average altitude of about 6,000 feet, has a dry continental climate of the steppe and desert variety. Salt Lake City has a mean temperature

of 26°F in January and 77°F in July with an annual average precipitation of 14 inches. About 72 percent of the land area, including almost 9,000,000 acres of national forests, is in Federal ownership. Total farm land is over 10,000,000 acres, divided among some 26,000 farms. Cattle and sheep are raised throughout the state. Wool, sheep, and lambs are important exports.

Soil erosion is severe. Only about three percent of the land is arable, and most of this is under irrigation. Wheat, hay, alfalfa, sugar beets, oats, barley, potatoes, truck crops, peaches, and apples are the principal crops. The majority of crop farms are in north and north-central Utah, especially in the valleys just west of the Wasatch Range. Turkey and dairy farming are also carried on in this region (Seltzer, 1962).

General Economic Facts Relating to the Sheep Industry in Utah

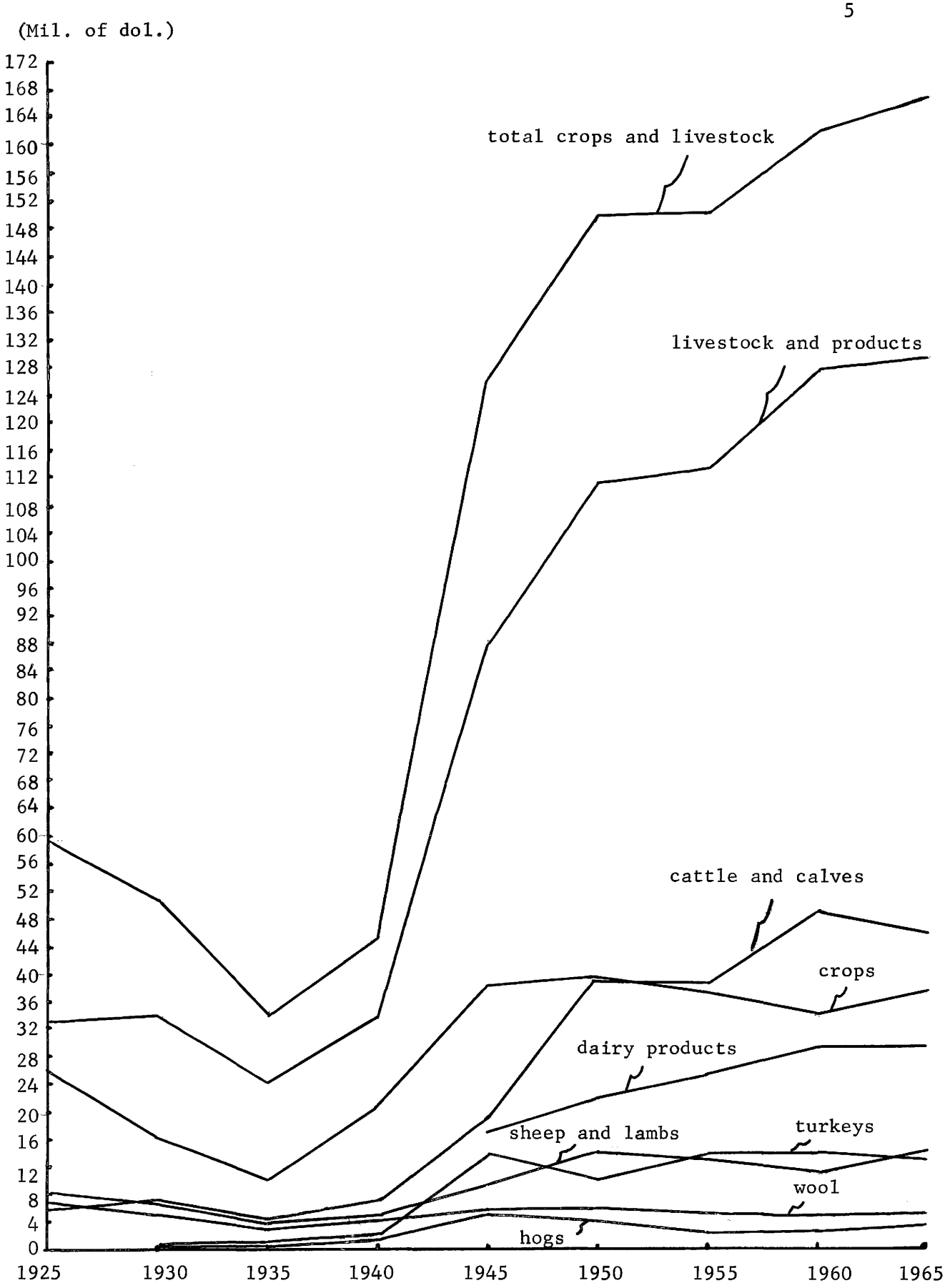
Cash receipts from marketings, Figure 1, show the relative importance of sheep receipts as compared to other major agricultural products of Utah. The trend since 1925 is generally up, which is due primarily to an increase in sheep prices as numbers of sheep have been declining during this period.

Since 1930 the production in pounds of sheep and lambs has trended downward, Figure 2. Turkeys, a major agricultural product, exceed lambs in receipts during three periods of time, Figure 1, but never once in pounds produced.

The prices per pound of lamb are close to and roughly parallel those for cattle and calves since 1925, Figure 3. Prices per pound for turkeys

Source: Farm Income Situation, Economic Research Service, USDA. Issued in August each year.

Figure 1. Cash receipts from marketings.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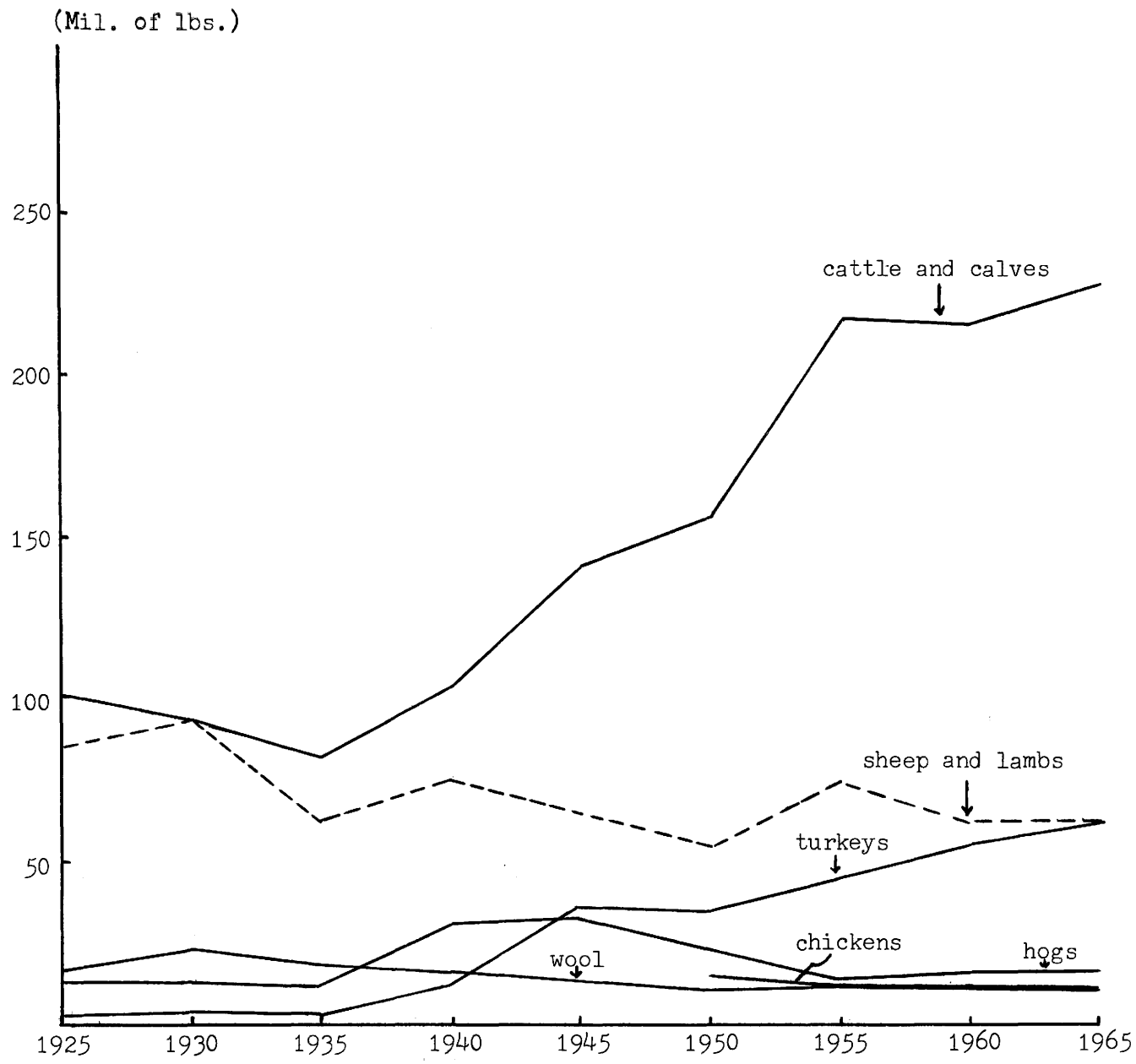
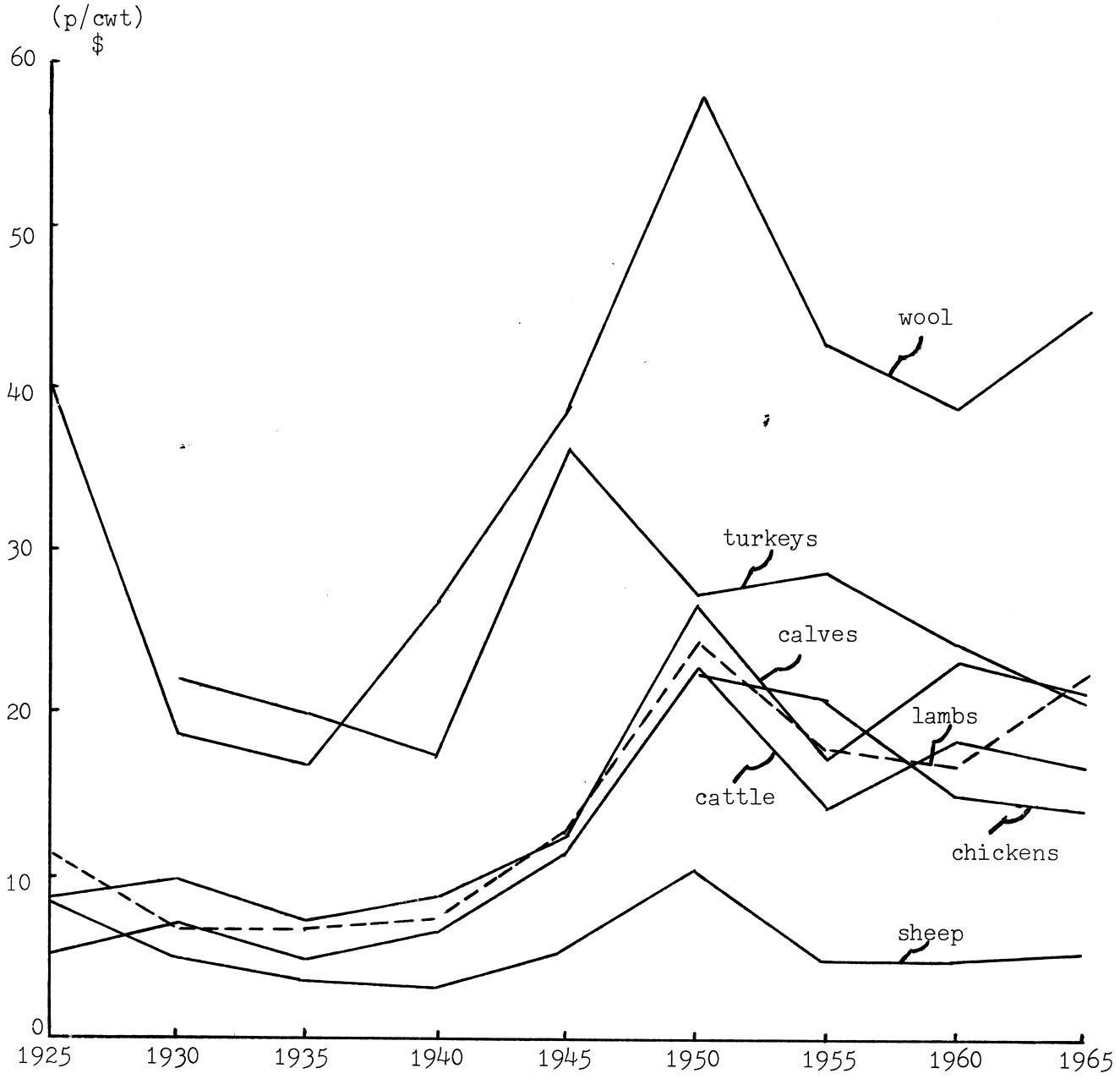


Sources:
1. Meat Animals - Farm Production, Disposition, and Income - by states, April, S.R.S. USDA Crop Reporting Board, Washington, D.C.
2. Annual Livestock Reports - S.R.S. USDA Federal Building, Salt Lake City, Utah, unpublished workbook.
3. Chickens - Chickens and Eggs - Farm Production, Disposition, Cash Receipts, and Gross Income - by states, S.R.S. USDA Washington, D.C.

Figure 2. Production of meat and wool.



Source: Prices of selected livestock and livestock products - S.R.S. Livestock Report, Glenn Casey, Agricultural Statistician, Federal Building, Salt Lake City, Utah, unpublished workbook.

Figure 3. Price per pound for various livestock (liveweight) and wool.

are higher than lambs or calves during the entire period with the exception of 1965.

The average percent lamb crop at docking since 1925 has fluctuated little, Figure 4. The years since 1950 indicate a higher percentage, about 85 percent, than any other time and with a smaller amount of fluctuation.

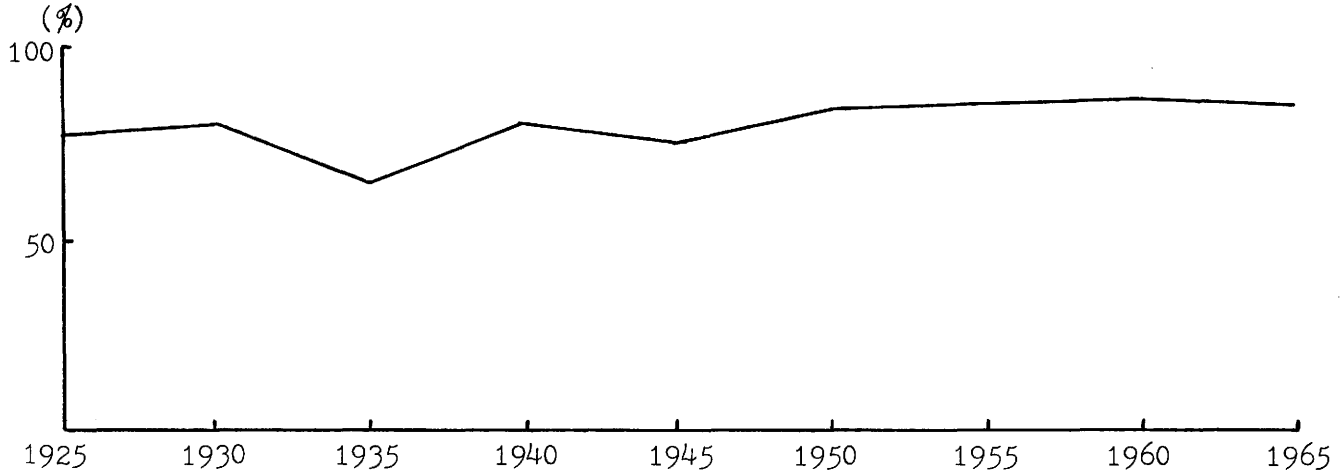
The percent of lamb and mutton consumed in the United States which is supplied by imports is shown in Figure 5. Since 1955 the imports have competed significantly with domestically produced lamb and mutton.

Sheep inventory in Utah from 1850 to 1900, Figure 6, shows a historical peak in 1900 at about 3 million head. Due to overstocking and an economic depression numbers have gradually declined since then.

Figure 7 shows the reduction in inventory since 1930. It has been constant since 1950.

Sampling Procedures

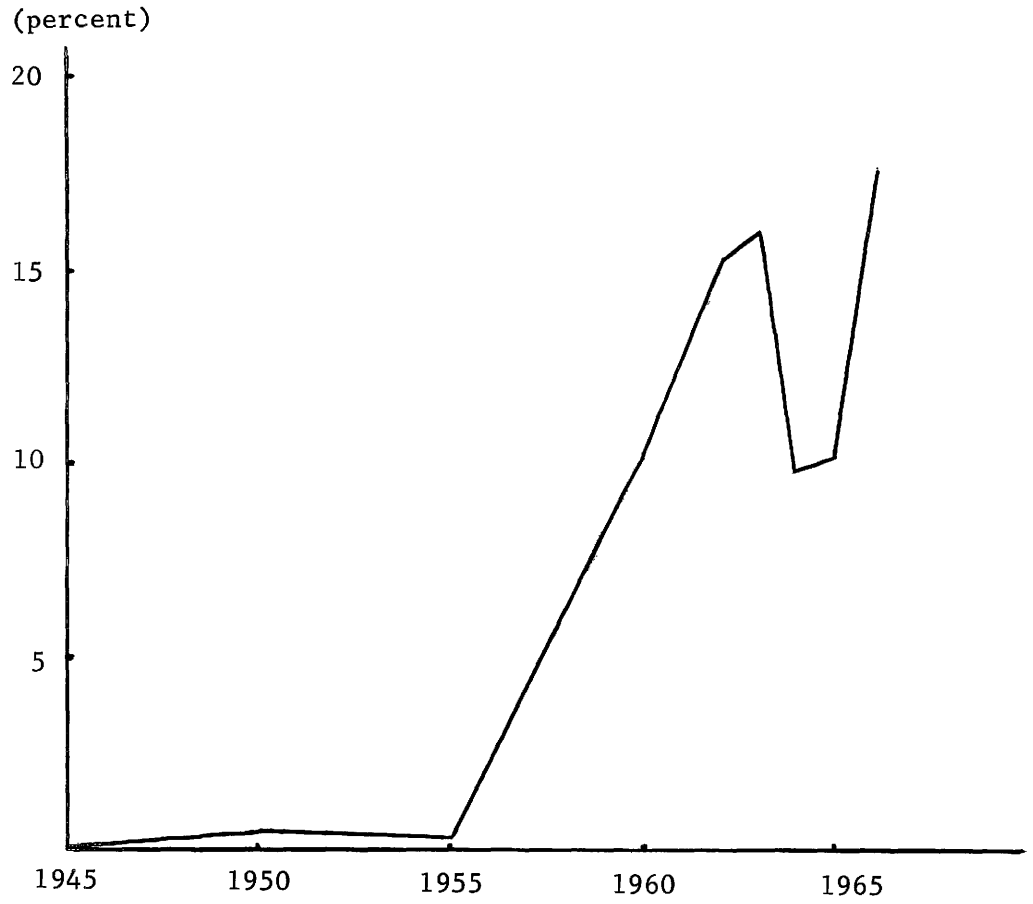
To obtain a list of all sheep ranches in Utah with over 750 head of sheep, county, Forest Service, and the Bureau of Land Management (BLM) records were used. This information was compiled and stratified according to ranch size and to season of use on government land. Four breeding herd size classifications were selected as follows: 1 = 750-1499 ewes, 2 = 1500-2499 ewes, 3 = 2500-5499 ewes, and 4 = 5500 ewes and over. A letter indicating seasonal use of public land was used as follows: a = winter (may include fall or spring or both), b = summer (may include fall or spring or both), c = year-long, none = no public land use. The stratum symbol 1a would indicate a ranch having from 750 to 1499 breeding ewes and public land permits for fall, winter, and spring grazing. Table 1



Source: Utah-Nevada Lamb Crop, Statistical Reporting Service, Office of Agricultural Statistician, 4418 Federal Building, Salt Lake City, Utah.

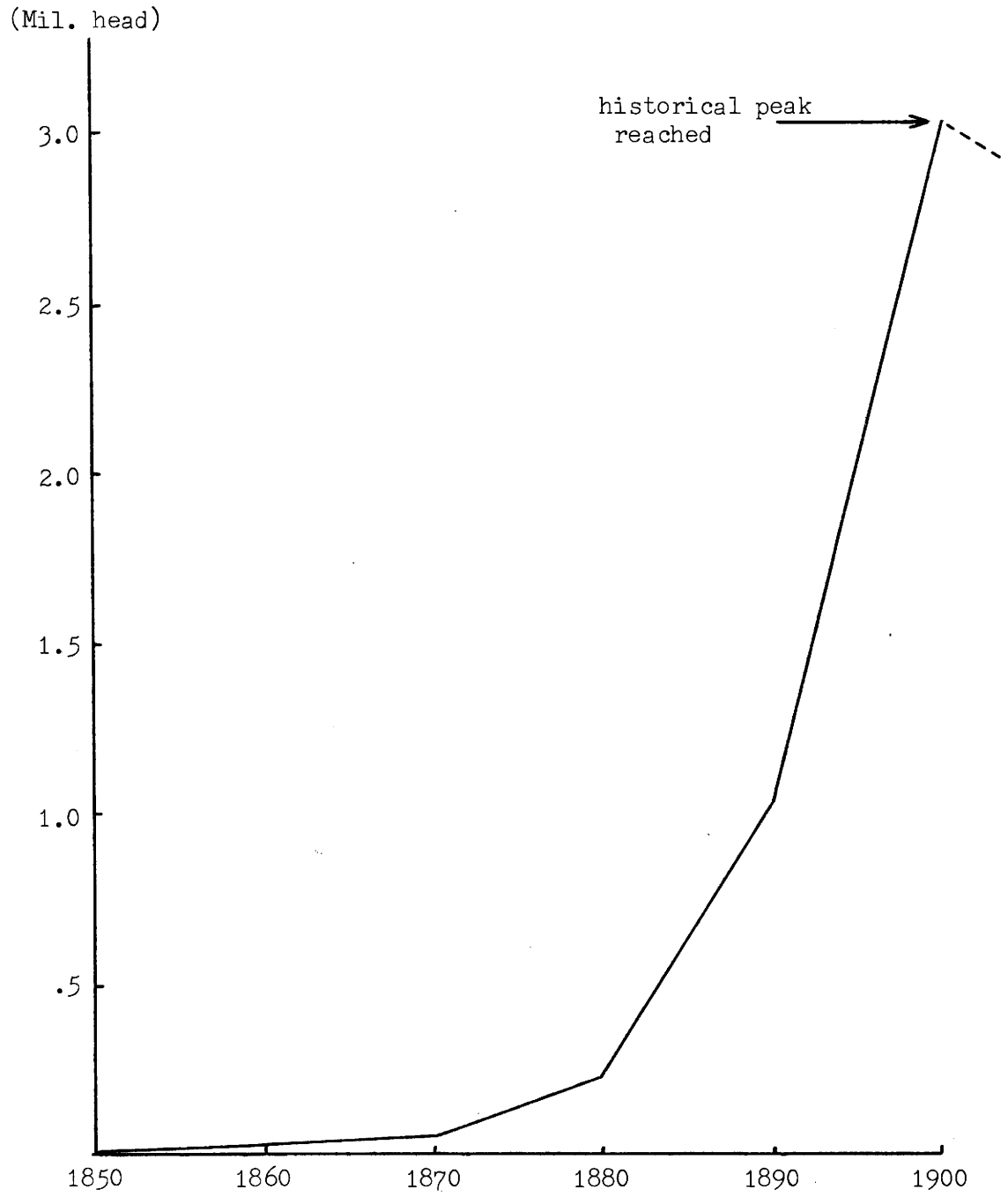
Note: The percent lamb crop is that of breeding ewes at docking time.

Figure 4. Average percent lamb crop in Utah.



Source: U. S. Bureau of the Census, Statistical Abstract of the United States: 1967. (88th edition) Washington, D.C., 1967.

Figure 5. Percentage of lamb and mutton imports consumed to total consumption of lamb and mutton in the United States.



Source: Wentworth, Edward Norris. America's Sheep Trails. The Iowa State College Press, Ames, Iowa, 1948.

Note: Wentworth reports that the sheep numbers were taken from the Census and that no sheep under twelve months old were included in the Census or in the assessor's reports. Sheep went to over 3 million head in year 1900 and then due to overstocking gradually reduced in numbers.

Figure 6. Sheep inventory in Utah.

Source: USDA Statistical Reporting Service.

Figure 7. Sheep inventory in Utah by classes.

Table 1. Sample design for 1964 sheep ranch survey

1	2	3	4	5	6	7	8
Stratum	Symbol[a]	Adjusted population in Utah[b]	Sample size	Sample percent 4 ÷ 3	Out of Utah residence[c]	Total 3 + 6	Sample percent 4 ÷ 7
1	1	5	2	40	--	5	40
2	1a	14	5	36	--	14	36
3	1b	22	9	41	4	26	35
4	1c	47	19	40	10	57	33
5	2	2	1	50	--	2	50
6	2a	16	4	25	--	16	25
7	2b	4	3	75	1	5	60
8	2c	57	26	46	18	75	35
9	3	--	--	--	--	--	--
10	3a	17	7	41	--	17	41
11	3b	--	--	--	--	--	--
12	3c	49	16	33	21	70	23
13	4	--	--	--	--	--	--
14	4a	3	2	67	--	3	67
15	4b	--	--	--	--	--	--
16	4c	14	10	71	1	15	67
Total		250	104	42	55	305	34

[a]Number in breeding herd:
1 = 750-1499, 2 = 1500-2499, 3 = 2500-5499, 4 = 5500.
Seasonal use of public land: a = winter (may include fall or spring or both), b = summer (may include fall or spring or both), c = year-long, none = no public land use.

[b]18.8 percent of the original population had either sold out or reduced herd below 750 head of ewes from 1962-1964. Most adjustments were in the 1 size class.

[c]These ranchers lived in Colorado, Wyoming, Idaho, and Nevada but grazed public lands in Utah.

shows the sample design, population sampled, and size of sample.

A random sample was selected from each stratum by using a table of random numbers. The sample in respect to the total population in each stratum averaged 34 percent and ranged from 23 percent to 67 percent.

About 18.8 percent of the sheepmen in the population sampled had either sold out or reduced herd size below 750 head of ewes in the years 1962-1964. Most of the adjustments were in the 750-1499 ewe size class.

The sheepmen were cooperative in filling out a 24-page questionnaire that covered most phases of their operation.

Data were collected on 104 ranches; then a typical ranch was constructed representing each stratum. Modal characteristics, such as quantity of rangeland, number of breeding ewes, land taxes, lamb sales, etc. were used to construct these typical ranches.

CHAPTER II

ECONOMIC PRINCIPLES

The economic principles discussed in this chapter, internal rate of return, marginal value product, and capitalization, are those most often referred to in the analysis of data later in the text.

Internal Rate of Return

The internal rate of return is used for comparing alternative investments over time. The equations used in this study will be presented here. For further information concerning these equations Duerr (1960) and Gray, Stubblefield, and Roberts (1965) may be consulted. The final part of the section will consist of examples showing the use of the internal rate of return.

Equation

The equation $P = F\ \frac{1-(1+i)^{-n}}{i}$ is the equation used in this study. P equals the dollar value invested, F the annual income, and i the rate of interest. To solve the equation $P = F\ \frac{1-(1+i)^{-n}}{i}$ for any of the unknowns would be very tedious. However, with the help of Tables (Nielsen, 1967, p. 44) where $\frac{1-(1+i)^{-n}}{i}$ has been worked out for various i and n values solutions for range economic problems can be worked out quite rapidly. To convert to a form so that the tables can be used both sides of the above equation must be divided by F. The equation now becomes $P/F = \frac{1-(1+i)^{-n}}{i}$ where P/F equals the present value of $1 received annually for n years.

Examples

If money is invested in a spraying project with a life of twelve years and the marginal value product (MVP) for each dollar is $1.72, then to have a stream of income of $1.72 for each of the twelve years, it will be necessary to invest $12 now. Consequently, $12 will equal P, the income stream of 1.72 will equal F, and P/F, or $\frac{12}{1.72}$, will be the present value of $1 received annually for twelve years. The internal rate of return for capital is 9.56 percent in this case.

Now consider an investment in a seeding project with a life of twenty years and the MVP for each dollar is $1.56, then to have a stream of income of $1.56 for each of the twenty years it will be necessary to invest $20 now in May seeding. Consequently, $20 will equal P, the income of $1.56 will equal F, and P/F, or $20/$1.56, will be the present value of $1 received annually for twenty years. Thus:

$$P/F = \frac{1-(1+i)^{-n}}{i}$$

$$\frac{\$20}{1.56} = \frac{1-(1+i)^{-20}}{i}$$

$$12.84 = \frac{1-(1+i)^{-20}}{i}$$

This gives an internal rate of return of 4.65 percent.

Marginal Value Product and Capitalized Values

The MVP or shadow price of a resource furnished by the solution of a linear program is defined by Heady and Candler (1958) as the amount added to or subtracted from profit by a one unit increase

or decrease of a particular resource.

The rancher is at times faced with the problem of purchasing or selling resources, and the question arises as to how much they are worth. It is important to know if the market price is above or below the price based on productive capacity. The productive value is determined by finding the capitalized value of the resource in question. The following two examples illustrate the use of this concept: Example (1): the MVP of a forest service permit is $2, the capitalized value of that particular permit unit at 5 percent interest is $\frac{\$2.00}{.05} = \$40$. The rationale for this is that if you expect 5 percent return per year for money invested and the annual return is $2, then algebraically expressed the problem is: $.05x = \$2$. Solving for x by dividing both sides of the equation by .05 would give: $x = \frac{\$2.00}{.05}$ or $x = \$40$. However, it must be remembered that only this one permit unit is worth $40, and the next one purchased or sold may have a different capitalized value. By using parametric programming where units of a resource are added or taken away, it is possible to get an overall idea of how much different quantities of a resource are worth to a rancher.

Example (2): Suppose the MVP for summer rangeland is $.58 per acre and the rancher requires 6 percent return on his money. At this income the capitalized value per acre of land is $9.66 or $.58 ÷ .06. Additional purchases of land at amounts greater than the capitalized value would result in rates of return lower than 6 percent. This can be shown by the purchase of $20 per acre land which returns $.58 per acre annually. The rate of return under this situation is 2.9 percent, $.58 ÷ $20, for

buying or holding this type land.

Some of the resources used will have a 0.0 shadow price or MVP. These resources are free resources at the margin, and they do not limit production in the optimum plan. This means that this resource does not constrain or limit further production and there is some of it unused in the optimum solution. Scarce resources, on the other hand, are those resources which do limit production. They are "scarce" relative to the amount the firm would like to employ.

The shadow prices or marginal value product are all based on the value received per unit of livestock as entered in the ranch model. If the price per unit of livestock is higher one year than another, then the MVP's of all resources will be higher. Also, the value received per unit of livestock in the ranch models used is based on the returns to the fixed resources. In other words, the annual cost for (1) Forest Service fees, (2) B.L.M. fees, (3) state land fees, (4) land rent, (5) land taxes, and (6) interest on investment has not been subtracted from total annual ranch sales when deriving the annual value received per unit of livestock. The solution of the linear programming model computes the return to these resources given the amounts available and their alternative uses in the model.

CHAPTER III

ANALYTICAL TECHNIQUES USED

Linear programming techniques are relatively new in the ranching business. Barr (1960) analyzed some of the alternatives available to Oklahoma ranchers by using linear programming techniques. He compared native grass seeding, brush control activities, and Bermuda grass establishment. Nielsen (1964) used the concepts of a linear programming model developed by Brown (1961) for determining the optimum allocation of resources of a Bureau of Land Management grazing allotment in Malheur County, Oregon. This model is used to estimate rates of return from range improvements and seemed especially suitable for use on this Utah study. Consequently, it was adopted.

To clarify some of the basic ideas of linear programming, a section on linear programming will be presented followed by limitations pertaining to linear programming.

Linear Programming

The general problem in linear programming is to maximize an objective, subject to the restrictions of a set of linear inequalities, as follows:
Maximize the linear function

$$F = C_1X_1 + C_2X_2 + \ldots + C_nX_n$$

Subject to

$$A_{11}X_1 + A_{12}X_2 + \ldots + A_{1n}X_n \leq B_1$$
$$A_{21}X_1 + A_{22}X_2 + \ldots + A_{2n}X_n \leq B_2$$

$$\cdots\cdots\cdots\cdots\cdots\cdots$$

$$A_{m1}X_1 + A_{m2}X_2 + \ldots + A_{mn}X_n \leq B_m$$

$$X_i \geq 0, \quad (i = 1, \ldots, n)$$

The A_{ij}, B_i and C_j are known constants.

The objective is to maximize profit. The particular problem is to assign values to the activity variables, X_1, X_2, etc., representing the amount of each activity produced, to attain the objective, subject to the restrictions of the resource supplies. In other words, the values assigned X_1, X_2, etc., must be such that when these quantities are multiplied by A_{ij}, the per unit requirement of the activities for the particular resource, the total requirements for the i-th resource is equal to or less than the supply. The values assigned must maximize the quantity in the linear function.

A second restriction on the plan is: the level of any activity must be equal to or greater than zero. An activity cannot be produced at a negative level. While this statement may appear redundant, since a negative amount of an agricultural commodity cannot be produced, it does have importance in respect to disposal activities. For further detailed information see Heady and Candler (1958).

Linear programming is a new tool mainly in the sense of precise problem formulation, computational procedures, and the capacity to process large quantities of data. It does not provide new concepts in respect to the nature of problems to be solved or the basic economic principles which define solution of these problems. Agricultural economists have long employed the basic assumptions which underlie linear programming. The farm budgeting technique developed by agricultural economists in the 1920's was a procedure implicitly embodying the main mathematical

assumptions of modern-day programming. Similarly the principles of maximization and minimization of relevant economic quantities were accepted knowledge prior to development of basic procedures for linear programming.

Linear Programming Limitations

The normative and positive conditions of linear programming and the basic assumptions pertaining to linear programming are, in a sense, limitations and will be discussed in these two general categories.

Normative and positive conditions of linear programming

The general linear programming technique for these typical ranches will produce normative results (what ought to be, given the coefficients used) rather than positive results (just reporting what is happening). The ranch budget and the calculated returns to the fixed resources per animal unit are calculated from conditions as they actually are. The coefficients in the model are determined from university and government research figures. Soil Conservation Service estimates of carrying capacities are used for the various sites based on sound range management practices.

The typical ranches in this study have approximately 28.8 percent less carrying capacity when figured on a what-ought-to-be basis rather than on a what-is basis. In the long run the rancher will receive greater economic returns by stocking properly to prevent damage to his natural resources than if he does not. Consequently, this is the proper method to be used for obtaining linear programming results.

Linear programming might be used to derive a normative supply function for farmers. It would indicate the amounts of product which should be produced at each price for factors and products if the farmer's goal is to maximize profits. In contrast, a regression analysis based on time series or cross-sectional data, might be used to derive a positive supply function. It would describe or predict how farmers actually do respond to price changes and would likely differ considerably from the normative supply function.

Linear programming assumptions

Linear programming is based on the following five basic assumptions.

Linearity

This is a concept that, in effect, says that the input factors are combined in fixed proportions at all levels of output and that the amount of resource used to produce a unit of a particular output is the same regardless of the output. The linear programming model which is properly developed allows for this. By parametrically changing the amount of one of the inputs a non-linear function can be approximated.

Additivity

Activities must be additive in the sense that when two or more are used their total product must be the sum of their individual products. This does not allow for the complimentary interaction often found between various activities. Where two crops have an interaction effect the complimentary aspect can be handled by considering various rotations, not single crops, as real activities.

Single value expectations

It is assumed that the quantity of resources, prices, and input-output coefficients are all known with certainty. Of course, this is not so in the majority of cases and, as a result, errors occur. However, these same assumptions of necessity must be made with other planning techniques, such as budgeting, and, consequently, hinder linear programming with no greater handicap.

Divisibility

This is a characteristic of linear programming that states resources used and output produced can be divided into fractional units. In other words, total tractors used may be one and one-half and total sheep produced may be 1130.5 ewes. This assumption is not serious since rounding may be done with no large change in the end result.

Finiteness

This assumption states there is a limit to the number of alternative activities from which to choose for any particular problem as well as a limited number of resources to use.

CHAPTER IV

ANALYSIS OF RANCH DATA

Three of the strata sampled contained 66 percent of the sheep ranches in Utah. In order to restrict this study to a reasonable size, these three strata are the ones used in the linear programming models.

The coefficients used in the models are based on previous research. The methods of arriving at these coefficients and the source of research will be discussed. Finally, the linear programming models constructed and the linear programming results will be analyzed.

Production Practices

The percentages of feed derived from aftermath grazing, hay, government grazing, and owned and leased grazing for the three typical ranches representing the three strata are:

	stratum 1c	stratum 2c	stratum 3c
aftermath	4.2	2.6	3.7
hay	9.0	6.6	2.8
gov't grazing	64.6	60.8	64.0
owned and leased	22.2	30.0	29.5
	100.0	100.0	100.0

The main breeding season runs from November 15 to December 15. Some of the ranchers supplement at this time with pellets or hay or graze the ewes on the better pastures. Approximately 14 percent of the ranchers have special breeding pastures, and others use the winter range area as

a breeding pasture. The ratio of ewes to rams for the three typical ranches are for stratum 1c, 38 ewes per ram; for stratum 2c, 41 ewes per ram; and for stratum 3c, 41 ewes per ram. The rams are left with the herd about 45 days.

Lambing starts about April 25 with shearing 5 to 10 days earlier. The ewes are fed supplemental feed, pellets, hay, etc., just prior to and during lambing. The average percent lamb crop of breeding ewes at docking time is approximately 108 percent. The lambs are sold, generally, between September 15 and October 15 with about 9 percent of the ranchers shipping their lambs to sale yards for auction. The rest of the operators contract their lambs to buyers while they are on the range or in the feed lot.

The predominant breed of ram used is Suffolk mixed with either Columbia or Rambouillet. However, because about 72 percent of the ranchers raise their own ewe lambs for replacement purposes, white faced bucks of Rambouillet or Columbia breeding are kept explicitly for this purpose. The ewes are various mixtures of Columbia and Rambouillet breeding.

A ewe is bred when 18 months old and has a life of 6 to 7 years. The rams are purchased at an average price of $77 and have a productive life of about 4 years.

The average trailing distance for the sheep on each ranch is about 142 miles. However, about one-third of the ranchers contacted do some trucking when moving from one range to another.

Approximately 68 percent of the ranchers hauled water to their sheep in the winter or spring and approximately 9 percent hauled water in the summer.

About 9.0 percent of the ranchers had done some spraying on their rangeland. Over half of them practiced some type of rotation grazing. A few followed a poisonous plant control program.

Penicillin, terramycin, and mixtures of these antibiotics were the chief stock medicines bought by ranchers. Vaccines were used mainly for soremouth, with a smaller number vaccinating for bluebag. There was very little dipping or spraying for sheep insects though many ranchers said that they should do more.

Economic Relationships of the Ten Strata

There are two general categories to be discussed in this section. Number one compares economic facts among the different strata relying heavily on graphs for the presentation. Number two concerns ranch budgets and how they were constructed.

Economic comparisons

There were eleven typical ranches constructed, and the attached graphs show some relationships among ten of the ranches. Stratum 2 was atypical and was not included. To save space on the graphs the code used to define the ten strata is presented here:

I. Number in breeding herd

1 = 750 to 1499

2 = 1500 to 2499

3 = 2500 to 5499

4 = 5500

II. Seasonal use of public land

a = winter (may include fall or spring or both)

b = summer, (may include fall or spring or both)

c = year-long

no letter = no public land use

The rate of return to fixed investments for the ranch strata is shown in Figure 8. Generally speaking, the rate of return to investment is not very high with the highest being 5.37 percent for stratum 1a and the lowest being -.66 for stratum 2b. The simple average for all of the ranches is 2.5 percent. The weighted average is 2.6 percent.

Figure 9 shows the relationship between money invested in sheep and other major investments in the operation. The investment in owned land and permits is roughly proportional to the investment in sheep. However, the investment in machinery and equipment, and buildings and improvements is not proportional to the investment in sheep. The investment becomes less per animal unit as the size of the breeding herd increases. The investment in owned land and permits is larger than any of the other investments.

The value of operator and family labor in Figure 10 tends to increase as the herd size increases. One reason is that the family pays itself a better salary as herd size increases. Another reason is that the larger herds make it possible for more members of the family to make a living wage from the operation.

Figure 11 shows the relationship between the net income, sheep and lamb sales, and crop sales. For the small ranches the net income and crop sales are roughly proportional. As the ranches become larger, net income becomes proportional to sheep and lamb sales. Wool sales are somewhere between sheep and lamb sales and crop sales.

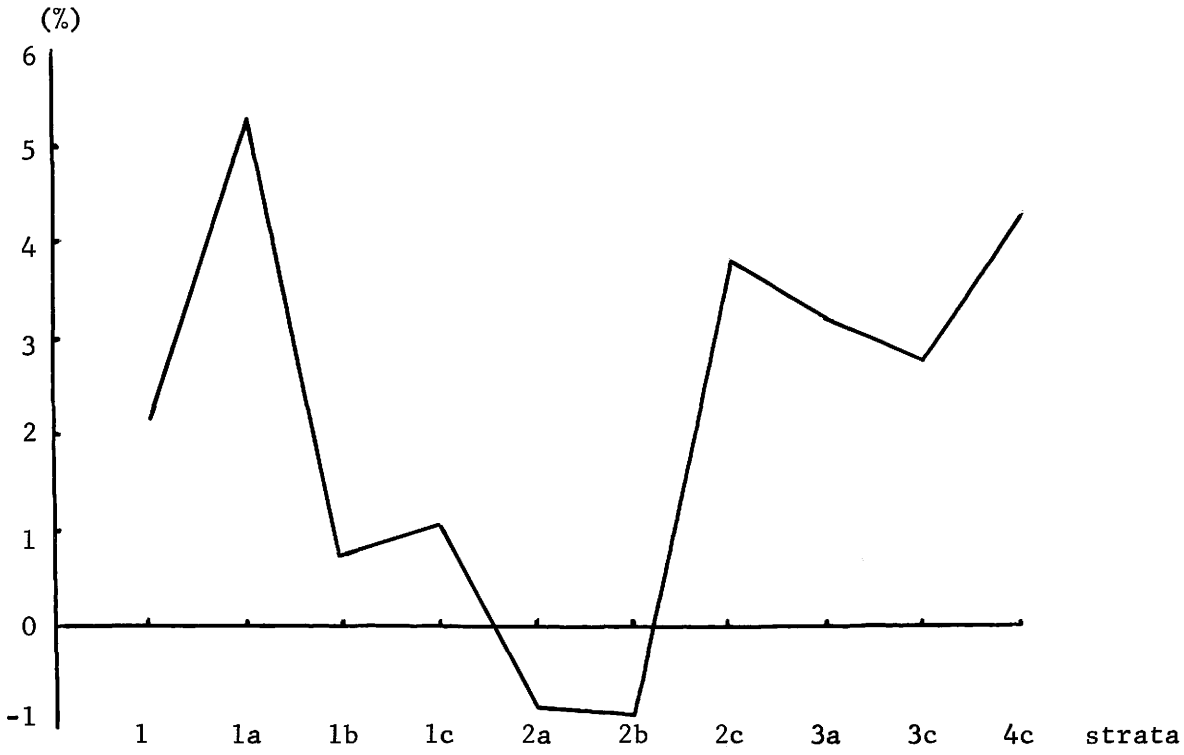


Figure 8. Rate of return to investment for different ranch strata of Utah sheep ranches.

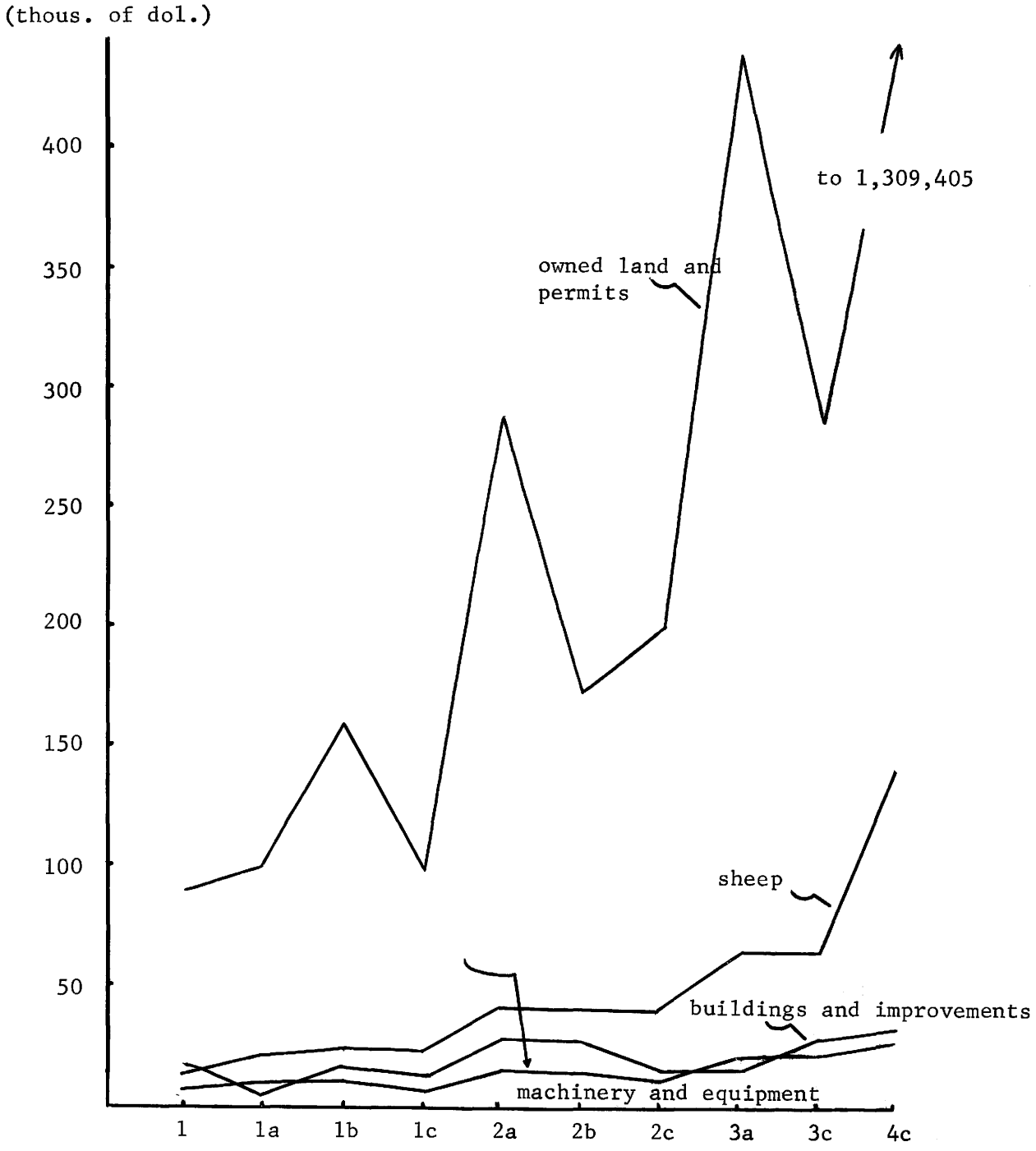


Figure 9. Summary of investment of Utah sheep ranches.

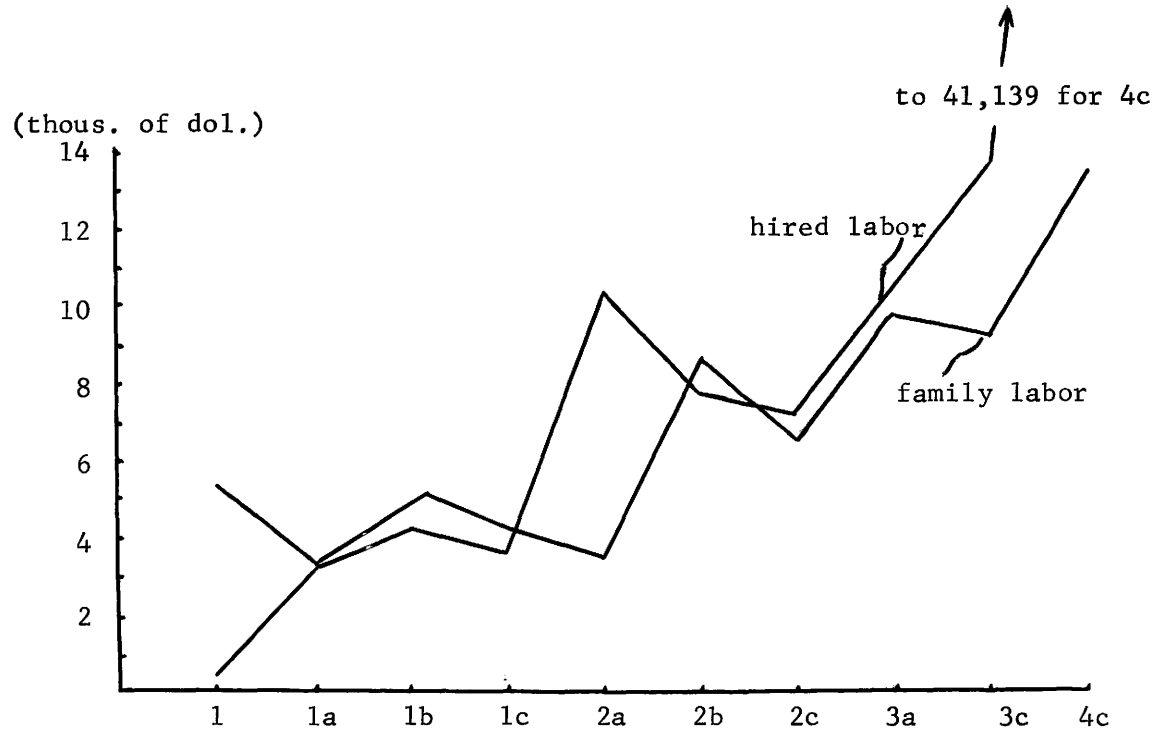


Figure 10. Value of operator, family, and hired labor for different ranch strata.

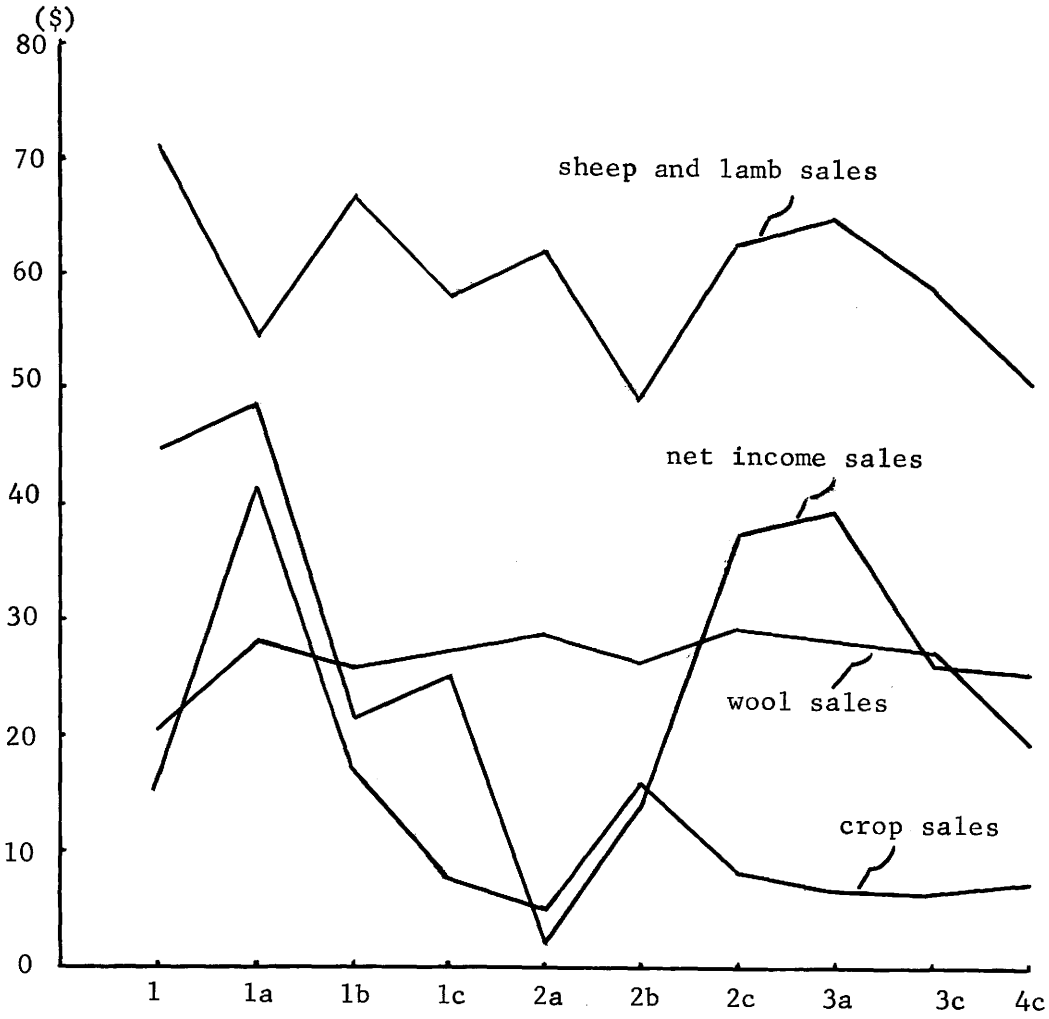


Figure 11. Average value per A.U. of sheep and lamb, wool, and crop sales for the ranch strata.

Total ranch income, cash costs, and non-cash costs are closely proportional for all strata as illustrated in Figure 12. Non-cash costs are lower and have less fluctuation than the other two.

Figure 13 indicates that generally the ranches sell more slaughter lambs than feeders.

Ranch budgets

Standard forms used in determining ranch budgets were recommended by the BLM Regional Committee which was organized in 1962. Consequently, the tables in this section and those in the Appendix are those suggested by the committee. Some of the pertinent assumptions and techniques used in the construction of the budgets are:

(1) For the interest on cash costs or operating capital a rate of 6 percent per annum was used. For return to investment in land, sheep, etc., a rate of 5 percent per annum was used.

(2) Privately owned leased range was charged for at a rate of $2.50 per A.U.M. Leased state land cost about $0.50 per A.U.M. or $.047 per acre.

(3) Shearing rates used were $0.55 per animal.

(4) Death losses represent 5 percent of average inventory values.

(5) Land values were assumed to be as follows:

a.	native hay land, cut	$250 per acre
b.	native hay land, not cut	$150 per acre
c.	improved pasture	$250 per acre
d.	alfalfa land	$250 per acre
e.	barley land	$250 per acre
f.	range land, owned	$20 per acre
g.	dry crop land	$60 per acre

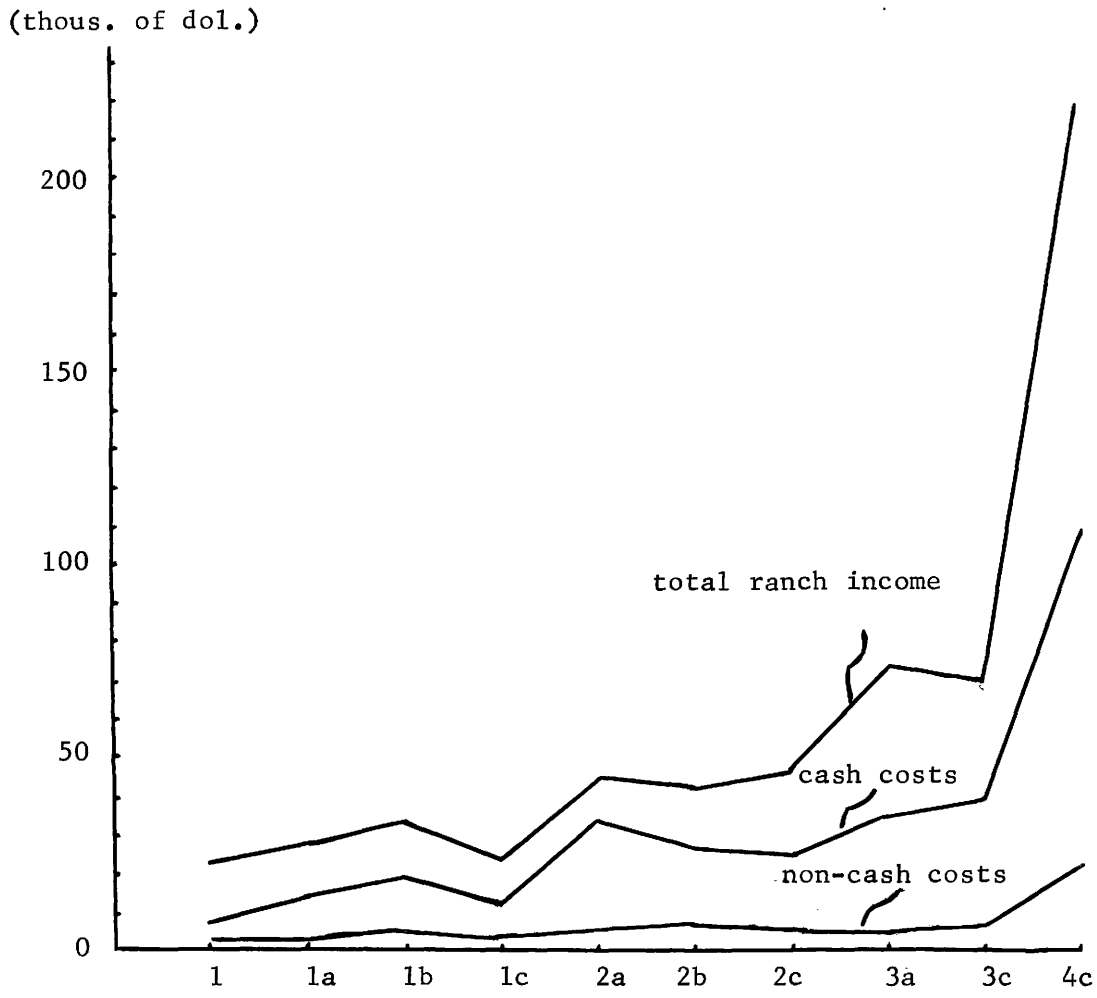


Figure 12. Total ranch income, cash costs, and non-cash costs of the ranch strata.

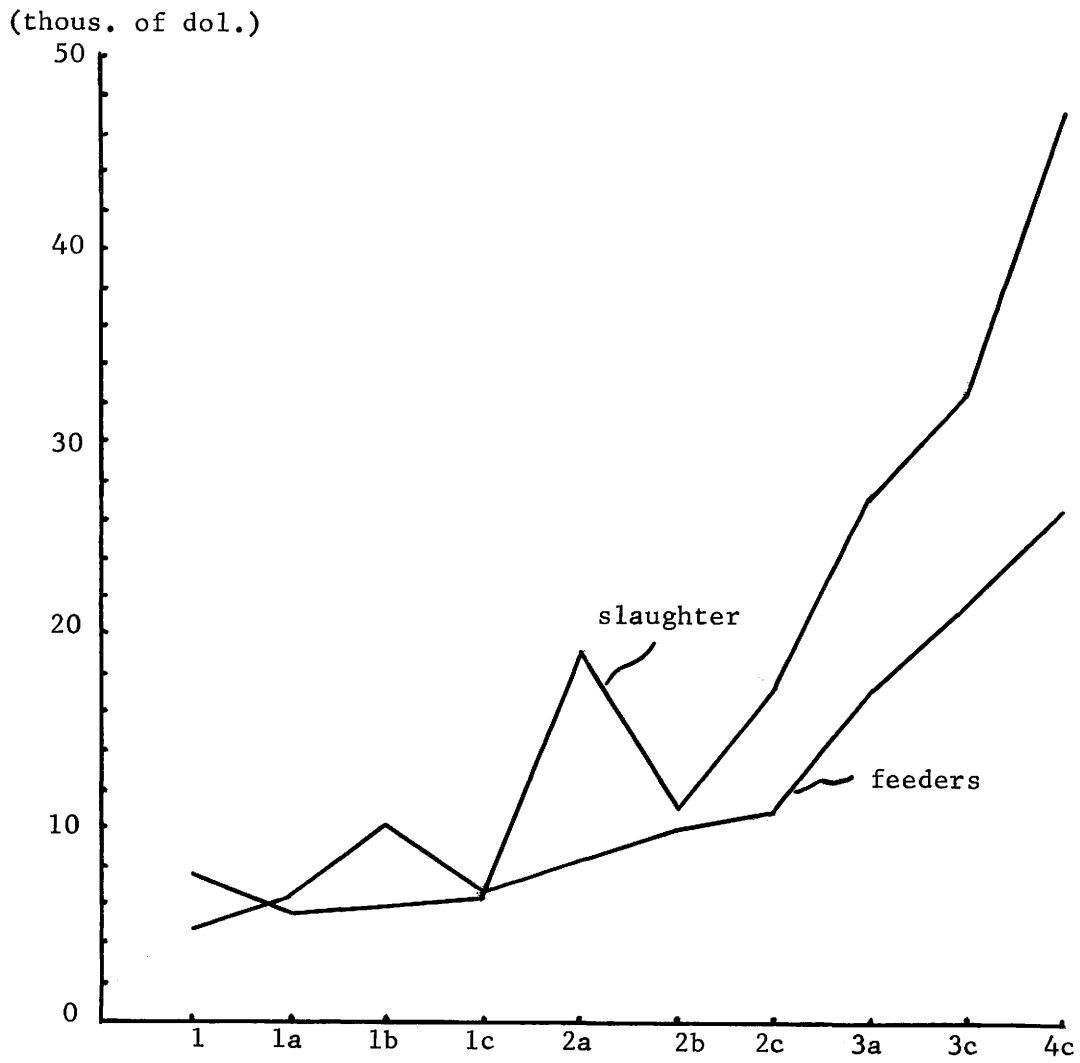


Figure 13. Sale of slaughter and feeder lambs in 1963.

(6) The investment in equipment was figured by subtracting salvage value from the replacement cost and dividing by 2.

(7) Lamb prices and ewe prices were obtained from the 1964 "Livestock Quotations."

(8) The coming-one inventory value, $17.50, was the weighted average price received for lambs taken from Ogden's 1964 "Livestock Quotations." It was weighted for feeders and slaughters, $19.67/cwt, times the weighted average weight of feeders and slaughters on the 1964 sheep survey.

(9) Marketing costs were computed using the formula in the publication of Roberts and Wright (1959) concerning marketing costs.

(10) The animal unit equivalents (number of animals required to equal one 1,000 lb. cow) used in putting the livestock on an animal unit basis are:

	animal unit equivalents
a. mature ewes	5
b. replacements coming-two	6
c. replacements coming-one	7
d. lambs	8
e. bucks	3.7
f. horses (1.25 AUM's = 1 horse)	.8

The tables used for arriving at the data in Table 2, a summary type table, are in Appendix A. The receipts, expenses, net ranch income and operator and family labor for each of the strata are given in Table 2.

Coefficients

The reliability of a linear programming model is highly dependent on the coefficients used. If the coefficients are in error, the

Table 2. Ranch income and expense summary for typical ranches

	Strata									
	1	1a	1b	1c	2a	2b	2c	3a	3c	4c
Receipts:										
Sheep and lambs	13,319	12,786	17,790	13,662	28,622	22,146	30,013	47,142	43,968	78,657
Wool	4,148	5,461	5,919	5,360	11,282	9,949	11,773	17,077	17,274	30,912
Wool incentive payment	859	1,074	1,212	1,068	2,244	1,942	2,344	3,445	3,422	6,530
Crop sales	2,917	9,685	5,892	1,889	2,388	7,518	4,044	5,764	5,785	27,222
Calves and cows	--	--	1,575	--	--	--	--	--	--	76,704
Pelts	--	30	--	44	50	166	80	102	158	200
Total ranch income	21,243	29,036	32,388	22,027	44,588	41,723	48,255	73,531	70,610	220,225
Expenses:										
Cash costs	8,732	14,081	19,990	12,366	37,542	27,247	24,943	37,181	40,011	109,468
Non-cash costs	4,043	3,676	5,279	3,698	5,726	7,552	5,708	7,541	9,634	21,770
Total operating expense	12,775	17,757	25,269	10,065	43,268	34,799	30,652	44,723	49,646	131,238
Net ranch income	8,468	11,279	7,119	5,961	1,319	6,924	17,602	28,808	20,963	88,987
Operator & family labor	5,400	3,600	5,290	4,350	3,600	8,700	6,600	9,900	9,150	13,750
Return to inv. & mgt.	3,068	7,679	1,829	1,611	-2,281	-1,776	11,002	18,908	11,813	75,237
Rate of return to inv. & mgt. (%)	2.25	5.3	0.8	1.1	-0.6	-0.7	4.0	3.5	2.9	4.3

programming results are distorted. Consequently, the best possible figures attainable should be used.

Biological coefficients

Seeding

Crested wheatgrass (Agropyron cristatum and Agropyron desertorum), intermediate wheatgrass (Agropyron intermedium), and Russian wildrye (Elymus junceous) were used in the models, and basic information was taken from studies at Eureka (Cook, 1966). Since crested wheatgrass grows earlier than the native grasses or the other introduced wheatgrasses, the system of grazing crested wheatgrass first, followed by grazing later-maturing species was compared to grazing crested wheatgrass throughout the full spring season, May 1 to June 26, during 1961 and 1964. It was found that grazing crested wheatgrass early in the spring until about June 1 followed by grazing intermediate wheatgrass until about June 25 gave considerably better gain than grazing crested wheatgrass the entire spring period. After June 1, ewes on crested wheatgrass lost 0.04 pounds per day until June 25 while ewes that were shifted to intermediate wheatgrass gained 0.12 pounds per day during this period. There was little difference in gain for lambs between the treatments.

In Wyoming, Hamilton and Lang (1961) found that Russian wildrye has a higher protein content than seeded wheatgrasses when compared at similar growth stages. Digestibility coefficients, digestible protein, and total digestible nutrients are comparable to tall (Agropyron elongatum) and intermediate wheatgrass and meet the requirements for lactating animals exceedingly well until about the first week in August. Similar results were obtained by McCall, Clark, and Patton (1943) in Montana.

Livestock gains on Russian wildrye during the spring were comparable to those from intermediate or tall wheatgrass and were considerably better than those from pubescent (Agropyron trichophorum) or crested wheatgrass.

Later studies (Stoddart and Cook, 1950) indicate that on the drier areas crested wheatgrass, Fairway (Agropyron cristatum) and Standard (Agropyron desertorum), in a commercial mixture survived better than any of the other introduced wheatgrass species tested. It grows early in the spring and is highly drought resistant. On foothill lands receiving 13 inches or more of annual precipitation, intermediate wheatgrass appeared promising.

A study conducted in semi-desert areas of northern Utah with only about 10 inches of annual precipitation showed that crested wheatgrass and Russian wildrye were better adapted to arid conditions than tall, pubescent, or intermediate wheatgrass (Cook, 1965b). Preliminary grazing trails indicated that even crested wheatgrass and Russian wildrye under these conditions could tolerate only light grazing[1] and during drought years little, if any, grazing.

In a study at Benmore and Eureka, sheep made better gains on seeded ranges early in the season (May 8 - June 13) than later in the season (June 18 - July 19). Sheep made better gains throughout the grazing season on intermediate wheatgrass than on either crested or tall wheatgrass (Cook and Stoddart, 1961).

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[1] It is assumed when grazing key species that 55-65 percent utilization is moderate use, 70 percent is heavy use, and 35 percent is light use..

When figuring the coefficients for benefits received from seeding, an increase in average lamb crop plus an increase in gain per lamb were considered along with reduced number of acres required per A.U.M. Cook (1966) in a study at Eureka, Utah, weighed ewes onto the experimental wheatgrass pastures about May 1, and then weighed them again with their lambs at docking time about May 27. Both ewes and lambs were weighed off the pastures onto natural mountain ranges about June 27 each year. Consequently, the following results came from grazing improved grasses only two months of the year, May and June. The average lamb crop on the seeded pastures was 120 percent compared to 96.5 percent for the native sagebrush-grass pastures. The ewes that grazed the seeded pastures produced about 20 pounds more lamb at weaning time than ewes that grazed on the sagebrush-grass range. Intermediate wheatgrass produced 8 pounds more weaning weight per lamb and about 26 pounds more lamb per ewe at weaning time compared to the native sagebrush pastures (Cook, 1966, p. 33).

Seeding on five sheep allotments in western Utah improved the average carrying capacity from about 10 acres to 2½ acres per AUM (Vallentine, Cook, and Stoddart, 1963).

Among other things, the forage increase obtained as a result of range seeding depends on the amount and distribution of precipitation, the quality and depth of soil, the species planted, and the method of seeding. Seeding experimental pastures on foothill sagebrush range near Eureka, where annual precipitation averages 13 inches yearly, has increased total grass production five times. Carrying capacity on these seeded pastures has averaged 2 to 3 acres per AUM, varying from 1½ acres on the best seedings to 6 acres on pastures reinvaded

by sagebrush. Adjacent unimproved sagebrush range requires 10 to 15 acres per AUM.

A recent study (Cook and Stoddart, 1964) covering about 9 years has shown that desert ranges can best withstand grazing if used only during the fall and winter rather than all year or during only spring and summer. If grazed in winter, desert ranges can be used twice as heavily as if grazed in the spring or summer. Therefore, if Utah's desert ranges are grazed during the winter (about October 1 to April 5) they will furnish grazing for twice the number of livestock that could be grazed during the spring and summer (April 6 to September 30). Proper use of forage plants on the desert ranges was indicated to be about 50 percent if used during the winter and only 25 to 30 percent during spring or summer.

The coefficients for April and May grazing are based on research by Harris, Frishkneckt, and Sudweeks (1965), and Cook and Stoddart (1964). It is acknowledged that the coefficients will vary depending on geographic location, elevation, etc. The following assumptions were made for the typical ranches used in this study. Since May and April are such a critical time of the year for growing plants, special care is required to prevent overgrazing. Native grasses may be grazed from April 15 to May 15 if an area is only grazed alternate years. Generally, native foothill ranges will withstand grazing on consecutive years if it is started approximately May 1. Since crested wheatgrass seedings are about two weeks earlier than native range, these areas may be grazed from April 1 to May 1 if grazed alternate years only. If grazed with care, crested wheatgrass may be grazed on consecutive years when started approximately April 15.

Fertilizing

The fertilizing coefficients were based on studies which indicate that on seeded foothill ranges applications of 30 to 40 pounds of nitrogen per acre produced an average of 800 to 1,000 pounds additional herbage per acre. About 60 percent of this increase was produced the first year, about 30 percent the second year and 10 percent the third year (Cook, 1965b). The total production from 35 pounds of nitrogen per acre is about 900 pounds of forage and 90 percent of this is produced the first two years. The increase in herbage is 900 pounds x 90 percent = 810 pounds of herbage per acre over a two year period or 405 pounds per year. The other 10 percent must certainly have an effect on yield but because of insufficient data the 90 percent figure will be used. This conservative estimate may be wise since fertilizing results depends so much on weather, soil, elevation, and other variable factors. Because the fertilization is done on seeded foothill ranges and it is assumed proper use is 60 percent, the total usable forage produced per acre is 405 pounds x 60 percent utilization = 243 pounds per year.[2]

Using Soil Conservation Service recommendations it is assumed that on the average it takes 800 pounds of usable forage for each AUM.[3] The grazing capacity on this range prior to fertilizing was 5.00 acres per

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[2] It should be noted that benefits due to fertilization not included in these coefficients are increases in percent protein, plant vigor, and palatability. When this occurs the amount of forage consumed per unit of time will also change.

[3] Later studies (Cook, 1966, p. 4) indicate that each lactating ewe and lamb utilize 7 pounds of forage each day. However, since the 800 pound per AUM figures had already been incorporated into the model and run on the computer no changes were made.

AUM or each acre produced 160 pounds of usable forage. Each acre produced 160 pounds of forage prior to fertilization plus 243 pounds from fertilization giving a total of 403 pounds of usable forage per acre. Consequently, the carrying capacity is 2 acres per AUM in this particular example.

Fertilizing coefficients were also calculated for the months April, May, and June. This was done by varying the amount of forage increase due to fertilization in the same proportion as these three months varied with July in regular forage production without fertilization. This is an assumption not based upon research but done in order to find out whether or not fertilizer would come into a solution under these conditions.

Cost and return coefficients

Cost of seeding

Seeding costs are based on BLM figures (Nielsen, et. al., 1966). They do not vary greatly from Cook's (1963) figures for the individual items, but include water developments which Cook's do not. Studies at Benmore show that wheatgrasses seeded in 1943 may have infinite longevity if they are adapted to the site (Cook, 1966). However, there are many cases where seedings have not had infinite longevity. Therefore, a somewhat arbitrary decision has to be reached on the expected life of a seeding. If the estimated expected life is longer than the actual life, then the project will appear more profitable than it actually is. Conversely, if the expected life is underestimated, the project will appear less profitable than it actually is. For the purposes of this study we will assume that a seeding lasts at

least 20 years (Nielsen, 1967, p. 20).

Costs were computed for two years' nonuse on the seedings. However, Vallentine, Cook, and Stoddart (1963) have cautioned that if dry years prevail during establishment, additional years may be required to allow seedlings to become firmly rooted. Plants are not sufficiently established if they can be pulled out of the ground by hand. The number of AUMs of grazing not used for a two-year period (based on unimproved carrying capacity) were valued at $3 per AUM. The $3 per AUM is based on private grazing fees reported in Utah in 1961. Table 3 shows the cost estimates for seeding crested wheatgrass.

Table 3. Cost estimates for seeding crested wheatgrass

Initial costs:	
Plowing and drilling	$ 9.71 per acre
Water developments	2.20 per acre
Nonuse	.63 per acre
	$12.54
Fencing...none because these are sheep ranches and herding is assumed. For cattle it is $.99 per acre	
Annual costs:	
Water maintenance and use	$ 0.10
Fence maintenance...none for sheep, for cattle it is $.08	
20-year life of seeding:	
$12.54 / 20 years = $.63 per year initial cost	
$.63 initial cost + $.10 annual costs =	$.73 per acre per year

Though not done with these models it may be desirable when figuring the cost of seeding to express risk as a cost as done by Lloyd (1959). Risk cost can be computed by multiplying probability of failure by the cost of seeding. The following hypothetical example will illustrate: A long-term probability of failure at 50 percent and seeding costs at 30 percent of seeding costs would yield a risk cost equal to 15 percent of seeding costs (0.50 x 0.30 = 0.15). This example is oversimplified since allowance should also be made for risk of failure of reseedings as well as seedings.

Seeding is usually done on range in poor condition. Studies have shown that sufficient native grass to fill in the stand must be present before brush control or changes in livestock management alone are practical (Vallentine, Cook and Stoddart, 1963). A minimum of one desirable grass plant for each 4 square feet or a 15 percent ground cover of desirable perennial grasses is often used on foothill sagebrush range as an index for successful recovery possibilities without artificial seeding.

Cost of supplementing

Harris, Frishkneckt, and Sudweeks (1965) conducted an experiment where they concluded that if cows on crested wheatgrass were fed the equivalent of 0.75 pounds of supplement, or if calves were nursing cows fed a supplement from early summer to late summer they did as well as cows or calves on adjacent National Forests on natural vegetation. This type of study for sheep was not available but because it was desirable to see if this expensive type of management was profitable a comparable type of management for sheep was simulated. Assuming that similar results could be obtained by supplementing sheep on crested wheatgrass during the summer at approximately the same cost the following figures

were used.

Supplement to be Fed with Crested Wheat

Soybean meal, 44 percent protein	88.2%	@ $5.75/100#
Dicalcium phosphate	10.8%	@ $6.15/100#
Trace mineral salt	1.0%	@ $2.40/100#

Cost per 100 pounds:

Soybean meal	$5.75 x .882 =	$5.07
Dicalcium phosphate	$6.15 x .108 =	.66
Trace mineral salt	$2.40 x .01 =	.02
		$5.75 per 100 lbs. supplement

Consequently, one pound will cost $.0575; .75 of a pound per A.U. per day will cost $.043 for the mix. Per AUM the cost would be $.043 x 30 days = $1.29.

To calculate the cost for seeding, fertilizing, and supplementing July grazing it is necessary to know that 1.99 acres of seeded land per AUM is required, $2.73 per acre is the cost of fertilizing, $0.73 per acre is the cost of seeding, and $1.29 per AUM is the cost of supplementing. These figures are then combined into the following equation: (1.99 acres x $2.73 per acre for fertilizer) + (1.99 acres x $0.73 per acre for seeding) + ($1.29 per AUM for supplementing) = $5.43 + $1.45 + $1.29 = $8.17 per AUM.

Cost of spraying

Since spraying sagebrush on foothill ranges with herbicides is about one-half as expensive as seeding, it is done when feasible. Because a certain amount of perennial grasses must be present spraying is usually done on range in fair condition.

Costs for spraying are based on BLM figures (Nielsen, et. al., 1966). Nonuse is for a two-year period, and the life of the spray project is estimated as 12 years. The costs are summarized in Table 4.

Table 4. Aerial spraying cost estimates

Initial cost:	
Spraying (included materials and application)	$3.42 per acre
Fencing (sheep are herded)	none
Water developments	.67 per acre
Nonuse	.33 per acre
	$4.42
Annual costs:	
Fence maintenance (sheep are herded)	none
Water development maintenance and use	$ .02
	$ .02
12-year life of the spraying:	
$\frac{\$4.42}{12} = \$.37$	
$.37 +$.02 = $.39 per acre	

Returns to seeding and spraying

To calculate the benefits due to range seeding it is assumed that grazing on seeded pastures during May and June rather than sagebrush-grass range resulted in a ewe producing about 20 pounds more lamb at weaning time (Cook, 1966). Multiplying the 20 pounds of lamb increase per ewe by $.1953, the selling price per pound of lamb taken from the 1964 "Livestock Quotations," is equal to $3.91, the increased return per ewe. To convert this to an A.U. basis, the $3.91 is multiplied by 5, which equals $19.55, the increased return per A.U. Consequently, the total return per A.U. when grazed during May and June on seeded ranges is the sum of the following: (1) $36.60, the return when grazed on sagebrush grass range, and (2) $19.55, the increase due to grazing on seeded range, resulting in a total of $56.15.

It was assumed that the increase of income resulting from range spraying was one-half of the increase due to range seeding. As a result, the total return per A.U. due to grazing on sprayed range during May and June is $36.60 + ($19.55 ÷ 2) = $46.38.

Cost of fertilizing

The fertilizing cost per acre is computed as follows: Ammonium nitrate with 33½ percent nitrogen was used at $83.06 per ton rate. Consequently, 1/3 of 2,000 pounds of ammonium nitrate will give 666.67 pounds of free nitrogen for each $83.06 spent. Thus 666.67 pounds of pure nitrogen divided by 35 pounds of nitrogen per acre will give 19.05 acres that will be fertilized at the rate of 35 pounds of nitrogen per acre at a cost of $83.06. Dividing $83.06 by 19.05 acres results in $4.36 per acre for the cost of the nitrogen. Then: $4.36 + $1.10 application costs = $5.46 total cost for two years. The total cost for one year will be: $5.46 ÷ 2 = $2.73 per acre per year.

Cost of chaining juniper

The cost for chaining juniper, windrowing the brush with bulldozers, plowing, drilling and seed is $12 to $14 per acre according to Vallentine, Cook, and Stoddart (1963). Consequently, a price of $14 per acre for the operation is used. Since water developments at $2.20 per acre are added to this chaining project with an annual water maintenance cost of $.10 per acre, the total cost per acre per year is ($14.00 + $2.20) ÷ 20 years + $.10 = $.91. The annual cost of chaining per AUM is then the number of acres required per AUM times $.91 per acre.

Cost and returns for hay and barley

In a situation where a ranch had hay to sell this was included as a separate activity, and the net price was figured as discussed previously, market price minus variable costs. The prices used in these models are based on Agricultural Prices, 1964 Annual Summary, and the return for hay is $21.67 per ton selling price of hay minus $10.96 variable costs for

harvesting, equals $10.71, return to fixed factors. It is more convenient in the models to figure the return on an acre basis so the yield per acre in tons will be multiplied by the $10.71 return to fixed factors. The return for barley selling is based upon the same principles as for hay selling. Again using the publication by Davis (1965) as a guide, the variable costs were calculated as $.64 per bushel of barley and $1.07 selling price per bushel minus $.64 variable cost equals $.43 per bushel return to fixed resources.

For each animal unit run on the ranch a certain amount of hay is required. This amount of hay is then figured as a fixed cost and fixed requirement per animal unit. However, in addition to this, hay is made available as a source of feed if the linear programming model indicates that it would be profitable. The time most likely for the hay to be used would be in April, and the cost for using hay would be $10.96, the variable costs used in harvesting the hay.

Return to fixed resources

Net prices are computed by calculating the gross or market price per unit of activity and subtracting the variable cost from it (Heady and Candler, 1958). This will give the return to the fixed resources. The typical ranch models have included the following for fixed costs and they have not been subtracted from the market price in order to obtain net price: (1) interest on investment, (2) forest service fees, (3) BLM fees, (4) state fees, (5) land and pasture rent, (6) land taxes.

Return per animal unit

To calculate the net price per A.U. of sheep, the following example taken from model 2c will be used. Total ranch income due to livestock sales, $46,427.98, minus variable costs,

$33,920.48, equals the return to fixed resources, $12,507.50. Then dividing the return to fixed resources, $12,507.50, by the number of breeding ewes on the ranch, 1709, the return per ewe equals $7.32. Since all the calculations in the model are based on an animal unit basis, the return per ewe, $7.32, is multiplied by 5 to obtain the return per A.U., $36.60.

Example of how the coefficients function within the model

When calculating the AUMs of grazing required during the year to operate the sheep ranch there are more animals to be considered than just the breeding ewes. For instance, on ranch 2c there are replacement ewes coming two, replacements coming one, lambs, bucks, and horses in addition to the breeding ewes. For the month of January the total number of AUMs required per AUM of breeding ewe, which includes the breeding ewe, is 1.39. To continue with this thought and to give the basic reasoning behind the models, assume that there is only one month in that year, January, in which we have to supply feed in order to get $36.60 per A.U. of breeding ewe on unimproved range. Since for each A.U. of breeding ewe there is .39 A.U. of supporting livestock, there will have to be enough feed for 1.39 A.U.'s of livestock for one month to make $36.60. Actually, the other eleven months need to be taken care of similarly to get the $36.60, but they are being ignored in this simple example. The linear programming model uses the available resources to support as many 1.39 A.U.'s of feed for the month of January as the restrictions will allow. If there is enough feed to support ten 1.39 A.U.'s, the return to fixed resources will be 10 x $36.60, or

$366.00. The restrictions or constraints for January, which allow only 10 of the 1.39 A.U.'s of livestock, may be available BLM permits of winter grazing plus the available acres of private land winter grazing. Supposing the BLM permits are the limiting factor, the constraint is set up as follows:

Eq.	Constraints or resource	Constraint no.	Units	Act. 1 January grazing	Act. 2 $36.60
A	BLM permits	14.0	AUMs	1	0.0
B	January	0.0	AUMs	-1	1.39

Algebraically the above constraints are as follows: For equation A, Activity 1, has to be $\leq$ 14.0 AUMs of permits. Also for equation B, Activity 1 + activity 2, has to be $\leq$ 0.0.

Both of the above relationships have to be complied with. Since the 1.39 in activity 2 is positive and constraint B is 0.0, then for each activity No. 2 there will have to be enough activity No. 1's or negative values, to keep relationship B below 0.0. For example, if one activity No. 2 is used, then two activity No. 1's will be used in order to keep relationship below 0.0. Consequently, the number of activity No. 2 will be increased to the point that activity No. 1 will be halted due to insufficient permits, remembering relationship A. In this example, it will be possible to use 10 activity No. 2's because due to relationship A it is possible to use 14 activity No. 1's which will supply 14 negative signs in relationship B, which will still keep relationship B below 0.0 if 10 activity No. 2's are used. The return to fixed resources would then be 10 x $36.60 = $366.00.

When calculating AUM's of grazing per breeding ewe A.U. needed for each month, allowances are made for the winter maintenance hay

ration fed. For instance, if during the month of January 475 AUM's of feed are needed and 16 AUM's of them are provided by hay then 475 AUM's - 16 AUM's = 459 AUM's will have to be provided by grazing. The requirement for hay is handled the same way as the grazing requirement, with number of tons of hay per A.U. of mature breeding ewe for the entire year put in the hay restraint row. As an example, on the typical ranch for stratum 3c there was a total of 192 tons of hay fed for winter maintenance. Dividing 192 tons of hay by 2,842 breeding ewes on the ranch results in .068 tons of hay per ewe. Multiplying the .068 tons of hay per breeding ewe by 5 equals .34 tons of hay fed per A.U. of breeding ewe.

Linear Programming Models

Linear programming models were constructed for the modal ranches in the three most prominent strata. These strata used government grazing land year around and each represented a different size class: (1) 750 to 1,499 breeding ewes, stratum 1c; (2) 1,500 to 2,499 breeding ewes, stratum 2c; and (3) 2,500 to 5,499 breeding ewes, stratum 3c. The greatest number of ranches fell into the 2c class.

All the strata were represented by models with alternative choices or activities offered to the decision maker made as typical as possible. Because improvement practices are dominant in the choice criterion of this study, government grazing land was broken down as to general types and condition classes and to number of acres of each. Range improvements are considered in the model for each class of land that could be improved. Since there was no time to gather this type of information

in the field, help was received from Mr. Ben Heywood of the Soil Conservation Service and Mr. Bruce Reese from the U. S. Forest Service. Data concerning proportions of good, fair, and poor range were taken from the Report to the Governor, Resource Development, Utah Grazing Lands (1966).

In addition to the regular model for stratum 2c, which included government land by classes, there was a smaller model constructed which included government grazing permits instead of land classes for the government grazing. This small model was used to determine the effect of reducing government grazing permits on ranch returns.

The size of the linear programming models made it impractical to present them in tabular form, which would have made it possible to follow the logic of the models easily. An exception to this is the presentation of the small model just mentioned. Even though the small model is bulky in tabular form, it seemed desirable to present it in order to illustrate the logic and an example of the coefficients used. The three models are discussed in more detail in the following sections, starting with the smallest.

Model 1c

Model 1c is the smallest ranch programmed with 814 breeding ewes. It has the same basic resources as models 2c and 3c with the exceptions that 2c is not broken into precipitation belts on the BLM land and 3c has potential juniper chaining areas that the other two do not have.

Private and leased land, Forest Service land, Bureau of Land Management land, and state land are assumed to have seedable acres. On private and leased land the rancher had a choice of planting half of

the seedable land to crested wheatgrass and half to intermediate wheat or Russian wildrye. The crested wheatgrass provides early forage, and the intermediate wheat and Russian wildrye provide late forage. The coefficients in the model reflect these characteristics.

The Forest Service land had only one type of seeding which was a mountain mix consisting of smooth brome, mountain brome, orchard grass and Kentucky bluegrass. BLM land and state land has areas that were best suited for either crested wheatgrass or intermediate wheatgrass seeding.

Areas of private land, Forest Service land, and BLM land are assumed to have sprayable acres. Range land was broken down into condition classes of good, fair and poor range on these three types of land and also on state land.

The BLM land has good, fair, and poor range located in two precipitation belts, 6 inches to 12 inches and 12 inches to 16 inches. The same condition classification of range varies in carrying capacity depending, among other things, on the precipitation belt in which it falls. It is apparent that most of the seedable and sprayable land would necessarily fall into the precipitation belt that had 12 or more inches of moisture.

The private land, in addition to that already mentioned, includes aftermath grazing, alfalfa land, irrigated pasture and barley land.

Private capital and public capital are handled as a resource. It is assumed that the rancher has no access to these funds until after a basic solution has been reached with the other resources. After a basic solution has been reached, private capital and public capital are added in increments. This is done by parametric programming. Thus,

the improvement practices on private or public land which are feasible come into the solution as private and public capital are made available.

The months for which grazing or feeding are required are treated as whole months except for April and May when grazing time becomes critical. These two months are treated in half month units.

Among the 225 activities or choices for the decision maker the following are considered: (1) a hay utilizing activity during April and May for hay raised on the ranch over and above that normally used in the year's activity; (2) a hay buying activity for April and May; (3) an income activity for each breeding ewe when no special seeded or sprayed areas are used during spring lambing; (4) an income activity for each breeding ewe when seeded areas are used during spring lambing, May and June; (5) an income activity when sprayed areas are used during spring lambing; (6) hay selling activities when sold from alfalfa land, irrigated pasture or barley land; (7) a barley selling activity; and (8) an activity for using irrigated pasture, for summer grazing.

More detailed information on this model may be obtained in Appendix B where it is listed in equation form. The logic may best be seen from Table 5, the tabular form of small model 2c, in the next section.

Model 2c

The representative ranch from which the following two models were constructed is most typical of sheep ranches in Utah with approximately 1,709 breeding ewes.

Large model 2c

The matrix of the large model is 49 by 183 and for all practical purposes is the same as that of model 1c. However, the BLM land is not broken down into precipitation belts and crested wheat

Table 5. Small linear programming model 2c

Resources		No.	Units	1 F.S. grazing permits	2 BLM grazing permits	3 S.L. grazing permits	4 April	5 May	6 June	7 July	8 August	9 September	10 October	11 November	12 December	13 April 1 – May 15 October 1 - 30
Cost Row																
Seedable (CW)	1	555	Acres				40.001	15.7	12.5	20.001	20.002	20.003	19.0	17.5	20.014	30.008
Seedable (IW or RW)	2	555	Acres													
Sprayable	3	696	Acres													
Aftermath	4	155	AUM's													
Good range	5	961	Acres													
Fair range	6	1299	Acres													
Poor range	7	3325	Acres													
Alfalfa land	8	73	Acres													
Irrigated pasture	9	99	Acres													
Capital	10	10.0	$													
Hay	11	1.0	Tons													
F.S. grazing permits	12	649	AUM's	1.01												
BLM grazing permits	13	2566	AUM's		1.02											
Stateland grazing permits	14	645.6	AUM's			1.03										
Barley land	15	34	AUM's													
January	16	.001	AUM's		-.167											
February	17	.002	AUM's		-.167											
March	18	.003	AUM's		-.167											
April	19	.004	AUM's		-.167		-1									-.4
May	20	.005	AUM's			-.004		-1								-.2
June	21	.006	AUM's			-.257			-1							
July	22	.007	AUM's	-.333		-.117				-1						
August	23	.008	AUM's	-.333		-.166					-1					
September	24	.009	AUM's	-.333		-.149						-1				
October	25	.0001	AUM's			-.208							-1			-.4
November	26	.0002	AUM's		-.167	-.019								-1		
December	27	.0003	AUM's		-.167										-1	

Table 5. (Continued)

Resources		14 April	15 May	16 June	17 July	18 August	19 September	20 October	21 November	22 December	23 April 1 – May 15 October 1 – 30	24 April	25 May	26 June	27 July	28 August
Cost Row																
Seedable (CW)	1															
Seedable (IW or RW)	2	40.011	15.701	12.501	20.003	20.004	20.005	19.001	17.501	20.011	40.021					
Sprayable	3											34.201	12.9	9.5	17.1	17.101
Aftermath grazing	4															
Good range	5															
Fair range	6															
Poor range	7															
Alfalfa land	8															
Irrigated pasture	9															
Capital	10															
Hay	11															
F.S. grazing permits	12															
BLM grazing permits	13															
Stateland grazing permits	14															
Barley land	15															
January	16															
February	17															
March	18															
April	19	-1									-.4	-1				
May	20		-1								-.2		-1			
June	21			-1										-1		
July	22				-1										-1	
August	23					-1										-1
September	24						-1									
October	25							-1			-.4					
November	26								-1							
December	27									-1						

Table 5. (Continued)

Resources		29 September	30 October	31 November	32 December	33 April 1 – May 15 October 1 – 30	34 Aftermath growing	35 April	36 May	37 June	38 July	39 August	40 September	41 October	42 November	43 December
Cost Row																
Seedable (CW)	1															
Seedable (IW or RW)	2															
Sprayable	3	17.102	14.2	12.4	17.103	34.2										
Aftermath grazing	4						1.001									
Good range	5							11.01	4.0	3.0	5.5	5.501	5.502	4.5	4.01	5.522
Fair range	6															
Poor range	7															
Alfalfa land	8															
Irrigated pasture	9															
Capital	10															
Hay	11															
F.S. grazing permits	12															
BLM grazing permits	13															
Stateland grazing permits	14															
Barley land	15															
January	16															
February	17															
March	18															
April	19					-.4		-1								
May	20					-.2			-1							
June	21									-1						
July	22										-1					
August	23											-1				
September	24	-1					-.187						-1			
October	25		-1			-.4	-.813							-1		
November	26			-1											-1	
December	27				-1											-1

Table 5. (Continued)

Resources		44 April 1 – May 15 October 1 – 30	45 April	46 May	47 June	48 July	49 August	50 September	51 October	52 November	53 December	54 April 1 – May 15 October 1 – 30	55 April	56 May	57 June	58 July
Cost Row																
Seedable (CW)	1															
Seedable (IW or RW)	2															
Sprayable	3															
Aftermath grazing	4															
Good range	5	11.0														
Fair range	6		19.7	7.5	5.6	10.1	10.101	10.102	8.4	7.3	10.103	19.701				
Poor range	7												73.6	26.8	19.9	35.8
Alfalfa land	8															
Irrigated pasture	9															
Capital	10															
Hay	11															
F.S. grazing permits	12															
BLM grazing permits	13															
Stateland grazing permits	14															
Barley land	15															
January	16															
February	17															
March	18															
April	19	-.4	-1									-.4	-1			
May	20	-.2		-1								-.2		-1		
June	21				-1										-1	
July	22					-1										-1
August	23						-1									
September	24							-1								
October	25	-.4							-1			-.4				
November	26									-1						
December	27										-1					

Table 5. (Continued)

Resources		59 August	60 September	61 October	62 November	63 December	64 April 1 – May 15 October 1 – 30	65 Alfalfa	66 Barley on land	67 Irrigated pasture	68 Irrigated pasture	69 June	70 July	71	72 April	73 May
Cost Row														$36.50		
Seedable (CW)	1														5.0	3.5
Seedable (IW or RW)	2															
Sprayable	3															
Aftermath grazing	4															
Good range	5															
Fair range	6															
Poor range	7	35.801	35.802	29.8	25.9	35.803	73.601									
Alfalfa land	8							1.002								
Irrigated pasture	9									1.004	1.005	1.006	1.007			
Capital	10														3.65	2.56
Hay	11							-3	-3.01	-2				.35		
F.S. grazing permits	12															
BLM grazing permits	13															
Stateland grazing permits	14															
Barley land	15								1.003							
Januray	16													1.34		
February	17													1.34		
March	18													1.34		
April	19						-.4							1.34	-1	
May	20						-.2				-1.0			.66		-1
June	21											-1		1.23		
July	22												-1.0	1.60		
August	23	-1												1.97		
September	24		-1											1.97		
October	25			-1			-.4							1.38		
November	26				-1									1.38		
December	27					-1								1.34		

Table 5. (Continued)

Resources		74 June	75 July	76 August	77 September	78 October	79 November	80 December	81 April 1 – May 15 October 1 – 30	82 May	83 June	84 July	85 August	86 September	87 October	88 November
Cost Row																
Seedable (CW)	1	2.5	5.001	5.002	5.003	4.0	3.501	5.004	5.005							
Seedable (IW or RW)	2									3.5012	2.5012	5.02	5.03	5.04	4.5	4.01
Sprayable	3															
Aftermath grazing	4															
Good range	5															
Fair range	6															
Poor range	7															
Alfalfa land	8															
Irrigated pasture	9															
Capital	10	1.82	4.94	4.94	4.94	2.92	2.56	3.65	3.65	2.55	1.82	3.65	3.65	3.65	3.28	2.92
Hay	11															
F.S. grazing permits	12															
BLM grazing permits	13															
Stateland grazing permits	14															
Barley land	15															
January	16															
February	17															
March	18															
April	19								-.4							
May	20								-.2	-1						
June	21	-1									-1					
July	22		-1									-1				
August	23			-1									-1			
September	24				-1									-1		
October	25					-1			-.4						-1	
November	26						-1									-1
December	27							-1								

Table 5. (Continued)

Resources		89 December	90 April	91 May	92 June	93 July	94 August	95 September	96 October	97 November	98 December	99 April 1 – May 15 October 1 – 30	100 August	101 September	102 Irrigated pasture
Cost Row															
Seedable (CW)	1														
Seedable (IW or RW)	2	5.05													
Sprayable	3		11.022	4.033	3.0	5.511	5.512	5.513	4.525	4.011	5.514	11.044			
Aftermath grazing	4														
Good range	5														
Fair range	6														
Poor range	7														
Alfalfa land	8														
Irrigated pasture	9												1.008	1.009	1.0
Capital	10	3.65	4.29	1.56	1.17	2.14	2.14	2.14	1.76	1.56	2.14	4.29			
Hay	11														
F.S. grazing permits	12														
BLM grazing permits	13														
Stateland grazing permits	14														
Barley land	15														
January	16														
February	17														
March	18														
April	19		-1									-.4			
May	20			-1								-.2			-.5
June	21				-1										-1.0
July	22					-1									-1.0
August	23						-1						-1		-1.0
September	24							-1						-1	-.5
October	25								-1			-.4			
November	26									-1					
December	27	-1									-1				

seeding, intermediate wheat seeding, and Russian wildrye seeding are considered on state lands. The equation form of this model is in Appendix B.

Small model 2c

The small model has a matrix of 27 by 102. The matrix is still fairly large for presentation in tabular form, but because of the desirability to present it in order to more clearly show the logic and the coefficients used in the models, it is shown in Table 5.

Grazing permits were used for public grazing on the Forest Service, Bureau of Land Management, and state lands. This technique reduced the constraints from 49 to 27, a substantial saving of space. This, in turn, was largely responsible for reducing the activities from 183 to 102. In addition, activities were dropped that gave different incomes due to spring lambing on seeded and sprayed areas. Also there are no hay or barley selling activities which, as a result, detracts from the flexibility of the ranching operation. One purpose of constructing this small model was to develop a model that would work on the IBM 1620 computer after which the models that were too large for the 1620 computer could be patterned. However, a dual purpose of the small model was to obtain some idea of how grazing permit cuts affected the income of the ranching operation.

Model 3c

There are 2,614 breeding ewes on the modal ranch from which this model was developed. It was similar in most respects to model 1c with few differences, one being that there was no barley raised on the ranch. Also, only crested wheat was used for seeding on Bureau

of Land Management land and both options of seeding (1) crested wheat or (2) intermediate wheat or Russian wildrye were available on state land.

This is the only model that included juniper land that could be chained. Range fertilizing activities are included on this model as they were on model 1c.

The 52 by 188 matrix is included in equation form in Appendix B where more details may be obtained.

Linear Programming Results

For each model there is a basic solution that includes no capital. Then capital, private and public, is added parametrically until a new basic solution is obtained with the optimum amount of capital. As capital is added, the internal rate of return is calculated for each improvement practice to determine the investment opportunities and the rate of return to each. The capitalized value of each of the resources is shown, which provides an estimate of the value of one more unit of a particular resource.

Forest Service permits and irrigated pasture are varied parametrically in small model 2c in order to observe the effect on ranch income. It is also illustrated with large model 2c how the linear program satisfactorily completes requirements of animal units of feeding for each of the 12 months.

Model 1c

The original basis, without capital for improvements is shown in Table 6. The status column shows the used and unused resources, the

Table 6. Original basis showing used and unused resources for model 1c

Resource		Status	Unit	Amount
C04[a]	Aftermath	unused	AUM	124.0
C19	BLM seedable (CW)	unused	acre	846.0
C20	BLM seedable (IW or RW)	unused	acre	999.5
C21	BLM sprayable	unused	acre	231.0
C23	BLM (6"-12" precip.) fair range	unused	acre	983.1
C24	BLM (6"-12" precip.) poor range	unused	acre	4,961.0
C26	BLM (12"-16" precip.) fair range	unused	acre	1,172.0
C27	BLM (12"-16" precip.) poor range	unused	acre	1,240.0
C33	February	unused	AUM	0.0
C34	March	unused	AUM	0.0
C36	April 16-30	unused	AUM	0.0
C38	May 16-31	unused	AUM	0.0
C46	May 1-15[b]	unused	AUM	10.9
C47	May 16-31[b]	unused	AUM	0.0
C49	May 1-15[c]	unused	AUM	0.0
C50	May 16-31[c]	unused	AUM	0.0
C1005[d]	July-pvt. seedable (CW)	used	acre	230.0
C1016	Sept.-pvt. seedable (IW or RW)	used	acre	230.0
C1024	July-pvt. sprayable	used	acre	289.0
C1035	July-pvt. good range	used	acre	101.3
C1036	Aug.-pvt. good range	used	acre	199.6
C1046	Aug.-pvt. fair range	used	acre	330.3
C1047	Sept.-pvt. fair range	used	acre	293.6

[a]Constraint.

[b]Used when there was lambing on seeded ranges.

[c]Used when there was lambing on sprayed ranges.

[d]Activity.

Table 6. Continued

	Resource	Status	Unit	Amount
C1057	Sept.-pvt. poor range	used	acre	1,386.9
C1058	Oct.-pvt. poor range	used	acre	5,249.0
C1062	Alfalfa land @ 4T/acre	used	acre	23.5
C1066	June 15 to Sept. 30,F.S. seedable	used	acre	52.0
C1067	June 15 to Sept. 30,F.S. sprayable	used	acre	471.0
C1068	June 15 to Sept. 30,F.S. good range	used	acre	301.0
C1069	June 15 to Sept. 30,F.S. fair range	used	acre	624.0
C1070	June 15 to Sept. 30,F.S. poor range	used	acre	1,386.9
C1078	Apr. BLM seedable (IW or RW)	used	acre	7,047.4
C1079	May BLM seedable (IW or RW)	used	acre	2,460.2
C1082	Nov. BLM seedable (IW or RW)	used	acre	3,082.4
C1083	Dec. BLM seedable (IW or RW)	used	acre	1,350.9
C1093	Nov. 1 to April 1, BLM (6"-12" precip.) good range	used	acre	564.0
C1095	Nov. 1 to April 1, BLM (6"-12" precip.) fair range	used	acre	4,767.0
C1100	June BLM (12"-16" precip.) good range	used	acre	141.0
C1107	June BLM (12"-16" precip.) fair range	used	acre	266.0
C1119	July 1 to Sept. 30, state land seedable (IW or RW)	used	acre	158.0
C1121	July 1 to Sept. 30, state land good range	used	acre	159.0
C1123	July 1 to Sept. 30, state land fair range	used	acre	796.0
C1125	July 1 to Sept. 30, state land poor range	used	acre	636.8
C1206	$14.95/A.U.	used	A.U.	124.6

Table 6. Continued

Resource		Status	Unit	Amount
C1210	June[b]-pvt. seeded (IW or RW)	used	acre	0.0
C1214	June[b] BLM seeded (IW or RW)	used	acre	0.0
C1215	$34.50/A.U.[b]	used	A.U.	0.0
C1220	$24.73/A.U.[c]	used	A.U.	0.0
C1220	Alfalfa land - hay selling activity	used	acre	25.5
C1222	Irrig. pasture - hay selling activity	used	acre	75.0
C1224	Barley land - barley selling activity	used	acre	37.0

[b]Used when there was lambing on seeded ranges.
[c]Used when there was lambing on sprayed ranges.

used resources being those in the final basis and the unused resources are those not included in the basis. For example, the rancher has more aftermath grazing, C04, than required to support the number of animal units in the solution of the model. Therefore, 124.0 AUM's of this aftermath would go unused. There are more BLM resources, C19 to C27, in this initial solution than the rancher can use. These resources go unused in this solution but are available for use as more animal units are added with various range improvements.

The MVP and the capitalized value of each resource are in Table 7. The resources in Table 6 that were not used have a zero MVP. If he has more of the resource than he can use, it would not be profitable for him to buy more of the resource, therefore, the MVP of these resources is zero. On the other hand, the scarce resources have non-zero MVPs, the highest being alfalfa land, no. 8, with an MVP of

Table 7. The MVP's and capitalized values of ranch resources for model 1c

Resources	Unit	MVP	Capitalized value[ab]
1. Seedable (CW)	acre	.062	1.24
2. Seedable (IW or RW)	acre	.062	1.24
3. Sprayable	acre	.073	1.46
4. Aftermath	AUM	.000	--
5. Private - good range	acre	.224	4.48
6. Private - fair range	acre	.122	2.44
7. Private - poor range	acre	.034	.68
8. Private - alfalfa land	acre	42.840	856.80
9. Private - irrig. pasture	acre	21.420	428.40
10. Private - barley land	acre	36.550	731.00
11. Private capital	dol.	8.447	--
12. Public capital	dol.	8.532	--
13. Private hay	tons	10.710	--
14. F.S. - seedable	acre	.100	2.00
15. F.S. - sprayable	acre	.118	2.36
16. F.S. - good range	acre	.441	8.82
17. F.S. - fair range	acre	.246	4.92
18. F.S. - poor range	acre	.086	1.72
19. BLM - seedable (CW)	acre	.000	--
20. BLM - seedable (IW or RW)	acre	.000	--
21. BLM - sprayable	acre	.000	--

[a]Capitalized at a rate of 5 percent.

[b]Capitalized value of ranch is $118,283.40 based on annual return of $5914.17.

Table 7. Continued

Resources	Unit	MVP	Capitalized value
22. 6" - 12" precip. - good range	acre	.000	--
23. 6" - 12" precip. - fair range	acre	.000	--
24. 6" - 12" precip. - poor range	acre	.000	--
25. 12" - 16" precip. - good range	acre	.000	--
26. 12" - 16" precip. - fair range	acre	.000	--
27. 12" - 16" precip. - poor range	acre	.000	--
28. State land - seedable	acre	.053	1.06
29. State land - good range	acre	.196	3.92
30. State land - fair range	acre	.109	2.18
31. State land - poor range	acre	.034	.68
32. January	AUM	.000	--
33. February	AUM	.000	--
34. March	AUM	.000	--
35. April 1 - 15	AUM	.000	--
36. April 16 - 30	AUM	.000	--
37. May 1 - 15	AUM	.000	--
38. May 16 - 31	AUM	.000	--
39. June	AUM	.000	--
40. July	AUM	1.233	--
41. August	AUM	1.233	--
42. September	AUM	1.233	--
43. October	AUM	.000	--
44. November	AUM	.000	--
45. December	AUM	.000	--

Table 7. Continued

Resources	Unit	MVP	Capitalized value
46. May 1 - 15	AUM	.000	--
47. May 16 - 31	AUM	.000	--
48. June	AUM	15.528	--
49. May 1 - 15	AUM	.000	--
50. May 16 - 31	AUM	.000	--
51. June	AUM	7,768	--

$42.84 per acre annually. The capitalized values, at 5 percent interest, have a range of $856.80 per acre of alfalfa land to $0.68 per acre of either private or state poor range land.

The addition of private and public capital

Private capital was added first to an optimum, then that amount was entered as a private capital constraint and public capital was added until its MVP got below one dollar. As each increment of capital was added, the internal rate of return was calculated for the improvement practices that the addition of capital made possible.

The internal rate of return can be used as a criterion for deciding whether or not to invest in range improvements. If the rancher has several alternative uses for his capital, he can determine the internal rate of return for each alternative and invest his capital on those projects with the highest return.

To determine the optimum amount of capital to be invested in model 1c was no problem because the internal rate of return remained above 16 percent up through the final optimum stage. It is shown in Table

8 that the internal rate of return for an annual investment of $194.40 was 42 percent. As the investment was increased by $92.72 the internal rate of return decreased to 17 percent. The internal rate of return gradually declines as capital is added until stage 5 where it jumps from 16 percent to 20 percent. The reason for this is that the $112.02 spent between stages four and five were spent on spraying instead of seeding as was the previous money. Because spraying has a life of 12 years in this study and seeding 20 years, the time element made the difference in the internal rate of return. The reason the rate of return is higher for spraying than for seeding is that money is tied up for a shorter period of time for a given amount of return. The linear programming models developed in this study are static, i.e., time is not taken into account directly in the models. However, the information shown in Table 8 can be used to make investment decisions. If the rancher considers a 16 percent return adequate he would make the maximum investment of $448.28 annually.

If it is desired to have the computer do this selection automatically, the model would need to be altered so that all the costs of improvements are in the cost row. Also, the costs would need to be discounted to obtain the true costs over time. These costs would be larger than those presently used in the model due to the time element included. Another requirement for the use of this technique would be the choice of the interest rate considered necessary for the money invested.

Stage 6 in Table 8 is used to illustrate what happens to the MVP's after a solution is reached by the linear programs. The solution reached in stage 5 has an annual investment of private capital of

Table 8. Results of parametric programming of private capital from 0 up for model 1c

	Levels of investment					
	(1) 0	(2) $194.40	(3) $287.12	(4) $336.26	(5) $448.28	(6) $448.28
MVP of private capital	8.45	3.46	3.40	2.66	.43	.00
Annual return	5914.20	6587.20	6908.30	7074.90	7372.82	7372.83
Internal rate of return	--	42%	17%	16%	20%	<0%
Seeding (CW) - acres May	--	155.54	230.01	230.01	230.01	230.01
Seeding (IW or RW) - acres June	--	111.00	163.95	191.45	191.45	191.38
May	--	--	--	38.46	38.46	38.46
Sprayed - acres May	--	--	--	--	165.44	165.44
June	--	--	--	--	123.56	123.56

$448.28. However, with an additional investment of a fraction of one penny the MVP dropped from .43 to 0 with the internal rate of return being negative in both cases. The internal rate of return on private capital never got below 16 percent as the investment was increased to $448.28. Therefore, $448.28 of private capital was put in the model as available private capital and public capital was increased parametrically.

The internal rate of return ranged from 17 percent to 6.23 percent, Table 9. Since the internal rate of return did not fall below 5 percent during the addition of private or public capital for model 1c, the final solution reached by the computer was used in both cases.

Table 9. Parametric increase of public capital after private capital, $448.28, was entered as a constraint for model 1c

	Levels of investment								
	(1) 0	(2) $1.38	(3) $131.98	(4) $344.63	(5) $549.33	(6) $729.54	(7) $781.00	(8) $1,086.48	(9) $1,115.64
MVP of public capital	3.557	3.547	3.547	3.481	2.449	2.449	2.105	1.773	.00
Annual return	7372.83	7377.76	7840.98	8581.21	9293.68	9735.06	9861.06	10,446.27	10,490.03
Internal rate of return	--	17.06%	17.02%	17.02%	16.64%	10.66%	10.66%	8.49%[a] 13.85%[b]	6.23%
BLM seeded (CW)- acres June	--	1.91	76.78	165.36	250.60	349.04	306.45	208.63	167.87
May	--	--	104.63	228.36	347.45	496.66	539.28	637.10	677.89
BLM seeded (IW or RW) - acres June	--	--	--	--	--	--	70.42	237.60	250.42
BLM sub-total	--	1.91	181.41	393.72	598.05	845.70	916.15	1,083.33	1,906.78
State land (IW or RW) - acres July, Aug. & Sept.	--	--	--	80.50	158.01	158.01	158.01	158.01	158.01
F.S. seeded-acres July, Aug. & Sept.	--	--	--	--	--	--	--	--	26.93
Total seeded-acres	--	1.91	181.41	474.22	756.06	1003.71	1074.16	1,241.34	1,281.12
F.S. sprayed-acres July, Aug. & Sept.	--	--	--	--	--	--	--	470.99	470.99

[a]Internal rate of return when seeding.

[b]Internal rate of return when spraying.

However, the individual rancher has to decide for himself the rate of return he requires for money invested.

Stage 8 in Table 9 shows two rates of return. The 8.49 percent is the return to seeding and the 13.85 percent is the return to spraying. Due to the insensitivity of the model to the time element involved, the spraying with a return of 13.85 percent was not properly placed immediately after stage 5, the seeding practice that returned a rate of 16.64 percent to the money invested.

Optimal basis after capital has been added

Table 10 shows the solution of the model with $448.28 of private capital and $1,115.64 of public capital invested annually. The improvement practices included in the final basis are those in stage 9 of Table 9 and stage 5 of Table 8 with rearrangements according to dates of grazing the seeded land. The improvement practices on private land in Table 10 are items C1157, C1207, and C1210. The improvement practices of public land in Table 10 are items C1165, C1166, C1186, C1211, C1212, and C1214.

Breeding ewes were allowed to enter the model under three different situations (activities): (1) the requirements and return per A.U. of livestock under a normal ranch operation, (2) the requirements and increased returns per A.U. when the ewes were grazed on seeded ranges during May and June during the spring of the year, and (3) the requirements and an increased return because ewes were grazed in sprayed ranges during May and June. The activity which included the requirements and increased return per A.U. when ewes were grazed on seeded ranges during May and June, C1215, is the activity exclusively used in the solution.

The resources are more completely used after capital is added, Table 11. The MVP's have many more zero values than the basis before

Table 10. Basis showing used and unused resources after private and public capital[a] has been added to the optimum amounts for model 1c

	Resources	Status	Unit	Amount
C04[b]	Aftermath grazing	unused	AUM	124.0
C20	BLM seedable (IW or RW)	unused	acre	4909.8
C21	BLM sprayable	unused	acre	231.0
C25	BLM (12" - 16" precip.) good range	unused	acre	141.0
C26	BLM (12" - 16" precip.) fair range	unused	acre	1438.0
C27	BLM (12" - 16" precip.) poor range	unused	acre	1240.0
C33	February	unused	AUM	0.0
C34	March	unused	AUM	0.0
C36	April 16 - 30	unused	AUM	0.0
C37	May 1 - 15	unused	AUM	0.0
C38	May 16 - 31	unused	AUM	0.0
C39	June	unused	AUM	54.8
C46	May 1 - 15[c]	unused	AUM	179.3
C49	May 1 - 15[d]	unused	AUM	0.0
C50	May 16 - 31[d]	unused	AUM	0.0
C51	June[d]	unused	AUM	0.0
C1035[e]	July-pvt. good range	used	acre	91.2
C1036	Aug.-pvt. good range	used	acre	209.8
C1046	Aug.-pvt. fair range	used	acre	56.0

a	Levels of investment	Rate of return
private	$ 448.28	16-20%
public	1,115.64	6.23%

[b]Constraint.

[c]Used when there was lambing on seeded ranges.

[d]Used when there was lambing on sprayed ranges.

[e]Activity.

Table 10. Continued

	Resources	Status	Unit	Amount
C1047	Sept.-pvt. fair range	used	acre	568.0
C1055	July-pvt. poor range	used	acre	0.0
C1057	Sept.-pvt. poor range	used	acre	1386.9
C1058	Oct.-pvt. poor range	used	acre	8663.8
C1062	Alfalfa land - 1 acre @ 4T	used	acre	38.8
C1066	June 15 to Sept. 30, F.S. seedable	used	acre	25.1
C1068	June 15 to Sept. 30, F.S. good range	used	acre	301.0
C1069	June 15 to Sept. 30, F.S. fair range	used	acre	624.0
C1070	June 15 to Sept. 30, F.S. poor range	used	acre	1386.9
C1078	Apr. BLM seedable (IW or RW)	used	acre	11,632.1
C1082	Nov. BLM seedable (IW or RW)	used	acre	5087.8
C1083	Dec. BLM seedable (IW or RW)	used	acre	2229.9
C1093	Nov. 1 to Apr. 1, BLM (6" - 12" precip.) good range	used	acre	564.0
C1095	Nov. 1 to Apr. 1, BLM (6" - 12" precip.) fair range	used	acre	5750.0
C1097	Nov. 1 to Apr. 1, BLM (6" - 12" precip.) poor range	used	acre	4961.1
C1121	July, Aug., Sept. S.L. good range	used	acre	159.0
C1123	July, Aug., Sept. S.L. fair range	used	acre	796.0
C1125	July, Aug., Sept. S.L. poor range	used	acre	636.8
C1134	July-pvt. fertilizing (IW or RW)	used	acre	0.4
C1157	Aug.-pvt. sprayed	used	acre	288.9
C1165	July, Aug., Sept. F.S. seeded	used	acre	26.9
C1166	July, Aug., Sept. F.S. sprayed	used	acre	471.0
C1186	July, Aug., Sept. S.L. seeded (IW or RW)	used	acre	158.0

Table 10. Continued

Resources		Status	Unit	Amount
C1207	May[c] seeded (CW)	used	acre	230.0
C1210	June-pvt. seeding (IW or RW)	used	acre	229.5
C1211	May[c] BLM seeded (CW)	used	acre	677.9
C1212	June[c] BLM seeded (CW)	used	acre	167.9
C1214	June[c] BLM seeded (IW or RW)	used	acre	250.4
C1215	$34.50/A.U.	used	A.U.	205.6
C1221	Alfalfa land - hay selling activity	used	acre	10.2
C1222	Irrig. pasture - hay selling activity	used	acre	75.0
C1224	Barley land - barley selling activity	used	acre	37.0

[c]Used when there was lambing on seeded ranges.

Table 11. The MVP's and capitalized[a] values of resources after private and public capital[b] has been added to the optimum amounts for model 1c

Resources	Unit	MVP	Capitalized value[ac]
1. Seedable (CW)	acre	.000	--
2. Seedable (IW or RW)	acre	.000	--
3. Sprayable	acre	.000	--
4. Aftermath	AUM	.000	--
5. Good range	acre	.000	--
6. Fair range	acre	.000	--
7. Poor range	acre	.000	--
8. Alfalfa land	acre	42.840	856.80
9. Irrig. pasture	acre	21.420	428.40
10. Barley land	acre	36.550	731.00
11. Pvt. capital	dol.	.000	--
12. Public capital	dol.	.000	--
13. Hay	Tons	10.710	--
14. F.S. - seedable	acre	.000	--
15. F.S. - sprayable	acre	.000	--
16. F.S. - good range	acre	.000	--
17. F.S. - fair range	acre	.000	--
18. F.S. - poor range	acre	.000	--
19. BLM - seedable (CW)	acre	.000	--

[a]Capitalized at a rate of 5 percent.

[b]

	Levels of investment	Rate of return
Private	$ 488.28	16-20%
Public	1,115.64	6.23%

[c]Capitalized value of ranch is $209,800.60 based on an annual income of $10,490.03.

Table 11. Continued

Resources	Unit	MVP	Capitalized value
20. BLM - seedable (IW or RW)	acre	.000	--
21. BLM - sprayable	acre	.000	--
22. 6" - 12" precip. - good range	acre	1.101	22.02
23. 6" - 12" precip. - fair range	acre	.560	11.20
24. 6" - 12" precip. - poor range	acre	.321	6.42
25. 12" - 16" precip. - good range	acre	.000	--
26. 12" - 16" precip. - fair range	acre	.000	--
27. 12" - 16" precip. - poor range	acre	.000	--
28. State land - seedable (IW or RW)	acre	.000	--
29. State land - good range	acre	.000	--
30. State land - fair range	acre	.000	--
31. State land - poor range	acre	.000	--
32. January	AUM	30.291	--
33. February	AUM	.000	--
34. March	AUM	.000	--
35. April 1 - 15	AUM	.000	--
36. April 16 - 30	AUM	.000	--
37. May 1 - 15	AUM	.000	--
38. May 16 - 31	AUM	.000	--
39. June	AUM	.000	--
40. July	AUM	.000	--
41. August	AUM	.000	--
42. September	AUM	.000	--
43. October	AUM	.000	--

Table 11. Continued

Resources	Unit	MVP	Capitalized value
44. November	AUM	.000	--
45. December	AUM	.000	--
46. May 1 - 15[a]	AUM	.000	--
47. May 16 - 31[a]	AUM	.000	--
48. June[a]	AUM	.000	--
49. May 1 - 15[b]	AUM	.000	--
50. May 16 - 31[b]	AUM	.000	--
51. June[b]	AUM	.000	--

[a]Capitalized at a rate of 5 percent.

[b]

	Levels of investment	Rate of return
Private	$ 488.28	16-20%
Public	1,115.64	6.23%

capital is added, which indicates fewer scarce resources and more complete utilization of existing ones. The resources that are still scarce are mainly those used for producing products sold off the ranch, i.e., alfalfa land, irrigated pasture used for producing hay, and barley land.

The annual income from the ranch after the improvement practices have been added is $10,490.03. Capitalizing this annual income at a rate of 5 percent gives a ranch value of $209,800.60. This is a substantial increase over the value before adding improvement practices. At that time there was an annual income of $5,914.17 capitalized to a ranch value of $118,283.43, shown in Table 7.

Model 2c

The two sizes of model 2c, small and large, presented here each fills a different purpose. The small model illustrates how changes in Forest Service permits affect income where the large one illustrates how government land improvements affect income.

Small model 2c

First the original basis, previous to adding capital, will be discussed followed by the addition of capital and then the basis after capital has been added to the optimum amount. In addition, Forest Service grazing permits and irrigated pasture will be varied parametrically.

Original basis. The original basis of small model 2c before capital is added is in Table 12. There are three resources that are not used completely in the model partly due to the fact that alfalfa selling or barley selling activities were not included in the model and all products were used as intermediate products for the production of sheep. The unused 73 acres of alfalfa land and 2.12 acres of barley land fall into this category. The 303.7 BLM permits represent excess grazing for a given season of the year. The other available resources limit further increases in the breeding herd. The resources are used efficiently on this particular ranch. Number C1071 indicates the number of animal units of breeding ewes (5 ewes per A.U.), 276.4, that the ranch will support with the available resources. Again, this is on a what-ought-to-be basis rather than what-is, whereas the $36.50/A.U. was calculated from a what-is basis. If the ranch were actually producing on a what-ought-to-be basis, the $36.50/A.U. would probably increase significantly.

Table 12. Original basis showing used and unused resources for small model 2c

	Resources	Status	Unit	Amount
C08[a]	Alfalfa land	unused	acre	73.0
C13	BLM permits	unused	AUM	303.7
C15	Barley land	unused	acre	2.1
C16	January	unused	AUM	0.0
C17	February	unused	AUM	0.0
C18	March	unused	AUM	0.0
C19	April	unused	AUM	0.0
C26	November	unused	AUM	0.8
C1001[b]	F.S. permits[c]	used	AUM	642.6
C1002	BLM permits[d]	used	AUM	2,218.0
C1003	State land permits[e]	used	AUM	626.8
C1008	Aug. - seedable (CW)	used	acre	555.0
C1019	Sept. - seedable (IW or RW)	used	acre	555.0
C1028	Aug. - sprayable	used	acre	102.3
C1029	Sept. - sprayable	used	acre	567.9
C1034	Aftermath - Sept. and Oct.	used	AUM	154.8
C1036	May - good range	used	acre	321.1
C1037	June - good range	used	acre	239.7
C1038	July - good range	used	acre	306.6
C1039	Aug. - good range	used	acre	93.6
C1049	Aug. - fair range	used	acre	773.2

[a]Constraint.

[b]Activity.

[c]Season is for July, Aug., and Sept.

[d]Season is for Nov., Dec., Jan., Feb., March, and April.

[e]Season is for May, June, July, Aug., Sept., Oct., and Nov.

Table 12. Continued

Resources		Status	Unit	Amount
C1051	Oct. - fair range	used	acre	525.8
C1060	Sept. - poor range	used	acre	3,324.7
C1066	Barley land for alfalfa	used	acre	31.8
C1071	$36.50/A.U.	used	A.U.	276.4
C1095	Sept. - sprayed	used	acre	25.7
C1102	Irrig. pasture for season	used	acre	99.0

The MVP and capitalized value of each resource are in Table 13. The MVP of alfalfa land, BLM permits, and barley land are zero since these resources do not restrict production. A rancher would not be willing to buy more of these resources until he used what he already has available.

The addition of private capital. Only private capital is added to this model because public grazing is handled on a permit basis. Capital was added parametrically until its MVP became zero, Table 14. The internal rate of return is calculated for each improvement practice so one can see how good his investment possibilities are. When this is done, the rational investment stages are the first four which have a rate of return of 8 percent. The assumption is made that 8 percent return is good enough in this case and that the rancher will invest $270.17 annually. The rancher would spray 331.81 acres for September grazing and 363.83 acres for August grazing as shown in stage 4.

Optimal basis after capital has been added. The addition of the capital has allowed the rancher to spray a total of 696 acres and brought 93 additional BLM permits into use. These changes are in Table 15. BLM

Table 13. The MVP's and capitalized values of ranch resources for small model 2c

	Resources	Unit	MVP	Capitalized value[ab]
1.	Seedable (CW)	acre	.251	5.02
2.	Seedable (IW or RW)	acre	.251	5.02
3.	Sprayable	acre	.294	5.88
4.	Aftermath	AUM	2.636	52.72
5.	Good range	acre	.913	18.26
6.	Fair range	acre	.487	9.94
7.	Poor range	acre	.400	2.80
8.	Alfalfa land	acre	.000	--
9.	Irrig. pasture	acre	17.128	342.56
10.	Capital	dol.	1.591	--
11.	Hay	tons	.000	--
12.	F.S. permits	AUM	4.975	99.50
13.	BLM permits	AUM	.000	--
14.	State land permits	AUM	3.511	70.22
15.	Barley land	acre	.000	--
16.	January	AUM	.000	--
17.	February	AUM	.000	--
18.	March	AUM	.000	--
19.	April	AUM	.000	--
20.	May	AUM	3.654	--
21.	June	AUM	2.740	--

[a]Capitalized at a rate of 5 percent.

[b]Capitalized value of ranch is $201,784.80 based on an annual income of $10,089.24.

Table 13. Continued

	Resources	Unit	MVP	Capitalized value
22.	July	AUM	5.024	--
23.	August	AUM	5.025	--
24.	September	AUM	5.025	--
25.	October	AUM	2.089	--
26.	November	AUM	.000	--
27.	December	AUM	.000	--

permits not used are shown in item C13. August spraying used and September spraying used are shown in items C1094 and C1095 respectively.

Table 16 indicates the capitalized value of the ranch is now $210,064.60 as compared to $201,784.80 before the improvement practices were added. The MVP's have all remained unchanged with the exception of capital, which has dropped from $1.59 to $1.16, row 10.

Decreasing Forest Service grazing permits. The effect of decreasing government grazing permits upon ranchers' operations are of interest to many people. Reducing Forest Service grazing permits provides an overall picture of the actual economic situation the ranch experiences as permits are reduced through four stages. The ranch has 642.6 AUM's of permits in the first stage, Table 17. Under this situation the ranch unit has an annual income of $10,094.24. When the Forest Service grazing permits are reduced by 96.3 AUM's to a total of 546.3, the annual income is reduced $483.63 to $9,605.61. As Forest Service permits are reduced, the use of Bureau of Land Management grazing permits also drops 108 AUM's as shown in item C1002. There are also other adjustments in the

Table 14. Results of parametric programming of public capital from 0 up for small model 2c

	Levels of investment						
	(1) $9.99	(2) $97.07	(3) $151.96	(4) $270.17	(5) $337.01	(6) $454.06	(7) $480.01
MVP of private capital	1.59	1.59	1.59	1.16	1.16	1.09	1.09
Annual income	10,089.20	10,227.80	10,315.10	10,503.20	10,580.80	10,716.70	10,745.00
Internal rate of return	--	8%	8%	8%	1%	1%	<1%
Sprayed - acres							
Sept.	25.73	249.93	275.89	331.81	354.90	395.29	412.86
Aug.	--	--	115.38	363.83	340.79	300.35	282.83
July	--	--	--	--	--	--	--
Total acres sprayed	--	--	391.27	695.74	695.69	695.64	695.69
Seeded (CW) - acres							
June	--	--	--	--	91.78	252.60	255.00
May	--	--	--	--	--	--	--
July	--	--	--	--	--	--	--
Seeded (IW or RW) - acres							
May	--	--	--	--	--	--	33.18
July	--	--	--	--	--	--	--
June	--	--	--	--	--	--	--
Total acres seeded	--	--	--	--	91.78	252.60	288.18

Table 14. Continued

	Levels of investment					
	(8) $591.65	(9) $718.84	(10) $886.51	(11) $1,078.76	(12) $1,142.20	(13) $1,192.25
MVP of private capital	1.09	1.09	1.04	.01	.01	.00
Annual income	10,867.00	11,005.59	11,180.70	11,380.20	11,381.10	11,381.70
Internal rate of return	<1%	<1%	<1%	<1%	<0%	<0%
Sprayed - acres						
Sept.	488.57	574.75	358.98	435.62	435.95	--
Aug.	207.12	120.89	336.72	260.07	259.74	559.49
July	--	--	--	--	--	136.26
Total acres sprayed	695.69	695.64	695.70	695.69	695.69	695.75
Seeded (CW) - acres						
June	265.28	276.98	291.70	308.52	308.58	116.62
May	--	--	--	246.47	--	--
July	--	--	--	--	246.35	438.30
Seeded (IW or RW) - acres						
May	176.16	339.01	350.04	116.20	362.74	362.78
July	--	--	204.82	438.75	192.12	--
June	--	--	--	--	--	192.00
Total acres seeded	441.40	615.99	846.56	1,109.94	1,109.79	1,109.70

Table 15. Basis showing used and unused resources after private capital[a] has been added to the optimum amount for small model 2c

Resource		Status	Unit	Amount
C08[b]	Alfalfa land	unused	acre	73.0
C13	BLM permits	unused	AUM	210.8
C15	Barley land	unused	acre	0.8
C16	January	unused	AUM	0.0
C17	February	unused	AUM	0.0
C18	March	unused	AUM	0.0
C19	April	unused	AUM	0.0
C26	November	unused	AUM	0.4
C1001[c]	July-Aug-Sept. F.S. permits	used	AUM	642.6
C1102	Nov-Apr. BLM permits	used	AUM	2,309.0
C1003	State land permits	used	AUM	626.8
C1008	Aug. seedable (CW)	used	acre	555.0
C1019	Sept. seedable (IW or RW)	used	acre	555.0
C1034	Sept-Oct. aftermath	used	AUM	154.8
C1036	May good range	used	acre	351.1
C1037	June good range	used	acre	281.6
C1038	July good range	used	acre	328.4
C1048	July fair range	used	acre	143.1
C1049	Aug. fair range	used	acre	564.2
C1051	Oct. fair range	used	acre	591.5
C1060	Sept. poor range	used	acre	3,324.7
C1066	Barley land for alfalfa	used	acre	33.1
C1071	$36.50/A.U.	used	A.U.	287.8
C1074	June seeded (CW)	used	acre	0.0
C1094	Aug. sprayed	used	acre	363.8
C1095	Sept. sprayed	used	acre	331.8
C1102	May-Sept. irrig. pasture	used	acre	99.0

[a]

	Level of investment	Rate of return
private	$270.17/yr.	8%

[b]Constraint.

[c]Activity.

Table 16. The MVP's and capitalized values of resources after private capital[a] has been added to the optimum amount for small model 2c

	Resources	Unit	MVP	Capitalized value[bc]
1.	Seedable (CW)	acre	.251	5.02
2.	Seedable (IW or RW)	acre	.251	5.02
3.	Sprayable	acre	.461	9.22
4.	Aftermath	acre	2.635	52.70
5.	Good range	acre	.913	18.26
6.	Fair range	acre	.497	9.94
7.	Poor range	acre	.140	2.80
8.	Alfalfa land	acre	.000	--
9.	Irrig. pasture	acre	17.128	342.56
10.	Capital	dol.	1.161	--
11.	Hay	tons	.000	--
12.	F.S. permits	AUM	4.975	99.50
13.	BLM permits	AUM	.000	--
14.	State land permits	AUM	3.511	70.22
15.	Barley land	acre	.000	--
16.	January	AUM	.000	--
17.	February	AUM	.000	--
18.	March	AUM	.000	--
19.	April	AUM	.000	--
20.	May	AUM	3.654	--
21.	June	AUM	2.740	--
22.	July	AUM	5.024	--
23.	August	AUM	5.024	--
24.	September	AUM	5.025	--
25.	October	AUM	2.089	--
26.	November	AUM	.000	--
27.	December	AUM	.000	--

[a]

	Level of investment	Rate of return
private	$270.17/yr.	8%

[b]Capitalized at a rate of 5 percent.

[c]Capitalized value of ranch is $210,064.60 based on an annual income of $10,503.23.

Table 17. Decreasing Forest Service grazing permits from 642.6 to .8 AUM's in four stages with the optimal solution at each stage for small model 2c[a]

				C1001 Forest Service permits (AUM's)			
				(1)	(2)	(3)	(4)
		Status	Unit	642.6	546.3	170.7	.8
	Annual return			$10,089.24	$9,605.61	$7,718.20	$6,777.97
	Alfalfa land	unused	acre	73.00	73.00	73.00	73.00
C03	BLM permits	unused	AUM	303.70	412.10	835.30	1,046.12
C13	Barley land	unused	acre	2.10	3.60	9.70	12.70
C1002	BLM permits	used	AUM	2,218.00	2,111.60	1,696.70	1,490.00
C1003	State land permits	used	AUM	626.80	626.80	626.80	626.80
C1008	Aug. seedable (CW)	used	acre	555.00	555.00	555.00	555.00
C1019	Sept. seedable (IW or RW)	used	acre	555.00	555.00	555.00	555.00
C1028	Aug. sprayable	used	acre	102.26	--	--	--
C1029	Sept. sprayable	used	acre	567.89	670.15	670.15	670.15
C1034	Aftermath	used	AUM	154.80	154.80	154.80	154.80
C1036	May good range	used	acre	321.12	286.12	286.12	286.12
C1037	June good range	used	acre	239.70	190.80	--	--
C1038	July good range	used	acre	306.60	366.40	600.00	684.80
C1039	Aug. good range	used	acre	93.60	117.60	211.30	194.60
C1049	Aug. fair range	used	acre	773.16	849.92	913.75	1,003.74
C1051	Oct. fair range	used	acre	525.24	448.98	149.27	--
C1060	Sept. poor range	used	acre	3,324.75	3,324.75	3,324.75	3,324.75
C1066	Barley land for alfalfa	used	acre	31.81	30.27	24.26	21.26
C1095	Sept. sprayed	used	acre	25.73	25.73	25.73	25.73
C1102	Irrig. past, for full seas.	used	acre	99.00	99.00	99.00	99.00
C1050	Sept. fair range	used	acre	--	--	235.84	295.12
C1071	A.U.'s of breeding ewe[b]			276.40	263.20	211.50	185.70

[a]These bases have no private capital included.

[b]1 A.U. = 5 breeding ewes. 1 A.U. returns $36.50/year.

basis as the linear program adjusts to the new situation in order to reach an optimum solution. In stage 3 the Forest Service permit level has fallen to 170.7 AUM's the annual income is $7,718.20. In the final stage there are essentially no AUM's of Forest Service permits. The annual income is $6,777.97 with 728 AUM's reduction in use of BLM permits as compared to stage one. This is an indication that the reduction of Forest Service grazing permits is not only a loss in itself but that other ranch resources may be caused to lie idle, necessitating management changes which may be costly or impossible for a given rancher to accomplish.

Table 18 gives an illustration of the effect on ranch value as the permits are reduced. The capitalized value of the ranch before permit reduction is $201,784.80. As the reductions take place, the value of the ranch falls until the last stage in which there are no Forest Service permits and the ranch value is $135,559.40, a total drop in value of $66,225.40.

The capitalized value of the Forest permits stayed at $99.50 through the first two stages of permit reductions and then increased to $109.62 and $120.06 in the last two stages. The value of a grazing permit to a rancher varies, depending on the quantity of permits already on hand as related to the other ranch resources. Thus, a parametric variation of any resource could give the ranch an idea of how much of the resource he should purchase and how much he could afford to pay for it.

Increasing Forest Service grazing permits. There are some ranchers that find themselves in a position to be able to acquire additional grazing permits. A rancher could get an idea of how this would effect his ranch by increasing grazing permits parametrically. The starting condition consisted of 642.6 permits followed by the addition of four

Table 18. Decreasing Forest Service permits from 642.6 AUM's to .8 AUM's and showing the MVP's and capitalized values[ab] for resources in each of the four optimal stages for small model 2c[c]

			Forest Service permits (AUM's)			
			(1) 642.6		(2) 546.3	
	Resources	Unit	MVP	Capitalized value	MVP	Capitalized value
1.	Seedable (CW)	acre	.251	5.02	.251	5.02
2.	Seedable (IW or RW)	acre	.251	5.02	.251	5.02
3.	Sprayable	acre	.294	5.88	.294	5.88
4.	Aftermath	AUM	2.636	52.72	2.636	52.72
5.	Good range	acre	.913	18.26	.913	18.26
6.	Fair range	acre	.497	9.94	.497	9.94
7.	Poor range	acre	.140	2.80	.140	2.80
8.	Alfalfa land (free resource)					
9.	Irrig. pâsture	acre	17.128	342.54	17.127	342.54
10.	Pvt. capital	dol.	1.591	31.82	1.591	31.82
11.	Hay (free resource)					
12.	BLM permits (free resource)					
13.	State land permits	AUM	3.511	70.22	3.511	70.22
14.	Barley land (free resource)					
15.	January (free resource)					
16.	February (free resource)					
17.	March (free resource)					
18.	April (free resource)					
19.	May	AUM	3.654	--	3.654	--
20.	June	AUM	2.740	--	2.740	--
21.	July	AUM	5.024	--	5.024	--
22.	August	AUM	5.025	--	5.024	--
23.	September	AUM	5.025	--	5.025	--
24.	October	AUM	2.089	--	2.089	--
25.	November (free resource)					
26.	December (free resource)					
27.	F.S. permits	AUM	4.975	99.50	4.975	99.50

[a]Capitalized at a rate of 5 percent.

[b]The annual ranch income and capitalized ranch values for each of the four permit levels are (1) annual income = $10,089.24, capitalized value = $201,784.80, (2) annual income = $9,605.61, capitalized value = $192,112.20, (3) annual income = $7,718.20, capitalized value = $154,364.00, (3) annual income = $6,777.97, capitalized value = $135,559.40.

[c]These bases have no private capital included.

Table 18. Continued

	Resources	Unit	Forest Service permits (AUM's) (3) 170.7 MVP	Capitalized value	(4) .8 MVP	Capitalized value
1.	Seedable (CW)	acre	.277	5.54	.303	6.06
2.	Seedable (IW or RW)	acre	.277	5.54	.303	6.06
3.	Sprayable	acre	.324	6.48	.355	7.10
4.	Aftermath	AUM	2.904	58.08	1.133	22.66
5.	Good range	acre	1.006	20.12	1.102	20.40
6.	Fair range	acre	.548	10.96	.600	12.00
7.	Poor range	acre	.155	3.10	.169	3.38
8.	Alfalfa land (free resource)					
9.	Irrig. pasture	acre	15.851	317.02	17.362	347.24
10.	Pvt. capital	dol.	1.753	35.06	1.920	38.40
11.	Hay (free resource)					
12.	BLM permits (free resource)					
13.	State land permits	AUM	3.115	62.30	2.903	58.06
14.	Barley land (free resource)					
15.	January (free resource)					
16.	February (free resource)					
17.	March (free resource)					
18.	April (free resource)					
19.	May	AUM	4.025	--	4.409	--
20.	June	AUM	--	--	--	--
21.	July	AUM	5.535	--	6.062	--
22.	August	AUM	5.536	--	6.063	--
23.	September	AUM	5.536	--	6.064	--
24.	October	AUM	2.302	--	--	--
25.	November (free resource)					
26.	December (free resource)					
27.	F.S.permits	AUM	5.481	109.62	6.003	120.06

successive increments until the final optimum stage in which a total of 912.6 AUM's of Forest Service grazing permits are used by the ranch. The increase of 270 permits changed the annual income from $10,089.24 to $11,443.57, a total increase of $1,354.33.

As the permits were increased, the utilization of previously unused resources increased. In the first stage there is an excess of 303.7 BLM permits, and in the fourth stage they are all used. Increased use is made of the alfalfa land and barley land. The animal units of breeding ewe, item C1071, produced by the ranch increased from 276.4 to 313.5 with the increase of Forest Service permits.

The value of the ranch shown in Table 20 increased from $201,784.80 to $228,871.40 through the five stages. The capitalized value of the Forest Service permits, item 12, remained at $99.50 through the first three stages then fell to $87.48 and $75.28 in the last two. One more increase in quantity of Forest Service permits would have dropped their value to zero. The BLM permits take on value in the last two stages as they become scarce. Irrigated pasture remains at $300 in value for all stages with the exception of the last one when it drops to $259.16 per acre. All the other resources hold about the same value until the number of Forest Service permits reach an optimum, and then they drop in value.

Increasing irrigated pasture. With a reduction of government grazing permits, ranchers are forced to consider increasing the carrying capacity of their private land. Increasing the amount of irrigated pasture is an alternative for some of them. Irrigated pasture is increased through seven successive stages from 99 acres to approximately 178 acres. The resulting bases for these seven stages are shown in Table 21.

Table 19. Increasing Forest Service permits from 642.6 AUM's to 912.6 AUM's with the optimal basis[a] at each of the five stages for small model 2c

				C1001 Forest Service permits (AUM's)				
				(1)	(2)	(3)	(4)	(5)
		Status	Unit	642.6	773.1	797.4	908.8	912.6
	Annual return			$10,089.24	$10,744.99	$10,867.02	$11,426.86	$11,443.57
C08	Alfalfa land	unused	acre	73.0	73.0	72.6	70.8	70.8
C13	BLM permits	unused	AUM	303.7	156.6	129.3	--	--
C15	Barley land	unused	acre	2.1	--	--	--	--
C1002	BLM permits	used	AUM	2,218.0	2,362.1	2,388.9	2,515.7	2,515.7
C1003	State land permits	used	AUM	626.8	626.8	626.8	626.8	626.8
C1008	Aug. seedable (CW)	used	acre	555.0	555.0	555.0	555.0	555.0
C1019	Sept. seedable (IW or RW)	used	acre	555.0	555.0	555.0	555.0	555.0
C1028	Aug. sprayable	used	acre	102.3	241.1	266.9	385.3	391.4
C1029	Sept. sprayable	used	acre	567.9	429.2	403.4	284.9	278.7
C1034	Aftermath	used	AUM	154.8	154.8	154.8	154.8	154.8
C1036	May good range	used	acre	321.1	368.6	377.4	417.9	419.1
C1037	June good range	used	acre	239.7	306.0	318.3	374.9	376.6
C1038	July good range	used	acre	306.6	225.4	210.3	141.0	138.0
C1039	Aug. good range	used	acre	93.6	61.0	55.0	27.2	27.2
C1049	Aug. fair range	used	acre	773.1	668.9	649.6	560.8	553.5
C1051	Oct. fair range	used	acre	525.8	629.9	649.3	738.2	740.9
C1060	Sept. poor range	used	acre	3,324.7	3,324.7	3,324.7	3,324.7	3,324.7
C1066	Barley land for alfalfa	used	acre	31.8	33.9	33.9	33.9	33.9
C1095	Sept. sprayed	used	acre	25.7	25.7	25.7	25.7	25.7
C1102	Irrig. pasture for season	used	acre	99.0	99.0	99.0	99.0	99.0
C1065	Alfalfa land for alfalfa	used	acre	--	--	.4	2.2	2.2
C1052	Nov. fair range	used	acre	--	--	--	--	4.6
C1071	A.U.'s of breeding ewe[b]			276.4	294.4	297.7	313.1	313.5

[a]These bases have no private capital included.

[b]1 A.U. = 5 breeding ewes. 1 A.U. returns $36.50/year.

Table 20. Increasing Forest Service permits from 642.6 AUM's to 912.6 AUM's and showing the MVP's and capitalized values[ab] for resources in each of the five optimal stages for small model 2c[c]

			Forest Service permits (AUM's)				
			(1) 642.6		(2) 773.1		(3) 797.4
	Resources	Unit	MVP	Capitalized value	MVP	Capitalized value	MVP
1.	Seedable (CW)	acre	.251	5.02	.251	5.02	.251
2.	Seedable (IW or RW)	acre	.251	5.02	.251	5.02	.251
3.	Sprayable	acre	.294	5.88	.294	5.88	.294
4.	Aftermath	AUM	2.636	52.72	2.636	52.72	2.636
5.	Good range	acre	.914	18.26	.913	18.26	.913
6.	Fair range	acre	.497	9.94	.497	9.94	.497
7.	Poor range	acre	.140	2.80	.140	2.80	.140
8.	Alfalfa land (free resource)						
9.	Irrig. pasture	acre	17.128	342.54	17.128	342.54	17.128
10.	Capital	dol.	1.591	31.82	1.591	31.82	1.591
11.	Hay (free resource)						
12.	F.S. permits	AUM	4.975	99.50	4.975	99.50	4.975
13.	BLM permits	AUM	--	--	--	--	--
14.	State land permits	AUM	3.511	70.22	3.511	70.22	3.511
15.	Barley land (free resource)						
16.	January (free resource)						
17.	February (free resource)						
18.	March (free resource)						
19.	April (free resource)						
20.	May	AUM	3.654	--	3.654	--	3.654
21.	June	AUM	2.740	--	2.740	--	2.740
22.	July	AUM	5.024	--	5.024	--	5.024
23.	August	AUM	5.025	--	5.025	--	5.025
24.	September	AUM	5.025	--	5.025	--	5.025
25.	October	AUM	2.089	--	2.089	--	2.089
26.	November	AUM	--	--	--	--	--
27.	December	AUM	--	--	--	--	--

[a]Capitalized at a rate of 5 percent.

[b]The annual ranch income and capitalized ranch values for each of the five permit levels are (1) annual income = $10,089.24, capitalized value = $201,784.80, (2) annual income = $10,744.99, capitalized value = $214,899.80, (3) annual income = $10,867.02, capitalized value = $217,340.40, (4) annual income = $11,426.86, capitalized value = $228,537.20, (5) annual income = $11,443.57, capitalized value = $228,871.40.

[c]These bases have no private capital included.

Table 20. Continued

	Resources	Unit	Forest Service permits (AUM's) (3) 797.4 Capitalized value	(3) 797.4 MVP	(4) 908.8 Capitalized value	(4) 908.8 MVP	(5) 912.6 Capitalized value
1.	Seedable (CW)	acre	5.02	.221	4.42	.190	3.80
2.	Seedable (IW or RW)	acre	5.02	.221	4.42	.190	3.80
3.	Sprayable	acre	5.88	.258	5.16	.222	4.44
4.	Aftermath	AUM	52.72	2.317	46.34	1.994	39.88
5.	Good range	acre	18.26	.803	16.06	.691	13.82
6.	Fair range	acre	9.94	.437	8.74	.376	7.52
7.	Poor range	acre	2.80	.123	2.46	.106	2.12
8.	Alfalfa land (free resource)						
9.	Irrig. pasture	acre	342.54	15.060	301.20	12.958	259.16
10.	Capital	dol.	31.82	1.399	27.98	1.204	24.08
11.	Hay (free resource)						
12.	F.S. permits	AUM	99.50	4.374	87.48	3.764	75.28
13.	BLM permits	AUM	--	.523	10.46	1.072	21.44
14.	State land permits	AUM	70.22	3.146	62.92	2.707	54.14
15.	Barley land (free resource)						
16.	January (free resource)						
17.	February (free resource)						
18.	March (free resource)						
19.	April (free resource)						
20.	May	AUM	--	3.212	--	2.764	--
21.	June	AUM	--	2.409	--	2.073	--
22.	July	AUM	--	4.417	--	3.801	--
23.	August	AUM	--	4.418	--	3.801	--
24.	September	AUM	--	4.418	--	3.802	--
25.	October	AUM	--	1.837	--	1.581	--
26.	November	AUM	--	3.193	--	2.747	--
27.	December	AUM	--	--	--	3.802	--

Table 21. Increasing irrigated pasture from 99 acres to 178.2 acres with the optimal solution at each stage for model 2c[a]

				C1102 Irrigated pasture (acres)						
				(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Status	Unit	99.0	113.1	137.3	144.4	177.1	178.2	178.2
	Annual income			$10,089.24	$10,330.68	$10,744.99	$10,867.01	$11,426.85	$11,443.57	$11,443.58
C08	Alfalfa land	unused	acre	73.0	73.0	73.0	72.6	70.8	70.8	70.8
C13	BLM permits	unused	AUM	303.7	249.5	156.6	129.3	--	--	--
C15	Barley land	unused	acre	2.1	1.3	--	--	--	--	--
C1001	F.S. permits	used	AUM	642.6	642.6	642.6	642.6	642.6	642.6	642.6
C1002	BLM permits	used	AUM	2,218.0	2,271.0	2,362.1	2,388.9	2,515.7	2,515.7	2,515.7
C1003	State land permits	used	AUM	626.8	626.8	626.8	626.8	626.8	626.8	626.8
C1008	Aug. seedable (CW)	used	acre	555.0	555.0	555.0	555.0	555.0	555.0	555.0
C1019	Sept. seedable (IW or RW)	used	acre	554.8	554.8	554.8	554.8	554.8	554.8	554.8
C1028	Aug. sprayable	used	acre	102.3	--	--	--	--	--	--
C1029	Sept. sprayable	used	acre	567.9	670.1	670.1	670.1	670.1	670.1	670.1
C1034	Aftermath	used	AUM	154.8	154.8	154.8	154.8	154.8	154.8	154.8
C1036	May good range	used	acre	321.1	310.4	292.0	286.6	261.7	260.6	260.6
C1037	June good range	used	acre	239.7	221.8	191.1	182.1	140.6	139.0	139.0
C1038	July good range	used	acre	306.6	287.2	254.1	244.3	199.5	197.4	197.4
C1039	Aug. good range	used	acre	93.6	141.5	223.8	248.0	359.1	363.8	363.8
C1049	Aug. fair range	used	acre	773.2	734.8	565.3	515.4	286.3	275.6	275.5
C1051	Oct. fair range	used	acre	525.8	564.1	629.9	649.3	738.2	740.9	740.9
C1060	Sept. poor range	used	acre	3,324.7	3,324.7	3,324.7	3,324.7	3,324.7	3,324.7	3,324.7
C1066	Barley land for alfalfa	used	acre	31.8	32.6	33.9	33.9	33.9	33.9	33.9
C1071	$36.50/A.U.	used	A.U.	276.4	283.0	294.4	297.7	313.1	313.5	313.5
C1095	Sept. sprayed	used	acre	25.7	25.7	25.7	25.7	25.7	25.7	25.7
C1050	Sept. fair range	used	acre	--	--	103.7	134.2	274.3	277.9	277.9
C1065	Alfalfa land	used	acre	--	--	--	.4	2.2	2.2	2.2
C1052	Nov. fair range	used	acre	--	--	--	--	--	4.6	4.6

[a]There is no private capital in this basis.

The starting basis included an excess of alfalfa land, BLM permits, and barley land. As irrigated pasture was increased, all the barley land was used in stage 3, all the BLM permits were used in stage 5, and most of the alfalfa land was used. The remaining resource use varied only slightly, and then it was merely a change in time of use.

Table 22 shows the capitalized value and MVP of the resource through the seven parametric stages. Irrigated pasture starts out in stage 1 with an MVP of $17.12 and a capitalized value of $342.56 per acre. These values hold fairly well until stage 5 where the MVP drops to $15.06, and the capitalized value drops to $301.20. The last two stages, 6 and 7, each show a MVP of $12.58 and a capitalized value of $259.16. As mentioned in another section, the MVP of $12.96 in the last stage is misleading unless a person is aware that this is the optimum and final stage for adding irrigated land and that a very small addition of irrigated land will drop the MVP and the capitalized value to zero.

As irrigated land is added, Forest Service permits decline in value, from $99.50 per AUM in stage 4 to $75.28 per AUM in stage 7. This is because irrigated land will graze sheep for the same months that they can graze the forest lands.

The BLM permits have no value until stage 5 at which point they become a scarce resource and take on a value of $10.46. In stages 6 and 7 BLM permits have a value of $21.44. Since all the other resources are declining in value and the BLM permits alone are increasing in value, this would indicate that BLM permits are the limiting factor.

The value of the ranch has increased from $201,784.80 to $228,871.60 due to the addition of 79 acres of irrigated pasture. This is an increase in value of approximately $27,086.

Table 22. Increasing irrigated pasture from 99 acres to 178.2 acres and showing the MVP's and capitalized values[ab] for resources in each of the seven optimal stages for model 2c[c]

			Irrigated pasture (acres)					
			(1) 99.0		(2) 113.1		(3) 137.3	(4) 144.4
	Resources	Unit	MVP	Capitalized value	MVP	Capitalized value	MVP	Capitalized value	MVP
1.	Seedable (CW)	acre	.25	5.02	.25	5.02	.25	5.02	.25
2.	Seedable (IW or RW)	acre	.25	5.02	.25	5.02	.25	5.02	.25
3.	Sprayable	acre	.29	5.88	.29	5.88	.29	5.88	.29
4.	Aftermath	AUM	2.63	52.72	2.63	52.72	2.63	52.72	2.63
5.	Good range	acre	.91	18.26	.91	18.26	.91	18.26	.91
6.	Fair range	acre	.49	9.94	.49	9.94	.49	9.94	.49
7.	Poor range	acre	.14	2.80	.14	2.80	.14	2.80	.14
8.	Alfalfa land (free resource)								
9.	Irrig. pasture	acre	17.12	342.56	17.12	342.54	17.12	342.54	17.12
10.	Capital	dol.	1.59	--	1.59	--	1.59	--	1.59
11.	Hay (free resource)								
12.	F.S. permits	AUM	4.97	99.50	4.97	99.50	4.97	99.50	4.97
13.	BLM permits	AUM	--	--	--	--	--	--	--
14.	State land permits	AUM	3.51	70.22	3.51	70.22	3.51	70.22	3.51
15.	Barley land (free resource)								
16.	January	AUM	--	--	--	--	--	--	--
17.	February	AUM	--	--	--	--	--	--	--
18.	March	AUM	--	--	--	--	--	--	--
19.	April	AUM	--	--	--	--	--	--	--
20.	May	AUM	3.65	--	3.65	--	3.65	--	3.65
21.	June	AUM	2.74	--	2.74	--	2.74	--	2.74
22.	July	AUM	5.02	--	5.02	--	5.02	--	5.02
23.	August	AUM	5.02	--	5.02	--	5.02	--	5.02
24.	September	AUM	5.02	--	5.02	--	5.02	--	5.02
25.	October	AUM	2.08	--	2.08	--	2.08	--	2.08
26.	November	AUM	--	--	--	--	--	--	--
27.	December	AUM	--	--	--	--	--	--	--

[a]Capitalized at a rate of 5 percent.

[b]The annual ranch income and the capitalized ranch value for each of the seven pasture levels are (1) annual income = $10,089.24, capitalized value = $201,784.80, (2) annual income = $10,330.68, capitalized value = $206,613,60, (3) annual income = $10,744,99, capitalized value = $214,899.80, (4) annual income

Table 22. Continued

			Irrigated pasture (acres)					
			(4) 144.4		(5) 177.1		(6) 178.2		(7) 178.2	
	Resources	Unit	MVP	Capitalized value	MVP	Capitalized value	MVP	Capitalized value
1.	Seedable (CW)	acre	5.02	.22	4.42	.19	3.80	.19	3.80
2.	Seedable (IW or RW)	acre	5.02	.22	4.42	.19	3.80	.19	3.80
3.	Sprayable	acre	5.88	.25	5.16	.22	4.44	.22	4.44
4.	Aftermath	AUM	52.72	2.31	46.34	1.99	39.88	1.99	39.88
5.	Good range	acre	18.26	.80	16.06	.96	13.82	.69	13.82
6.	Fair range	acre	9.94	.43	8.74	.37	7.52	.37	7.52
7.	Poor range	acre	2.80	.12	2.46	..10	2.12	.10	2.12
8.	Alfalfa land (free resource)								
9.	Irrig. pasture	acre	342.54	15.06	301.20	12.95	259.16	12.95	259.16
10.	Capital	dol.	--	1.39	--	1.20	--	1.20	--
11.	Hay (free resource)								
12.	F.S. permits	AUM	99.50	4.37	87.48	3.76	75.28	3.76	75.28
13.	BLM permits	AUM	--	.52	10.46	1.07	21.44	1.07	21.44
14.	State land permits	AUM	70.22	3.14	62.92	2.70	54.14	2.70	54.14
15.	Barley land (free resource)								
16.	January	AUM	--	--	--	--	--	--	--
17.	February	AUM	--	--	--	--	--	--	--
18.	March	AUM	--	--	--	--	--	--	--
19.	April	AUM	--	--	--	--	--	--	--
20.	May	AUM	--	3.21	--	2.76	--	2.76	--
21.	June	AUM	--	2.40	--	2.07	--	2.07	--
22.	July	AUM	--	4.41	--	3.80	--	3.80	--
23.	August	AUM	--	4.41	--	3.80	--	3.80	--
24.	September	AUM	--	4.41	--	3.80	--	3.80	--
25.	October	AUM	--	1.83	--	1.58	--	1.58	--
26.	November	AUM	--	3.19	--	2.74	--	2.74	--
27.	December	AUM	--	--	--	3.80	--	3.80	--

= $10,867.01, capitalized value = $217,340.20, (5) annual income = $11,426.85, capitalized value = $228,537.00, (6) annual income = $11,443.57, capitalized value = $228,871.40, (7) annual income = $11,443.58, capitalized value = $228,871.60.

[c]These bases have no private capital included.

Large model 2c

The original basis before capital is added will be the first consideration followed by the parametric addition of private and public capital and then the bases after capital has been added to the optimum level. Finally a table is discussed in this section showing how the linear program suggests the monthly AUM's of feed can be supplied in order to meet the total requirement of a rounded out yearly operation.

Original basis. All the ranch resources are used in the original basis shown in Table 23. In this model increased flexibility was created by adding hay and barley selling activities. In addition, government grazing was treated on a land type basis rather than a permit basis, and the season was varied for BLM permits causing different coefficients to be used depending on the season. The coefficients are reviewed in the coefficients section.

Table 24 contains the MVP's and capitalized values of the ranch resources for large model 2c. The annual return for the ranch using this model is $12,813.09 as compared to $10,089.24 for small model 2c. The total return to the ranch is calculated as follows:

(1)	A.U.'s of breeding ewe	220.42 A.U.'s @ $36.60	= $ 8,067.26
(2)	Alfalfa sold	73 ac. @ $32.13/ac.	= $ 2,345.49
(3)	Alfalfa sold from barley land	8.7 ac @ $32.13/ac.	= $ 279.56
(4)	Hay sold from irrigated pasture	99 ac. @ $21.42/ac.	= $ 2,120.58
	Total		$12,812.89

The capitalized value of the ranch is $256,261.80 as compared to $201,784.80 of the small model 2c. These contrasting figures would imply that ranch incomes will vary according to the use that ranch

Table 23. Original basis showing used and unused resources for large model 2c

	Resources	Status	Unit	Amount
C31	February	unused	AUM	.000
C32	March	unused	AUM	.000
C34	April 16 - 30	unused	AUM	.000
C36	May 16 - 31	unused	AUM	.000
C43	December	unused	AUM	.000
C44	May 1 - 15[a]	unused	AUM	.000
C45	May 16 - 31[a]	unused	AUM	.000
C47	May 1 - 15[b]	unused	AUM	.000
C48	May 16 - 31[b]	unused	AUM	.000
C1001	Apr. seedable (CW)	used	acre	555.2
C1011	Apr. seedable (IW or RW)	used	acre	555.2
C1021	Apr. sprayable	used	acre	1.0
C1024	July sprayable	used	acre	546.2
C1027	Oct. sprayable	used	acre	148.5
C1031	Aftermath	used	AUM	155.0
C1034	June good range	used	acre	376.9
C1038	Oct. good range	used	acre	584.1
C1046	Aug. fair range	used	acre	1,065.7
C1048	Oct. fair range	used	acre	233.2
C1056	Aug. poor range	used	acre	292.6
C1057	Sept. poor range	used	acre	3,032.3
C1063	Barley land for alfalfa	used	acre	25.3
C1070	July-Aug-Sept. F.S. seedable	used	acre	216.0
C1071	July-Aug-Sept. F.S. sprayable	used	acre	763.0
C1072	July-Aug-Sept. F.S. good range	used	acre	1,168.0
C1073	July-Aug-Sept. F.S. fair range	used	acre	795.0
C1074	July-Aug-Sept. F.S. poor range	used	acre	952.0
C1075	Nov. 1 to Apr. 30, BLM seedable (CW)	used	acre	2,981.0
C1077	Nov. 1 to Apr. 30, BLM sprayable	used	acre	406.0
C1079	Nov. 1 to Apr. 30, BLM good range	used	acre	1,411.0
C1081	Nov. 1 to Apr. 30, BLM fair range	used	acre	13,073.1
C1082	Nov. 1 to Apr. 1, BLM fair range	used	acre	916.0
C1083	Nov. 1 to Apr. 30, BLM poor range	used	acre	9,439.1
C1087	Oct. State land seedable (CW)	used	acre	161.1
C1091	Oct. State land seedable (IW or RW)	used	acre	23.5
C1092	Nov. State land seedable (IW or RW)	used	acre	137.6
C1093	May & June State land sprayable	used	acre	44.0
C1097	May & June State land good range	used	acre	407.0
C1101	May & June State land fair range	used	acre	664.1
C1102	July-Aug-Sept. State land fair range	used	acre	1,324.8
C1105	May & June State land poor range	used	acre	1,305.0
C1167	$36.60/A.U.	used	A.U.	220.4

[a]To be used when lambing on seeded ranges.

[b]To be used when lambing on sprayed ranges.

Table 23. Continued

	Resources	Status	Unit	Amount
C1169	June[a] seedable (CW)	used	acre	0.0
C1172	May 16 to June 30[a]	used	acre	0.0
C1174	$56.15/A.U.[a]	used	A.U.	0.0
C1178	$46.38/A.U.[b]	used	A.U.	0.0
C1179	Hay selling activity @ $32.13/ac.	used	acre	73.0
C1181	Barley land for alfalfa selling @ $32.13/ac.	used	acre	8.7
C1182	Irrig. pasture for alfalfa selling @ $21.42/ac.	used	acre	99.0

[a]To be used when lambing on seeded ranges.
[b]To be used when lambing on sprayed ranges.

managers make of their resources. Small model 2c and large model 2c have the same basic resources. The difference in incomes is due to varying practices in marketing the products of the resources and the utilization of resources in producing breeding ewes.

The addition of private and public capital. Private capital is added in increments until its MVP gets below one dollar, Table 25. The levels of investment range from zero to $1,079.77 through the fifteen investment stages. The MVP or private capital drops from $9.81 to $.59 through the same range. It is illogical to add capital after its MVP falls below one dollar.

The advantage of handling capital this way is that the internal rate of return may be calculated for each investment level and the rancher can see just how good any specific investment is. In this particular case the internal rate of return ranged from 49.10 percent down to 27.31 percent, which represents a good investment opportunity for most managers.

Table 24. The MVP's and capitalized values[ab] of ranch resources for large model 2c

	Resources	Unit	MVP	Capitalized value
	Pvt. land & pvt. leased			
1.	Seedable (CW)	acre	.135	2.70
2.	Seedable (IW or RW)	acre	.135	2.70
3.	Sprayable	acre	.158	3.16
4.	Aftermath	AUM	2.329	46.58
5.	Good range	acre	.499	9.98
6.	Fair range	acre	.267	5.34
7.	Poor range	acre	.075	1.50
8.	Alfalfa land	acre	32.130	642.60
9.	Irrig. pasture	acre	21.420	428.40
10.	Capital	dol.	6.451	--
11.	Public capital	dol.	3.739	--
12.	Hay	tons	10.674	213.48
13.	Barley land	acre	32.130	642.60
	F.S. land			
14.	Seedable (Mtn Mix)	acre	.252	5.04
15.	Sprayable	acre	.296	5.92
16.	Good range	acre	1.112	22.24
17.	Fair range	acre	.620	12.40
18.	Poor range	acre	.217	4.34
	BLM land			
19.	Seedable (CW)	acre	.093	1.86
20.	Sprayable	acre	.148	2.96
21.	Good range	acre	.198	3.96
22.	Fair range	acre	.100	2.00
23.	Poor range	acre	.049	0.98
	State land			
24.	Seedable (CW)	acre	.123	2.46
25.	Seedable (IW or RW)	acre	.123	2.46
26.	Sprayable	acre	.135	2.70
27.	Good range	acre	.425	8.50
28.	Fair range	acre	.236	4.72
29.	Poor range	acre	.074	1.48
30.	January	acre	1.583	--
31.	February	acre	.000	--
32.	March	acre	.000	--
33.	April 1 - 15	AUM	10.810	--
34.	April 16 - 30	AUM	.000	--
35.	May 1 - 15	AUM	2.958	--

[a]Capitalized at a rate of 5 percent.

[b]Capitalized value of ranch is $256,261.80 based on an annual income of $12,813.09.

Table 24. Continued

Resources	Unit	MVP	Capitalized value
36. May 16 - 31	AUM	.000	--
37. June	AUM	1,496	--
38. July	AUM	2.687	--
39. August	AUM	2.699	--
40. September	AUM	2.699	--
41. October	AUM	2.244	--
42. November	AUM	1.924	--
43. December	AUM	.000	--
44. May 1 - 15	AUM	.000	--
45. May 16 - 31	AUM	.000	--
46. June	AUM	12.079	--
47. May 1 - 15	AUM	.000	--
48. May 16 - 31	AUM	.000	--
49. June	AUM	4.136	--

The optimal amount of private capital is considered to be $884.50 which will return a minimum of 34.70 percent for spraying and 27.31 precent for seeding. This amount of private capital is entered as a constraint, then public capital is increased parametrically. The MVP of public capital was $5.71 before either private or public capital was added, Table 25, finally falling to $1.78 during the last addition of private capital. This illustrates how the need for public capital decreased as private capital was used for improvements on the ranch. As public capital is added, the MVP of $1.78 falls to a low of $1.09 at the end of 22 parametric additions of public capital. However, the rational amount of capital added would end at stage 15 where it returned 8.73 percent on money invested.

Optimal basis after capital has been added. After the optimal amounts of capital have been added, the rancher is lambing almost entirely on seeded ranges with an insignificant amount on sprayed ranges, items C1174 and C1178 in Table 27. In this situation there are

Table 25. Results of parametric programming private capital from zero to an optimum for large model 2c

	Levels of investment							
	(1) 0.0	(2) 80.31	(3) 290.38	(4) 334.87	(5) 404.86	(6) 426.33	(7) 562.02	(8) 703.82
MVP of pvt. capital	9.81	5.51	5.50	5.50	5.50	5.50	5.50	5.50
Annual return	13,813.13	13,255.47	14,412.52	14,657.20	15,041.94	15,159.90	15,905.86	16,685.15
Internal rate of return	--	49.1%	27.36%	27.31%	27.31%	27.31%	27.31%	27.31%
Seeded (CW)-acres								
May	--	47.20	170.76	196.91	238.07	250.70	330.50	413.88
June	--	62.90	227.30	262.12	316.92	304.30	224.50	141.10
Seeded (IW or RW)-acres								
June	--	--	--	--	--	29.42	215.42	409.85
Total acres seeded	--	110.10	398.06	459.03	554.99	584.42	770.42	964.83
Sprayed-acres								
June	--	.03	.03	.03	.03	.03	.03	.03
May	--	--	--	--	--	--	--	--
Sept.	--	--	--	--	--	--	--	--
Aug.	--	--	--	--	--	--	--	--
Total acres sprayed	--	--	--	--	--	--	--	--

Table 25. Continued

	Levels of investment						
	(9) 716.55	(10) 720.08	(11) 809.51	(12) 880.55	(13) 884.50	(14) 1,021.67	(15) 1,079.77
MVP of pvt. capital	5.50	5.50	4.67	4.28	.64	.59	.59
Annual return	16,754.88	16,774.42	17,265.70	17,597.46	17,601.73	17,682.73	17,717.02
Internal rate of return	27.31%	27.31%	27.31%	38.24%	34.70%	<0%	<0%
Seeded (CW)-acres							
May	421.76	423.43	476.04	476.04	476.04	476.04	476.04
June	133.65	131.55	78.98	79.00	78.98	78.98	78.98
Seeded (IW or RW)-acres							
June	427.25	432.12	554.70	554.70	554.70	554.70	554.70
Total acres seeded	982.26	987.10	1,109.74	1,109.74	1,109.72	1,109.72	1,109.72
Sprayed-acres							
June	.03	.03	.03	106.17	106.56	113.55	116.52
May	--	--	--	76.53	76.77	81.85	83.99
Sept.	--	--	--	--	9.59	350.71	359.47
Aug.	--	--	--	--	--	--	135.71
Total acres sprayed	--	--	--	182.70	192.92	546.11	695.69

Table 26. Parametric increase of public capital after private capital, $884.50, was entered as a constraint for large model 2c

	Levels of investment							
	(1) 0.0	(2) 10.49	(3) 117.30	(4) 127.38	(5) 201.88	(6) 241.30	(7) 259.06	(8) 320.86
MVP of public capital	1.78	1.78	1.78	1.77	1.75	1.69	1.68	1.68
Annual return	17,601.74	17,620.35	17,810.16	17,828.05	17,960.04	18,028.90	18,058.91	18,162.80
Internal rate of return	--	6.28%	6.28%	6.28%	6.21%	6.05%[a] 9.88%[b]	5.66%[a] 9.20%[b]	5.59%[a] 9.09%[b]
State land seeded (CW)-acres May 16 to June 30	--	14.39	161.00	161.00	161.00	161.00	161.00	161.00
State land seeded (IW or RW)-acres May 16 to June 30	--	--	--	13.83	116.09	128.10	133.34	151.45
F.S. seeded-acres July, Aug., & Sept.	--	--	--	--	--	--	--	--
BLM seeded (CW)-acres April	--	--	--	--	--	--	--	--
Total seeded acres	--	14.39	161.00	174.83	277.09	289.10	294.34	312.45
F.S. sprayed-acres July, Aug., & Sept.	--	--	--	--	--	78.79	114.63	239.46

[a]Internal rate of return when seeding.

[b]Internal rate of return when spraying.

Table 26. Continued

	Levels of investment						
	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	347.48	352.72	421.36	499.23	512.47	516.60	531.46
MVP of public capital	1.68	1.65	1.65	1.65	1.65	1.65	1.15
Annual return	18,207.53	18,216.31	18,329.87	18,458.67	18,480.55	18,487.37	18,511.87
Internal rate of return	5.59%[a] 9.09%[b]	5.59%[a] 9.09%[b]	8.73%	8.73%	8.73%	8.73%	8.73%
State land seeded (CW)-acres May 16 to June 30	161.00	161.00	161.00	161.00	161.00	161.00	161.00
State land seeded (IW or RW)-acres May 16 to June 20	159.24	160.78	160.78	160.78	160.78	160.78	160.78
F.S. seeded-acres July, Aug., & Sept.	--	--	--	--	--	--	--
BLM seeded (CW)-acres April	--	--	--	--	--	--	--
Total seeded acres	320.24	321.78	321.78	321.78	321.78	321.78	321.78
F.S. sprayed-acres July, Aug., & Sept.	293.27	303.83	480.17	680.20	714.20	724.81	763.00

[a]Internal rate of return when seeding.

[b]Internal rate of return when spraying.

Table 26. Continued

	Levels of investment						
	(16) 676.66	(17) 701.88	(18) 982.42	(19) 1,055.13	(20) 1,131.56	(21) 1,197.62	(22) 1,370.41
MVP of public capital	1.12	1.09	1.09	1.09	1.09	1.09	1.09
Annual return	18,679.21	18,707.55	19,014.70	19,094.32	19,177.94	19,250.21	19,439.08
Internal rate of return	1.39%	1.11%	<1%	<1%	<1%	<1%	<1%
State land seeded (CW)-acres May 16 to June 30	161.00	161.00	161.00	161.00	161.00	161.00	161.00
State land seeded (IW or RW)-acres May 16 to June 30	160.78	160.78	160.78	160.78	160.78	160.78	160.78
F.S. seeded-acres July, Aug., & Sept.	199.13	216.00	216.00	216.00	216.00	216.00	216.00
BLM seeded (CW)-acres April	--	17.70	402.00	501.60	606.30	696.80	933.50
Total seeded acres	520.91	555.48	939.78	1,039.38	1,144.08	1,234.58	1,471.28
F.S. sprayed-acres July, Aug., & Sept.	763.00	763.00	763.00	763.00	763.00	763.00	763.00

Table 27. Basis showing used and unused resources after private and public capital[a] have been added to the optimum amounts for large model 2c

	Resources	Status	Unit	Amount
C31	February	unused	AUM	0.0
C32	March	unused	AUM	0.0
C34	Apr. 16 - 30	unused	AUM	0.0
C35	May 1 - 15	unused	AUM	0.0
C36	May 16 - 31	unused	AUM	0.0
C37	June	unused	AUM	0.0
C43	December	unused	AUM	0.0
C45	May 16 - 31[b]	unused	AUM	37.9
C48	May 16 - 31[c]	unused	AUM	0.0
C1021	Apr. sprayable	used	acre	503.8
C1031	Sept.-Oct. aftermath	used	AUM	155.0
C1036	Aug. good range	used	acre	505.1
C1037	Sept. good range	used	acre	36.4
C1038	Oct. good range	used	acre	419.4
C1042	Apr. fair range	used	acre	1,002.4
C1047	Sept. fair range	used	acre	296.4
C1052	Apr. poor range	used	acre	3,325.2
C1063	Barley land for alfalfa (3 Ton/ac.)	used	acre	28.5
C1070	July-Aug-Sept. F.S. seedable	used	acre	216.0
C1072	July-Aug-Sept. F.S. good range	used	acre	1,168.0
C1073	July-Aug-Sept. F.S. fair range	used	acre	795.0
C1074	July-Aug-Sept. F.S. poor range	used	acre	952.0
C1075	Nov. 1 to Apr. 30, BLM seedable (CW)	used	acre	2,981.0
C1077	Nov. 1 to Apr. 30, BLM sprayable	used	acre	406.0
C1079	Nov. 1 to Apr. 30, BLM good range	used	acre	1,411.0
C1081	Nov. 1 to Apr. 30, BLM fair range	used	acre	10,917.8
C1082	Nov. 1 to Apr. 1, BLM fair range	used	acre	3,071.2
C1083	Nov. 1 to Apr. 30, BLM poor range	used	acre	9,439.1
C1095	Oct. State land sprayable	used	acre	44.0
C1099	Oct. State land good range	used	acre	407.0
C1102	July-Aug-Sept. State land fair range	used	acre	1,827.1
C1103	Oct. State land fair range	used	acre	74.5
C1104	Nov. State land fair range	used	acre	87.4
C1107	Oct. State land poor range	used	acre	1,305.0
C1132	Sept. sprayed	used	acre	148.2
C1139	July-Aug-Sept. F.S. seeded	used	acre	0.0

[a]

	Annual levels of invest.	Rate of return
private	$884.50	27.31% for seeding
		34.70% for spraying
public	$531.46	5.59% for seeding
		8.73% for spraying

[b]Used when there was lambing on seeded ranges.

[c]Used when there was lambing on sprayed ranges.

Table 27. Continued

	Resources	Status	Unit	Amount
C1140	July-Aug-Sept. F.S. sprayed	used	acre	763.0
C1168	May[b] seeded (CW)	used	acre	555.0
C1170	May[b] seeded (IW or RW)	used	acre	2.3
C1171	June[b] seeded (IW or RW)	used	acre	552.3
C1172	May 16 to June 30,[b] State land seeded (CW)	used	acre	161.0
C1173	May 16 to June 30,[b] State land seeded (IW or RW)	used	acre	160.8
C1174	$56.15[b] per A.U.	used	A.U.	241.3
C1175	May[c] sprayed	used	acre	18.4
C1176	June[c] sprayed	used	acre	25.6
C1178	$46.38[c] per A.U.	used	A.U.	6.9
C1179	Alfalfa land for hay selling activity @ $32.13/ac.	used	acre	73.0
C1181	Barley land for hay selling activity @ $32.13/ac.	used	acre	5.5
C1182	Irrig. pasture for hay selling activity @ $21.42/ac.	used	acre	99.0

[b]Used when there was lambing on seeded ranges.
[c]Used when there was lambing on sprayed ranges.

1,109.72 private seeded acres, 192.92 private sprayed acres, 321.78 public seeded acres and 763.00 public sprayed acres.

Table 28 gives the capitalized value of the ranch after the addition of capital as $370,237.40, an increase of $113,975.60. This is the result of an annual investment of $1,415.96 on both public and private rangeland. The annual income increased from $12,813.09 to $18,511.87.

The capitalized values of seedable and sprayable land have generally dropped with the exception of those on Forest Service land. This is because the Forest Service land can provide seasonal grazing which is in short supply compared to BLM and state lands that are grazed mostly during other seasons. The lands producing hay that is sold off the

Table 28. The MVP's and capitalized values of resources after private and public capital has been added to the optimum amounts[a] for large model 2c

	Resources	Unit	MVP	Capitalized value[bc]
1.	Seedable (CW)	acre	1.992	39.84
2.	Seedable (IW or RW)	acre	1.976	39.52
3.	Sprayable	acre	.282	5.64
4.	Aftermath	AUM	2.427	48.54
5.	Good range	acre	.518	10.36
6.	Fair range	acre	.282	5.64
7.	Poor range	acre	.131	2.62
8.	Alfalfa land	acre	32.130	642.60
9.	Irrig. pasture	acre	21.420	428.40
10.	Capital	dol.	.605	--
11.	Public capital	dol.	1.152	--
12.	Hay	tons	10.674	213.48
13.	Barley land	acre	32.130	642.60
	F.S. land			
14.	Seedable	acre	.246	4.92
15.	Sprayable	acre	.482	9.64
16.	Good range	acre	1.086	21.72
17.	Fair range	acre	.606	12.12
18.	Poor range	acre	.212	4.24
	BLM land			
19.	Seedable (CW)	acre	.165	3.30
20.	Sprayable	acre	.265	5.30
21.	Good range	acre	.353	7.06
22.	Fair range	acre	.179	3.58
23.	Poor range	acre	.088	1.76
	State land			
24.	Seedable (CW)	acre	.585	11.70
25.	Seedable (IW or RW)	acre	.584	11.68
26.	Sprayable	acre	.132	2.64
27.	Good range	acre	.416	8.32
28.	Fair range	acre	.231	4.62
29.	Poor range	acre	.073	1.46
30.	January	AUM	4.228	--
31.	February	AUM	.000	--

[a]

	Annual levels of invest.	Rate of return
private	$884.50	27.31% for seeding 34.70% for spraying
public	$531.46	5.59% for seeding 8.73% for spraying

[b]Capitalized at a rate of 5 percent.

[c]Capitalized ranch value is $370,237.40 based on an annual income of $18,511.87.

Table 28. Continued

Resources	Unit	MVP	Capitalized value
32. March	AUM	.000	--
33. April 1 - 15	AUM	19.293	--
34. April 16 - 30	AUM	.000	--
35. May 1 - 15	AUM	.000	--
36. May 16 - 31	AUM	.000	--
37. June	AUM	.000	--
38. July	AUM	2.203	--
39. August	AUM	2.849	--
40. September	AUM	2,849	--
41. October	AUM	2.330	--
42. November	AUM	2.030	--
43. December	AUM	.000	--
44. May 1 - 15	AUM	17.039	--
45. May 16 - 31	AUM	.000	--
46. June	AUM	6.042	--
47. May 1 - 15	AUM	4.162	--
48. May 16 - 31	AUM	.000	--
49. June	AUM	1.554	--

ranch have a constant capitalized value, whereas the capitalized value of the remaining resources varies slightly.

Monthly contribution of resources to a year around operation. It has been assumed in the previous discussions that the linear program results provide adequate forage for each month of the year to support the number of breeding ewes indicated. This section is an itemized breakdown of the original basis showing how the feed requirements for each month are met. As previously discussed, each breeding ewe requires a certain number of AUM's of grazing each month and a specific amount of hay to winter properly. These requirements are in column 3 of Table 29. One animal unit of breeding ewe (5 ewes per A.U.) requires .35 ton of hay per year, 1.34 AUM's of grazing for January, and so on. In the original basis of the model item C1167 shows there are 220.4 animal

Table 29. Comparing animal units required for year-around operation with those supplied as a result of linear programming for large model 2c[a]

1	2	3	4	5	6	7	8	9	10	11	12
					Units making up total supplied by linear programming						
	Unit	Req. per A.U. of breeding ewe[b]	Total req. for 220.417 A.U.'s	Total supplied by L.P.	CW seed-able	IW or RW seed-able	Spray-able	After-math	Good range	Fair range	Poor range
Hay	ton	.35	77.15	76.15	--	--	--	--	--	--	--
January	AUM	1.34	295.36	295.36	--	--	--	--	--	--	--
February	AUM	1.34	295.36	295.36	--	--	--	--	--	--	--
March	AUM	1.34	295.36	295.36	--	--	--	--	--	--	--
Apr. 1 - 15	AUM	.67	147.68	147.68	6.94	6.94	.02	--	--	--	--
Apr. 16 - 30	AUM	.67	147.68	147.68	6.94	6.94	.02	--	--	--	--
May 1 - 15	AUM	.33	72.74	72.73	--	--	--	--	--	--	--
May 16 - 31	AUM	.33	72.74	72.73	--	--	--	--	--	--	--
June	AUM	1.23	271.11	271.10	--	--	--	--	125.64	--	--
July	AUM	1.60	352.67	355.52	--	--	32.13	--	--	--	--
August	AUM	1.97	434.22	437.07	--	--	--	--	--	105.51	8.17
September	AUM	1.97	434.22	437.07	--	--	--	28.98	--	--	84.70
October	AUM	1.38	304.18	304.20	--	--	10.46	126.02	129.80	--	--
November	AUM	1.38	304.18	304.18	--	--	--	--	--	--	--
December	AUM	1.34	295.36	295.36	--	--	--	--	--	--	--

[a]Capital has not been considered in obtaining this solution.

[b]As determined from year-around operation of large model 2c.

Table 29. Continued

1	2	13	14	15	16	17	18	19	20	21	22
		Units making up total supplied by linear programming									
	Unit	Alfalfa from barley land	F.S. seed-able	F.S. spray-able	F.S. good range	F.S. fair range	F.S. poor range	BLM CW seed-able	BLM spray-able	BLM good range	BLM fair range
Hay	ton	76.15	--	--	--	--	--	--	--	--	--
January	AUM	--	--	--	--	--	--	31.11	6.78	31.42	147.51
February	AUM	--	--	--	--	--	--	31.11	6.78	31.42	147.51
March	AUM	--	--	--	--	--	--	31.11	6.78	31.42	147.51
Apr. 1 - 15	AUM	--	--	--	--	--	--	15.46	3.37	15.61	73.31
Apr. 16 - 30	AUM	--	--	--	--	--	--	15.46	3.37	15.61	73.31
May 1 - 15	AUM	--	--	--	--	--	--	--	--	--	--
May 16 - 31	AUM	--	--	--	--	--	--	--	--	--	--
June	AUM	--	--	--	--	--	--	--	--	--	--
July	AUM	--	6.79	28.26	162.22	61.63	25.80	--	--	--	--
August	AUM	--	6.79	28.26	162.22	61.63	25.80	--	--	--	--
September	AUM	--	6.79	28.26	162.22	61.63	25.80	--	--	--	--
October	AUM	--	--	--	--	--	--	31.11	6.78	31.42	147.51
November	AUM	--	--	--	--	--	--	31.11	6.78	31.42	147.51
December	AUM	--	--	--	--	--	--	31.11	6.78	31.42	147.51

Table 29. Continued

1	2	23	24	25	26	27	28	29	30	31	32
		Units making up total supplied by linear programming									
	Unit	BLM fair range	BLM poor range	S.L. CW seed-able	S.L. IW or RW seed-able	S.L. IW or RW seed-able	S.L. spray-able	S.L. good range	S.L. fair range	S.L. fair range	S.L. poor range
Hay	ton	--	--	--	--	--	--	--	--	--	--
January	AUM	26.17	52.37	--	--	--	--	--	--	--	--
February	AUM	26.17	52.37	--	--	--	--	--	--	--	--
March	AUM	26.17	52.37	--	--	--	--	--	--	--	--
Apr. 1 - 15	AUM	--	26.03	--	--	--	--	--	--	--	--
Apr. 16 - 30	AUM	--	26.03	--	--	--	--	--	--	--	--
May 1 - 15	AUM	--	--	--	--	--	1.00	29.07	26.35	--	16.31
May 16 - 31	AUM	--	--	--	--	--	1.00	29.07	26.35	--	16.31
June	AUM	--	--	--	--	--	2.00	58.14	52.70	--	32.62
July	AUM	--	--	--	--	--	--	--	--	38.69	--
August	AUM	--	--	--	--	--	--	--	--	38.69	--
September	AUM	--	--	8.85	1.29	--	--	--	--	38.69	--
October	AUM	26.17	52.37	--	--	8.82	--	--	--	--	--
November	AUM	26.17	52.37	--	--	--	--	--	--	--	--
December	AUM	26.17	52.37	--	--	--	--	--	--	--	--

units of breeding ewe supported. Consequently, 220.4 animal units of breeding ewe times the yearly requirement of hay and monthly requirement for each animal unit of breeding ewe will give the total requirement as shown in column 4. Column 5 gives the total supplied by the various land resources, and columns 6 through 32 give the itemized breakdown. Column 6 shows that seedable land (CW) supplies 6.94 animal units of grazing for both April 1 to 15 and April 16 to 30. Column 31 shows that state land, fair range, supplies 38.69 animal units of grazing for July, August and September, etc.

Model 3c

The outline for discussing the results of model 3c varies from the other three models in that after the original basis public capital is added first, then private capital, rather than the addition of private capital then public capital. This technique gives some idea of how government improvements alone could improve the income of a ranching area.

Original basis

The original basis in Table 30 is different from large model 2c because of the large amount of unused resources present. Items C01 to C32 are all unused and involve a number of acres that are not being utilized in the model. This model is just as flexible in marketing hay and barley and all other factors as is large model 2c. The main difference is one of size with model 3c being the larger of the two.

Row C1174 shows that there are 396.55 A.U.'s of breeding ewes or 5 times 396.55, giving 1,983 breeding ewes total. Multiplying the 396.55 by the annual return per A.U. of breeding ewe, or $28.20, results

Table 30. Original basis showing used and unused resources for model 3c

	Resources	Status	Unit	Amount
C01	Pvt. seedable (CW)	unused	acre	1,351.00
C02	Pvt. seedable (IW or RW)	unused	acre	1,351.00
C03	Sprayable	unused	acre	1,699.00
C06	Fair range	unused	acre	96.80
C07	Poor range	unused	acre	8,168.00
C17	F.S. poor range	unused	acre	429.20
C18	BLM seedable (CW)	unused	acre	4,703.00
C19	BLM sprayable	unused	acre	641.00
C20	BLM needs draining	unused	acre	600.00
C24	BLM (12"-16" precip.) good range	unused	acre	390.00
C25	BLM (12"-16" precip.) fair range	unused	acre	3,974.00
C26	BLM (12"-16" precip.) poor range	unused	acre	3,429.00
C27	State land seedable (CW)	unused	acre	274.00
C28	State land seedable (IW or RW)	unused	acre	274.00
C29	State land sprayable	unused	acre	75.00
C32	State land poor range	unused	acre	2,520.00
C34	February	unused	AUM	0.00
C35	March	unused	AUM	0.00
C37	Apr. 16 - 30	unused	AUM	0.00
C39	May 16 - 31	unused	AUM	0.00
C45	November	unused	AUM	2.519
C46	December	unused	AUM	1,190
C47	May 1 - 15[a]	unused	AUM	0.00
C48	May 16 - 31[a]	unused	AUM	0.00
C50	May 1 - 15[b]	unused	AUM	0.00
C51	May 16 - 31[b]	unused	AUM	0.00
C1011	Apr. seedable (IW or RW)	used	acre	19,674.12
C1031	Aftermath	used	AUM	353.00
C1033	Apr. good range	used	acre	344.20
C1036	Aug. good range	used	acre	854.26
C1038	Oct. good range	used	acre	571.41
C1044	June fair range	used	acre	326.42
C1045	July fair range	used	acre	367.14
C1048	Oct. fair range	used	acre	2,885.65
C1062	Alfalfa land	used	acre	44.61
C1065	F.S. seedable July-Aug-Sept.	used	acre	158.05
C1066	F.S. sprayable July-Aug-Sept.	used	acre	1,427.04
C1067	F.S. good range July-Aug-Sept.	used	acre	1,902.00
C1068	F.S. fair range July-Aug-Sept.	used	acre	2,536.01
C1069	F.S. poor range July-Aug-Sept.	used	acre	1,472.80
C1077	BLM good range (6"-12" precip.) Nov. 1 to Apr. 1	used	acre	1,559.03
C1079	BLM fair range (6"-12" precip.) Nov. 1 to Apr. 1	used	acre	15,898.04

[a]To be used when lambing on seeded ranges.

[b]To be used when lambing on sprayed ranges.

Table 30. Continued

	Resources	Status	Unit	Amount
C1081	BLM poor range (6"-12" precip.) Nov. 1 to Apr. 1	used	acre	13,715.92
C1100	State land good range May & June	used	acre	630.00
C1104	State land fair range May & June	used	acre	3,149.50
C1174	$28.20	used	A.U.	396.50
C1176	Seedable (CW) June[a]	used	acre	0.00
C1179	State land seedable (CW) May & June[a]	used	acre	0.00
C1181	$47.75[a]	used	A.U.	0.00
C1185	$37.95[b]	used	A.U.	0.00
C1186	Hay selling-alfalfa land @ $32.13/ac.	used	acre	108.39
C1187	Hay selling-irrig. past. @ $21.42/ac.	used	acre	92.00

[a]To be used when lambing on seeded ranges.
[b]To be used when lambing on sprayed ranges.

in annual income of $11,182.71. Hay sold from alfalfa land returns $3,492.57 annually as can be seen when 108.39 acres of hay is sold at a rate of $32.13 per acre in row C1186. Hay selling from irrigated land, item C1187, returns $1,970.64 annually, resulting from 92 acres at $21.42 per acre. The total annual income to the ranch is a sum of the three, being $16,635.92.

The large number of unused acres in Table 30 correlates fairly well with the fact that there are so many zero MVP's in Table 31. Because they are unused also indicates that an additional unit of any one of them would not return any more income to the ranch.

Row 49 shows that an AUM of June grazing has an MVP of 17.46. Available June grazing is needed to increase production on this model. Also needed in conjunction with this is May grazing on seeded ranges in

Table 31. The MVP's and capitalized values of ranch resources for model 3c

	Resources	Unit	MVP	Capitalized value[ab]
	Pvt. land & pvt. leased			
1.	Seedable (CW)	acre	0.00	--
2.	Seedable (IW or RW)	acre	0.00	--
3.	Sprayable	acre	0.00	--
4.	Aftermath	AUM	0.00	--
5.	Good range	acre	0.00	--
6.	Fair range	acre	0.00	--
7.	Poor range	acre	0.00	--
8.	Alfalfa land	acre	32.13	642.60
9.	Irrig. pasture	acre	21.42	428.40
10.	Capital	dol.	9.59	--
11.	Public capital	dol.	4.28	--
12.	Hay	ton	10.71	--
	F.S. land			
13.	Seedable	acre	0.00	--
14.	Sprayable	acre	0.00	--
15.	Good range	acre	0.00	--
16.	Fair range	acre	0.00	--
17.	Poor range	acre	0.00	--
	BLM land			
18.	Seedable (CW)	acre	0.00	--
19.	Sprayable	acre	0.00	--
20.	Needs chaining	acre	0.00	--
	6" - 12" precip. belt			
21.	Good range	acre	.71	14.28
22.	Fair range	acre	.36	7.26
23.	Poor range	acre	.21	4.16
	12" - 16" precip. belt			
24.	Good range	acre	0.00	--
25.	Fair range	acre	0.00	--
26.	Poor range	acre	0.00	--
	State land			
27.	Seedable (CW)	acre	0.00	--
28.	Seedable (IW or RW)	acre	0.00	--
29.	Sprayable	acre	0.00	--
30.	Good range	acre	0.00	--
31.	Fair range	acre	0.00	--

[a]Capitalized at a rate of 5 percent.

[b]Capitalized ranch value is $332,724.20 based on an annual income of $16,636.21.

Table 31. Continued

Resources	Unit	MVP	Capitalized value
32. Poor range	acre	0.00	--
33. January	mon.	19.65	--
34. February	mon.	0.00	--
35. March	mon.	0.00	--
36. Apr. 1 - 15	mon.	0.00	--
37. Apr. 16 - 30	mon.	0.00	--
38. May 1 - 15	mon.	0.00	--
39. May 16 - 31	mon.	0.00	--
40. June	mon.	0.00	--
41. July	mon.	0.00	--
42. August	mon.	0.00	--
43. September	mon.	0.00	--
44. October	mon.	0.00	--
45. November	mon.	0.00	--
46. December	mon.	0.00	--
47. May 1 - 15[c]	mon.	0.00	--
48. May 16 - 31[c]	mon.	0.00	--
49. June[c]	mon.	17.46	--
50. May 1 - 15[d]	mon.	0.00	--
51. May 16 - 31[d]	mon.	0.00	--
52. June[d]	mon.	8.73	--

[c]To be used when lambing on seeded ranges.
[d]To be used when lambing on sprayed ranges.

order to allow the activity C1181 to come in where the return is based on grazing on seeded ranges during May and June. Since the coefficient relating to June grazing was larger than the coefficients relating to May grazing, because May was broken into half month periods, it was considered the limiting factor. This resulted in a high MVP for June grazing while the MVP for the two units of May grazing remained at zero. Tied in with the high MVP of June grazing on seeded ranges is the relatively high MVP of both private and public capital, rows 10 and 11. Capital is needed to do the reseeding job. Alfalfa land and irrigated pastures have high MVP's because of the hay selling activities

related to them.

January grazing, row 33, is another limiting grazing month with an MVP of 19.65. If more January grazing were available, more breeding ewes could be produced.

The capitalized value of this ranch is $332,724.20, the largest one to be considered, which is a result of capitalizing the annual income of $16,636.21 at a rate of 5 percent.

The addition of public and private capital

Table 32 presents the six investment levels. The internal rate of return remains high for each investment level with a range of 21 percent to 19.6 percent for seeding and 24.5 percent for spraying. On a yearly basis the spraying investment is $29.10 as shown by the computer, but since the total investment needs to be made at one time and it lasts for a 12-year period, total investment would be in excess of $350 when the interest for the use of the money is included. The total improvement practices completed would be: (1) 274.01 acres of seeding state land to crested wheat, (2) 72.80 acres of seeding state land to intermediate wheat or Russian wildrye, (3) 135.34 acres of seeding state land to intermediate wheat or Russian wildrye, (4) 65.48 acres of seeding state land to intermediate wheat or Russian wildrye, and finally, (5) 74.90 acres of spraying state land.

After the optimum amount of public capital has been added, there will be 74.90 acres sprayed, 274.01 acres seeded to crested wheat, and 274.62 acres seeded to intermediate wheat or Russian wildrye. This increases the annual return from $16,636.21 to $18,330.72.

Table 32. Results of parametric programming public capital from zero to an optimum for model 3c

	Levels of investment					
	(1) 0.0	(2) 199.63	(3) 252.67	(4) 351.06	(5) 398.98	(6) 428.08
MVP of public capital	4.28	4.03	4.03	4.03	3.21	0.00
Annual return	16,636.21	17,440.06	17,653.64	18,049.82	18,242.74	18,330.72
Internal rate of return	--	21%	19.6%	19.6%	19.6%	24.5%
State land seeded (CW)-acres[a] May & June	--	274.01	274.01	274.01	274.01	274.01
State land seeded (IW or RW)-acres[a] May & June	--	--	72.80	208.14	273.62	273.62
Total seeded acres	--	274.01	346.81	482.15	547.63	547.63
State land sprayed-acres[a] May & June	--	--	--	--	--	74.90

[a]Used for lambing.

After $428.08 of public capital has been added as a constraint, private capital is increased parametrically, Table 33. Private capital is increased through 11 stages to a total of $1,588.09 per year. The internal rate of return ranges from 32.16 percent to 7.27 percent for seeding, which is the only improvement practice considered. Stage 3 shows that spraying 2.7 acres will return 35 percent, but the amount sprayed is so small that it can be disregarded. The total amount of private acres seeded after the optimum amount of capital has been added is 2,175.28 acres consisting of 1,309.38 acres of crested wheat to be grazed during May, 41.70 acres of crested wheat to be grazed during June, and 824.30 acres of intermediate wheat or Russian wildrye to be grazed during June.

Optimal basis after capital has been added

Table 34 shows the profit maximizing combination of resources after capital has been added to the optimum amount. There are still a large number of unused resources present indicating a lack of balance in the year around operation. In this model only, 600 acres of juniper infested land needing chaining was included to see if it were economical to chain juniper. The basis shows that the 600 acres were not cleared and went unused, item C20.

The main increase of income as a result of the increase of capital is not due to added tons of hay sold or number of breeding ewes carried. Rather it is because the breeding ewes are grazed on seeded ranges during May and June. The number of breeding ewes on the ranch after capital has been added is the same as before the addition of capital. The difference in income is attributed to the fact that when the breeding

Table 33. Parametric increasing of private capital after public capital, $428.08, was entered as a constraint for model 3c

	Levels of investment					
	(1) 0.0	(2) 15.64	(3) 16.69	(4) 276.21	(5) 720.20	(6) 923.59
MVP of private capital	6.42	5.27	3.84	3.84	3.84	3.84
Annual return	18,330.72	18,431.10	18,436.57	19,434.40	21,141.39	21,923.44
Internal rate of return	--	32.16%	35.0%	18.6%	18.6%	18.6%
Seeded (CW)-acres						
May	--	21.38	21.38	233.98	597.62	764.22
June	--	--	--	142.90	387.40	499.40
Seeded (IW or RW)-acres						
June	--	--	--	--	--	--
Total seeded acres	--	21.38	21.38	376.88	985.02	1,263.62
Sprayed-acres						
May	--	--	2.70	2.69	2.70	2.70

Table 33. Continued

	Levels of investment				
	(7)	(8)	(9)	(10)	(11)
	959.89	987.38	1,540.55	1,542.31	1,588.09
MVP of private capital	3.84	3.84	3.03	1.92	0.0
Annual return	22,062.96	22,168.65	24,295.46	24,300.93	24,388.84
Internal rate of return	18.6%	18.6%	18.6%	14.1%	7.27%
Seeded (CW)-acres					
May	793.98	816.48	1,269.59	1,271.90	1,309.38
June	519.38	534.53	81.42	79.08	41.60
Seeded (IW or RW)-acres					
June	--	--	757.70	761.60	824.30
Total seeded acres	1,313.36	1,351.01	2,108.71	2,112.58	2,175.28
Sprayed-acres					
May	2.70	2.70	2.70	--	--

Table 34. Basis showing used and unused resources after public and private capital[a] have been added to the optimum amounts for model 3c

	Resources	Status	Unit	Amount
C02	Pvt. seedable (IW or RW)	unused	acre	526.26
C03	Pvt. sprayable	unused	acre	1,699.00
C06	Fair range	unused	acre	1,977.16
C07	Poor range	unused	acre	8,168.00
C17	F.S. poor range	unused	acre	1,902.00
C18	BLM seedable (CW)	unused	acre	4,703.00
C19	BLM sprayable	unused	acre	641.00
C20	BLM needs chaining	unused	acre	600.00
C24	BLM (12"-16" precip.) good range	unused	acre	390.00
C25	BLM (12"-16" precip.) fair range	unused	acre	3,974.00
C26	BLM (12"-16" precip.) poor range	unused	acre	3,429.00
C29	Pvt. sprayable - Dec.	unused	acre	0.00
C32	State land poor range	unused	acre	2,520.00
C34	February	unused	AUM	0.00
C35	March	unused	AUM	0.00
C37	Apr. 16 - 30	unused	AUM	0.00
C38	May 1 - 15	unused	AUM	6.79
C39	May 16 - 31	unused	AUM	6.79
C40	June	unused	AUM	13.59
C41	July	unused	AUM	1.66
C43	September	unused	AUM	5.30
C45	November	unused	AUM	2.52
C46	December	unused	AUM	1.19
C48	May 16 - 31[b]	unused	AUM	0.00
C50	May 1 -- 15[c]	unused	AUM	.54
C51	June[c]	unused	AUM	.54
C1011	Apr. seedable (IW or RW)	used	acre	1,971.84
C1031	Aftermath[d]	used	AUM	353.00
C1036	Aug. good range	used	acre	102.31
C1038	Oct. good range	used	acre	1,207.17
C1048	Oct. fair range	used	acre	1,698.82
C1062	Alfalfa land	used	acre	44.61
C1065	F.S. seedable July-Aug-Sept.	used	acre	158.05
C1066	F.S. sprayable July-Aug-Sept.	used	acre	1,427.04
C1067	F.S. good range July-Aug-Sept.	used	acre	1,902.00
C1068	F.S. fair range July-Aug-Sept.	used	acre	2,536.01

[a]

	Annual levels of invest.	Rate of return
public	$ 428.08	19.6% seeding 24.5% spraying
private	$1,588.09	7.27% seeding

[b]Used when lambing on seeded ranges.

[c]Used when lambing on sprayed ranges.

[d]Used during May, June, Sept., Oct., and Nov.

Table 34. Continued

	Resources	Status	Unit	Amount
C1077	BLM good range (6"-12" precip.) Nov. 1 to Apr. 1	used	acre	1,559.03
C1079	BLM fair range (6"-12" precip.) Nov. 1 to Apr. 1	used	acre	15,898.04
C1081	BLM poor range (6"-12" precip.) Nov. 1 to Apr. 1	used	acre	13,715.92
C1100	State land good range May & June	used	acre	630.00
C1105	State land fair range July-Aug-Sept.	used	acre	3,149.99
C1175	May seeded (CW)[b]	used	acre	1,309.38
C1176	June seeded (CW)[b]	used	acre	41.60
C1177	May seeded (IW or RW)[b]	used	acre	0.00
C1178	June seeded (IW or RW)[b]	used	acre	824.28
C1179	State land seeded (CW) May & June[b]	used	acre	274.01
C1180	State land seeded (IW or RW)[b]	used	acre	273.62
C1181	$47.75 per A.U.[b]	used	A.U.	396.56
C1184	State land sprayed May & June[b]	used	acre	74.90
C1186	Hay selling from alfalfa land @ $32.13 per ac.	used	acre	108.39
C1187	Hay selling from irrig. pasture @ $21.42 per ac.	used	acre	92.00

[b]Used when lambing on seeded ranges.

ewes are grazed on seeded May and June ranges there is a greater return per breeding ewe due to a larger lambing percentage, heavier lambs and less death loss. Row C1181, Table 34, shows the return per Animal Unit of breeding ewe as $47.75 as compared to $28.20 per Animal Unit, row C1174, Table 30, when not grazed on seeded ranges during May and June. Each activity shows the same number of animals carried.

The BLM ranges are grazed during November 1 to April 1, rather than November 1 to April 30. This agrees with the idea that grazing the desert ranges during the month of April is not desirable (Cook and Stoddart, 1964) and is reflected in the coefficients used in the model.

The annual income to the ranch after capital is added is $24,388.84, Table 35, an increase of $7,752.63. Capitalized at a rate of 5 percent the value of the ranch is $487,776.80. The MVP's of alfalfa land and irrigated land remain the same as before the addition of capital because of the hay selling activity associated with them.

Table 35. The MVP's and capitalized values of resources after public and private capital[a] have been added to the optimum amounts for model 3c

	Resources	Unit	MVP	Capitalized value[bc]
1.	Seedable (CW)	acre	0.00	--
2.	Seedable (IW or RW)	acre	0.00	--
3.	Sprayable	acre	0.00	--
4.	Aftermath	AUM	0.00	--
5.	Good range	acre	0.00	--
6.	Fair range	acre	0.00	--
7.	Poor range	acre	0.00	--
8.	Alfalfa land	acre	32.13	642.60
9.	Irrig. pasture	acre	21.42	428.40
10.	Pvt. capital	dol.	0.00	--
11.	Public capital	dol.	0.00	--
12.	Hay	ton	10.71	--
	F.S. land			
13.	Seedable	acre	0.00	--
14.	Sprayable	acre	0.00	--
15.	Good range	acre	0.00	--
16.	Fair range	acre	0.00	--
17.	Poor range	acre	0.00	--
	BLM land			
18.	Seedable (CW)	acre	0.00	--
19.	Sprayable	acre	0.00	--
20.	Needs chaining	acre	0.00	--

[a]

	Annual levels of invest.	Rate of return
public	$ 428.08	19.6% for seeding 24.5% for spraying
private	$1,588.09	7.27% for seeding

[b]Capitalized at a rate of 5 percent.

[c]Capitalized value of ranch is $487,776.80 based on an annual income of $24,388.84.

Table 35. Continued

	Resources	Unit	MVP	Capitalized value
	6"-12" precip.			
21.	Good range	acre	1.28	25.66
22.	Fair range	acre	.65	13.04
23.	Poor range	acre	.37	7.46
	12"-16" precip.			
24.	Good range	acre	00	--
25.	Fair range	acre	00	--
26.	Poor range	acre	0.00	--
	State land			
27.	Seedable (CW)	acre	0.00	--
28.	Seedable (IW or RW)	acre	0.00	--
29.	Sprayable	acre	0.00	--
30.	Good range	acre	0.00	--
31.	Fair range	acre	0.00	--
32.	Poor range	acre	0.00	--
33.	January	AUM	35.29	705.74
34.	February	AUM	0.00	--
35.	March	AUM	0.00	--
36.	Apr. 1 - 15	AUM	0.00	--
37.	Apr. 16 - 30	AUM	0.00	--
38.	May 1 - 15	AUM	0.00	--
39.	May 16 - 31	AUM	0.00	--
40.	June	AUM	0.00	--
41.	July	AUM	0.00	--
42.	August	AUM	0.00	--
43.	September	AUM	0.00	--
44.	October	AUM	0.00	--
45.	November	AUM	0.00	--
46.	December	AUM	0.00	--
47.	May 1 - 15[d]	AUM	.00	--
48.	May 16 - 31[d]	AUM	0.00	--
49.	June[d]	AUM	0.00	--
50.	May 1 - 15[e]	AUM	0.00	--
51.	May 16 - 31[e]	AUM	0.00	--
52.	June[e]	AUM	0.00	--

[d]Used when lambing on seeded ranges.

[e]Used when lambing on sprayed ranges.

CHAPTER V

SUMMARY AND CONCLUSIONS

This study was initiated to determine how sheep ranches were physically and economically organized in 1964 and to select range and livestock management alternatives which would be profitable to sheep ranches. To accomplish these two objectives a list of the ranches in Utah was obtained from tax records in each county, Forest Service records, and Bureau of Land Management records. After selection by means of a random sample the ranches were analyzed for their physical and economic organization. With the data collected from the ranches three modal ranches representing the three most prominent strata were constructed. Each represented a different size class: (1) 700 to 1,499 breeding ewes, stratum 1c, (2) 1,500 to 2,499 breeding ewes, stratum 2c, and (3) 2,500 to 5,400 breeding ewes, stratum 3c. The ranches were then programmed to find the profit maximizing combination of resources before and following the addition of private and public capital. Capital was added in increments, and the internal rate of return was calculated for each level to determine the profitability of each investment. Private capital was introduced followed by public capital on two of the ranches, which illustrated the effects of private capital alone before public capital was added. Public capital was added before private capital on one other ranch. Capitalized values of the ranch resources were computed showing the value of one more unit of each resource to the ranch concerned.

Because Forest Service permits are being reduced on many ranches and the economic impact is being felt in many small communities, Forest

Service permits were reduced in increments through successive stages on one of the ranches in order to observe the reduction in annual income for each permit reduction. Likewise, Forest Service permits were increased from the base level to show how ranch income could be improved if there were an opportunity to acquire more permits.

Irrigated pasture was also increased incrementally on one ranch model which may be useful information for some ranchers who are considering this possibility as a source of more feed.

Generally speaking, the rate of return to fixed investment for the ranches in the ten strata is not high. The return to the modal ranches of the three prominent strata are 1.12 percent for 1c, 3.96 percent for 2c, and 2.88 percent for 3c. The simple average for all ten ranch strata is 2.5 percent, and the weighted average is 2.6 percent.

Improvement practices on both private and government land increased annual return significantly for all linear programming models.

Table 36 shows the increase of annual return for all models during various levels of capital input.

Table 36. Annual income for all models during various levels of capital input

	Annual income			
Models	Before capital is added	After adding private capital	After adding public capital	After adding both private and public capital
1c	$ 5,914.17	$ 7,372.83	--	$10,490.03
large 2c	12,813.09	17,682.73	--	18,511.87
small 2c	10,089.24	10,503.20	--	--
3c	16,636.21	--	$18,330.72	24,388.84

The range of the internal rate of return when private and public capital are used for improvement practices in all models, Table 37, shows that these investments will probably compete favorably with other investments in our economy. The range of values depends on how much money is invested and whether the improvement practice is seeding or spraying. Range fertilization and chaining juniper were considered as improvement practices in the model, but neither was used in any of the final solutions.

The optimal yearly level of investment for both private and public capital for all models is given in Table 38. The models were arbitrarily constructed so that the investments were handled on a yearly basis rather than discounted over time. Interest was not included as a cost in the model but was obtained after the computer solution as the rate required to equate annual income to the initial investment. This technique made it possible to see what the internal rate of return was for each improvement practice rather than having to select a minimum rate of return and let the computer do the selection of improvement practices.

Table 37. Range of the internal rate of return when private and public capital are used for improvement practices on all models

Models	Private capital	Public capital
1c	16.0% to 42.0%	6.2% to 17.1%
large 2c	27.3% to 49.1%	5.6% to 9.1%
small 2c	8%	
3c	7.3% to 35.0%	19.6% to 24.5%

Table 38. Optimal yearly level of investment[a] for both private and public capital for all models

Models	Private	Public
1c	$ 448.28	$1,115.64
large 2c	884.50	531.46
small 2c	270.17	--
3c	1,588.09	428.08

[a]Interest on money invested into improvement practices is not included.

Lambing on seeded ranges during May and June is economically better than lambing on unimproved ranges according to the linear programming results. This supplements the biological results published by Cook (1966) indicating increased production of sheep products if this were done.

Forest Service grazing permits on the ranch represented by small model 2c were reduced from 642.6 AUM's to approximately zero. This reduction caused the annual income to fall from $10,094.24 to $6,777.97. At the same time the capitalized value of the ranch dropped from $201,784.80 to $135,559.40, a total fall in value of $66,225.40. The MVP of the Forest Service grazing permits remained at $4.97 through the first part of the permit reductions and then increased to $6.00 in the last part.

When Forest Service permits are increased from the base value of 642.6 AUM's to an optimum amount of 912.6 AUM's, the annual income changed from $10,089.24 to $11,443.57, a difference of $1,354.33. The value of the ranch increased from $201,784.80 to $228,871.40. The capitalized value of the Forest Service permits remained at $99.50 through the first part of the increase and then fell to $75.28 in the last increase.

During the increase of irrigated pasture from 99 acres to 178 acres, the capitalized value of the ranch increased from $201,784.80 to $228,871.60, a total increase of $27,086. Irrigated pasture has a capitalized value of $342.56 at the first part of the increase and then falls to $259.16, after which it drops rapidly to zero.

The Soil Conservation Service will make a ranch management plan in cooperation with the rancher who desires such a plan that allows the Soil Conservation Service to furnish the technical work of range mapping and to offer suggestions for range improvement practices. The rancher in turn decides his overall objectives and how he wants to attain them. The Soil Conservation Service range mapping furnishes some of the necessary coefficients needed by a rancher if he decides to use linear programming on his ranch. Then by calculating the internal rate of return for investment opportunities on the ranch using linear programming results more information would be available for the rancher to make sound economical decisions. Other uses of the linear programming computational procedure exists depending largely on the imagination of the user.

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APPENDIXES

Appendix A
Budget Tables

The key to the ranch strata for the following tables is:

I. Number in breeding herd
1 = 750-1499
2 = 1500-2499
3 = 2500-5499
4 = 5500 +

II. Seasonal use of public land
a = winter (may include fall, or spring, or both)
b = summer (may include spring, or fall, or both)
c = year-long
no letter = no public land use

Table 39. Animal inventory for modal ranches of the ten strata

	Strata									
	1	1a	1b	1c	2a	2b	2c	3a	3c	4c
Avg. inventory										
Sheep:										
ewes	698	882	943	814	1,697	1,615	1,709	2,614	2,842	5,370
rams	19	24	28	26	45	36	52	67	67	159
coming 2 ewes	126	149	201	172	311	340	348	543	480	1,258
coming 1 ewes	130	153	207	177	321	350	359	560	495	1,297
Horses	4	2	6	5	7	10	8	12	10	47
Cattle:										
cows			37							1,305
bulls			3							68
coming 2 cows			8							263
coming 1 cows			9							271

Table 40. Land and permit inventory for modal ranches of the ten strata

	Strata									
	1	1a	1b	1c	2a	2b	2c	3a	3c	4c
Class of land (acres)										
Irr. land:										
alfalfa	40	84	73	49	55	100	73	167	153	420
barley	20	50	26	37	45	---	34	---	---	70
pasture-leased	---	---	35	---	---	---	---	---	---	---
pasture	15	---	79	75	200	150	99	28	92	700
Dry cropland	30	---	---	---	---	75	---	---	---	---
Other cropland	---	---	59	---	---	---	---	---	---	---
Rangeland leased or owned										
State	40	---	2,436	1,750	3,800	7,745	4,067	1,920	6,922	11,380
Pvt. leased	1,040	4,745	2,124	1,102	1,950	1,100	1,578	8,200	10,250	12,800
Pvt. owned	3,605	2,619	4,917	1,958	10,050	5,612	5,813	17,388	7,764	36,833
Totals - sub	4,685	7,364	9,477	4,810	15,800	14,457	11,458	27,508	24,936	61,013
Federal range permits										
BLM	---	1,423	249	1,456	2,762	---	2,566	4,177	4,049	23,900
FS	---	---	445	436	---	536	649	---	1,321	3,197

Table 41. Investment in buildings and improvements for modal ranches of the ten strata

	Strata									
	1	1a	1b	1c	2a	2b	2c	3a	3c	4c
Livestock facilities:										
Sheds, lambing	1,875	---	1,862	2,833	7,250	---	4,000	2,000	3,000	---
Corrals	400	1,000	600	400	2,000	1,250	600	1,500	600	6,050
Feed	219	---	325	240	1,200	187	---	110	400	2,362
Barn	1,200	---	---	250	---	---	---	800	3,000	1,500
Stock shelter	500	---	---	---	---	---	---	---	---	---
Feed troughs & bunks	---	---	---	---	---	---	---	150	---	---
Watering facilities:										
Stock water	900	---	1,250	---	---	---	---	---	---	4,500
Well and pump	250	550	2,150	2,750	5,000	---	---	---	3,000	3,625
Well and pump	100	---	---	---	---	---	---	---	---	---
Stationary tank	250	---	500	250	300	900	---	1,800	1,500	1,400
Improved springs	---	600	---	---	1,000	4,400	1,200	400	1,200	---
Stationary troughs	---	---	---	---	100	---	200	400	1,250	---
Pump (water haul)	---	---	---	---	---	---	---	200	---	---
Ponds	---	---	---	---	1,200	---	---	300	---	---
Reservoirs	---	---	---	---	---	4,600	800	---	1,600	---
Crop facilities:										
Grainaries	1,000	500	500	500	500	2,000	1,000	1,000	600	1,500
Other facilities:										
Machine sheds	500	800	---	---	1,500	2,000	1,283	1,000	2,000	1,000
Stock yards	100	---	---	---	---	---	---	---	---	---
Kohler power plant	---	---	---	---	600	---	---	---	---	---
Shop	---	---	---	---	---	---	---	500	2,000	---
Fences:										
Boundary	10,450	3,500	7,000	3,500	4,000	8,000	5,000	5,000	7,000	10,000
Cross		1,000	2,500	1,750	4,000	6,000	1,000	2,500	2,500	---
TOTAL Investment	17,744	7,950	16,687	12,473	28,650	29,337	15,083	17,660	29,650	31,937

Table 42. Investment in machinery and equipment for modal ranches of the ten strata

	Strata									
	1	1a	1b	1c	2a	2b	2c	3a	3c	4c
Tractors	3,800	3,800	3,800	1,700	3,800	3,800	1,900	3,800	3,800	7,700
Trucks	2,800	1,650	3,450	3,700	4,900	5,250	5,750	7,400	7,400	12,600
Auto (ranch share)	900	900	900	900	900	900	900	900	900	3,206
Haying equipment	138	1,850	1,613	500	1,025	1,495	500	2,150	1,650	1,650
Tillage equipment	350	900	492	1,043	792	1,200	800	450	1,000	1,320
Other crop equipment	250	---	385	---	1,460	563	---	---	400	---
Livestock equipment	508	300	449	300	510	1,140	590	1,204	895	425
Shop equipment and small tools	50	260	112	100	433	567	150	100	300	100
Other:										
Campwagons	150	500	565	855	1,500	1,600	1,500	2,000	4,000	2,290
Gas pump & tank	92	---	118	---	80	105	100	50	150	125
Wagon	88	175	112	---	---	60	200	200	400	---
Combine	250	---	---	---	---	---	---	---	---	---
Grain drill	225	---	---	---	---	---	---	---	---	---
Portable water tanks	23	100	250	286	800	627	300	200	400	200
Portable water troughs	30	300	112	235	900	224	600	400	400	315
Utility trailer	---	50	---	---	---	---	---	---	---	---
Post hole auger	---	---	101	---	---	---	---	---	---	---
Tents	---	---	---	45	---	25	---	80	---	---
Total investment	9,654	10,785	12,459	9,664	17,100	17,556	13,290	18,934	21,695	29,931

Table 43. Summary of investment for modal ranches of the ten strata

	Strata									
	1	1a	1b	1c	2a	2b	2c	3a	3c	4c
Owned land and permits	91,150	102,600	161,583	100,419	288,454	178,256	204,981	442,790	289,449	1,309,405
Buildings and improvements	17,744	7,950	16,687	12,473	28,650	29,337	15,083	17,660	29,650	31,937
Machinery and equipment	9,654	10,785	11,972	9,664	17,100	17,556	13,290	18,934	21,695	29,931
Livestock:										
Sheep	17,193	21,305	24,539	21,189	41,947	41,407	43,881	67,073	68,295	144,278
Horses	340	170	510	425	595	850	680	1,020	850	3,995
Cattle	---	---	7,567	---	---	---	---	---	---	248,244
Total investment	136,081	142,810	222,858	144,170	376,746	267,406	277,916	545,477	409,940	1,767,790

Table 44. Labor costs for modal ranches of the ten strata

	Strata									
	1	1a	1b	1c	2a	2b	2c	3a	3c	4c
Family:										
Operator	3,600	3,600	3,600	3,600	3,600	7,200	3,600	8,400	8,400	12,000
Unpaid family workers	1,800	---	1,690	750	---	1,500	3,000	750	750	1,750
Total family	5,400	3,600	5,290	4,350	3,600	8,700	6,600	9,900	9,150	13,750
Hired labor:										
Herders-summer	---	2,700	1,380	3,000	3,600	6,000	6,000	9,000	12,000	10,800
Herders-winter	---	---	1,380	---	6,000	---	---	---	---	10,800
F.I.C.A.	27	114	147	117	366	272	250	380	489	1,439
Lambing help	300	450	1,300	250	500	1,500	900	1,500	1,500	9,000
Hay hands	450	---	---	---	---					1,000
Tenders	---	---	---	---	---	---	---	---	---	8,100
Total hired	777	3,264	4,207	3,367	10,466	7,772	7,150	10,880	13,989	41,139
Total labor	6,177	6,864	9,497	7,717	14,066	16,472	13,750	20,780	22,139	54,889

Table 45. Forage and feed use for modal ranches of the ten strata

	Strata									
	1	1a	1b	1c	2a	2b	2c	3a	3c	4c
Alfalfa hay	48T	---	51T	123T	335T	50T	118T	68T	192T	150T
Barley	---	---	104cwt	13T	---	---	---	---	35T	14T
Salt	2½T	2T	52cwt	3½T	7T	6T	6T	10T	10T	14T
Pellets	12T	300cwt	14T	---	13T	32T	18T	16T	---	35T
Oats	---	---	---	2T	½T	3T	3T	2T	---	---
Owned land (AUMs):										
Rangeland	1,696	471	1,375	265	1,386	1,645	924	2,949	880	6,923
Aftermath grazing	173	141	149	124	---	---	155	---	353	None
Pasture	---	---	---	---	---	---	---	5	---	---
Leased land (AUMs):										
State land	19	---	682	236	514	2,210	646	326	776	2,423
Rangeland	489	854	594	149	264	314	251	1,391	1,149	2,192
Federal range permits:										
BLM	---	1,423	407	1,456	2,762	---	2,566	4,177	4,049	23,900
FS	---	---	508	436	---	536	649	---	1,321	3,197

Table 46. Sales from sheep and wool for modal ranches

	Strata									
	1	1a	1b	1c	2a	2b	2c	3a	3c	4c
Ewes:										
Culls	561	531	646	551	751	841	1,097	1,861	1,885	3,019
Yearlings	---	---	---	---	---	---	---	---	---	---
Lambs:										
Slaughter	7,814	5,888	6,634	6,652	19,673	11,205	17,502	27,664	33,152	47,832
Feeders	4,944	6,367	10,510	6,459	8,198	10,099	11,413	17,616	8,931	27,806
Wool sales (fleeces)	4,128	5,461	5,861	5,360	11,282	9,949	11,773	17,077	17,274	30,912
Pelts	20	30	58	44	50	166	80	102	158	200
Total sales	17,467	18,277	23,709	19,068	39,955	32,262	41,867	64,321	61,401	109,769
Wool incentive prog.										
Payment on wool	684	905	971	888	1,869	1,648	1,950	2,829	2,861	5,502
Payment on lambs	175	169	241	180	375	294	393	616	560	1,028
Total payments	859	1,074	1,212	1,068	2,244	1,942	2,344	3,445	3,422	6,530
Total sheep income	18,326	19,351	24,921	20,137	42,200	34,205	44,211	67,767	64,824	116,299

Table 47. Crop production for modal ranches of the ten strata

	Strata									
	1	1a	1b	1c	2a	2b	2c	3a	3c	4c
Alfalfa	100T	252T	263T	196T	---	300T	219T	334T	459T	1260T
Barley	1020bu.	4000bu.	1430bu.	25T	2295bu.	---	1734bu.	---	---	86T
Wheat	510bu.	---	---	---	---	1500bu.	---	---	---	---

Table 48. Cost and expenses for modal ranches of the ten strata

	Strata									
	1	1a	1b	1c	2a	2b	2c	3a	3c	4c
Cash costs:										
Grazing fees										
BLM	---	427	122	430	828	---	769	1,253	1,214	6,270
FS	---	---	290	239	---	295	356	---	726	1,823
State	2	---	122	118	257	1,105	323	163	388	1,211
Land & pasture rent	200	2,391	1,663	417	739	879	702	3,894	3,217	6,138
F.I.C.A.	27	114	147	117	366	272	250	380	489	1,439
Labor hired	750	3,150	4,060	3,250	10,100	7,500	6,900	10,500	13,500	39,700
Feed purchased	790	1,010	913	890	4,684	2,235	1,395	1,337	1,840	2,492
Repairs & maint.										
Buildings & imp.	812	344	1,289	463	1,109	1,166	633	641	1,224	1,341
Mach. & equip.	589	657	823	499	1,046	1,072	810	1,154	1,323	1,826
Vet. serv. & sup.	150	20	134	---	230	82	162	419	240	1,621
Taxes										
Sheep	302	374	427	368	735	725	765	1,173	1,204	2,506
All other property	311	45	304	29	60	200	30	100	251	500
Land	634	665	1,149	613	1,876	1,306	1,179	2,581	1,520	7,132
Seed & fertilizer	292	282	1,272	201	650	691	145	300	250	920
Mach. op. costs	1,625	1,452	2,068	1,082	2,325	1,827	2,332	2,468	2,753	4,875
Mach. hire	---	---	---	291	3,800	413	1,900	---	490	400
Transportation	347	430	380	560	1,756	1,562	1,309	3,479	1,789	10,000
Shearing	464	580	647	557	1,129	1,095	1,159	1,773	1,863	3,733
Camp supplies	---	1,367	1,586	946	1,200	1,530	1,600	2,247	2,813	4,806
License	36	18	98	98	138	138	178	193	193	327
Insurance	278	120	276	161	530	410	433	487	744	1,183
Utilities	155	352	1,093	362	3,010	807	465	360	327	3,844
Irrig. water	123	---	240	230	64	504	304	322	274	407
Miscellaneous	730	150	730	200	250	988	548	1,000	700	2,000
Wool & lamb prom.	115	133	159	140	278	240	291	428	424	825
Sheep purchases	---	---	---	---	---	202	---	---	---	---
Accounting	---	---	---	---	378	---	---	424	229	2,149
Total cash costs	8,732	14,081	19,990	12,366	37,542	27,247	24,943	37,181	40,011	109,468

Table 49. Non-cash costs for modal ranches of the ten strata

	Strata									
	1	1a	1b	1c	2a	2b	2c	3a	3c	4c
Depreciation										
Buildings & imp.	1,579	728	1,522	1,037	2,477	2,514	1,297	1,518	2,549	2,746
Mach. & equip.	1,796	1,989	2,272	1,746	1,046	3,265	2,471	3,521	4,035	5,567
Bucks	285	450	420	390	843	675	975	1,005	1,256	2,385
Horses	68	34	102	85	119	170	85	204	425	799
Bulls	---	---	237	---	---	---	---	---	---	5,372
Buck death loss	36	45	52	49	84	67	97	125	125	298
Horse death loss	17	8	26	21	29	42	34	51	42	200
Bull death loss	---	---	49	---	---	---	---	---	---	1,119
Interest on cash costs	262	422	599	370	1,126	817	748	1,115	1,200	3,284
Total non-cash costs	4,043	3,676	5,279	3,698	5,726	7,552	5,708	7,541	9,634	21,770
Total operating costs	12,775	17,757	25,269	16,065	43,268	34,799	30,652	44,723	49,646	131,238
Operator and family labor	5,400	3,600	5,290	4,350	3,600	8,700	6,600	9,900	9,150	13,750
Interest on invest.	8,165	8,569	13,371	8,650	22,604	16,044	16,674	32,728	24,596	106,067
Total ranch costs and expenses	26,340	29,926	43,930	29,065	69,473	59,543	53,927	87,351	83,392	251,055

Table 50. Income and expense summary for modal ranches of the ten strata

	Strata									
	1	1a	1b	1c	2a	2b	2c	3a	3c	4c
Total ranch income (1)	21,243	29,036	32,388	22,027	44,588	41,723	48,255	73,531	70,610	220,225
Cash costs (2)	8,732	14,081	19,990	12,366	37,542	27,247	24,943	37,181	40,011	109,468
Non-cash costs (3)	4,043	3,676	5,279	3,698	5,726	7,552	5,708	7,541	9,634	21,770
Operator and family labor (4)	5,400	3,600	5,290	4,350	3,600	8,700	6,600	9,900	9,150	13,750
Interest on investment (5)	8,165	8,569	13,371	8,650	22,604	16,044	16,674	32,728	24,596	106,067
(1) less (2), (a)	12,511	14,955	12,398	9,660	7,045	14,476	23,311	36,349	30,598	110,757
(a) less (3), (b)	8,468	11,279	7,119	5,961	1,319	6,924	17,602	28,808	20,963	88,987
(b) less (4), (c)	3,068	7,679	1,829	1,611	-2,280	-1,775	11,002	18,908	11,813	75,237
(c) less (5), (d)	-5,097	-890	-11,542	-7,038	-24,885	-17,820	-5,672	-13,820	-12,782	-30,830

Table 51. Comparative summary per A.U. and per breeding ewe for modal ranches of the ten strata

	Strata									
	1	1a	1b	1c	2a	2b	2c	3a	3c	4c
Av. per A.U.										
Sheep & lamb prod.	403	318	383	340	339	280	358	371	332	285
Wool production	43	46	43	46	49	43	49	46	45	39
Sheep & lamb sales	70	55	66	59	62	49	63	64	58	50
Wool sales	21	28	26	27	29	26	29	28	27	19
Crop sales	15	41	18	8	5	16	8	7	7	8
Gross ranch income	111	125	100	95	97	92	101	101	94	66
Costs:										
Cash	45	60	62	53	81	60	52	51	53	32
Non-cash	21	15	16	16	12	16	12	10	12	6
Total	67	76	78	69	94	76	64	61	66	39
Net ranch income	44	48	22	25	2	15	37	39	27	26
Return to operator's management	-26	-3	-35	-30	-54	-39	-11	-19	-17	-9
Av. per breeding ewe										
Sheep & lamb prod.	109	83		96	91	78	99	103	87	83
Wool production	11	12		13	13	12	13	13	12	11
Sheep & lamb sales	19	14		16	16	13	17	18	15	14
Wool sales	5	7		7	7	7	8	7	7	5
Crop sales	4	10		2	1	4	2	2	2	
Gross ranch income	30	32		27	26	25	28	28	24	
Costs:										
Cash	12	15		15	22	16	14	14	14	
Non-cash	5	4		4	3	4	3	2	3	
Total	18	20		19	25	21	17	17	17	
Net ranch income	12	12		7	0	4	10	11	7	
Return to operator's management	-7	-1		-8	-14	-11	-3	-5	-4	

Cattle included in these figures

Cattle included in these figures

Appendix B

Models in Equation Form

Table 52. Equation and inequalities representing model 1c

Objective function	=	$-10.96X_{127} - 10.96X_{128} - 21.67X_{129} - 21.67X_{130} + 14.95X_{206} + 34.50X_{215} + 24.73X_{220} + 42.84X_{221} + 21.42X_{222} + 32.13X_{223} + 36.55X_{224}$
Pvt. land and pvt. leased		
Seedable range (CW)	$230 \geq$	$40.001X_1 + 15.7X_2 + 12.5X_3 + 20.001X_4 + 20.002X_5 + 20.013X_6 + 19.0X_7 + 17.5X_8 + 20.014X_9 + 30.008X_{10} + 4.0X_{131} + 1.4X_{132} + 10.0X_{135} + 3.5X_{136} + 2.5X_{137} + 5.001$ (+ supp)$X_{138} + 5.002$(+ supp) $X_{139} + 5.003$(+ supp)$X_{140} + 4.0X_{141} + 3.501X_{142} + 5.004X_{143} + 2.507X_{144} + 5.0X_{163} + 31.4X_{188} + 3.51X_{207} + 2.51X_{208}$
Seedable range (IW or RW)	$230 \geq$	$40.011X_{11} + 15.701X_{12} + 12.501X_{13} + 20.003X_{14} + 20.004X_{15} + 20.005X_{16} + 19.001X_{17} + 17.501X_{18} + 20.011X_{19} + 30.021X_{20} + .99X_{133} + 1.9901X_{134} + 3.5012X_{145} + 2.5013X_{146} + 5.02X_{147} + 5.03X_{148} + 5.04X_{149} + 4.5X_{159} + 4.01X_{151} + 5.05X_{152} + 31.402X_{189} + 3.50121X_{209} + 2.50131X_{210}$
Sprayable	$289 \geq$	$34.201X_{21} + 12.9X_{22} + 9.5X_{23} + 17.0X_{24} + 17.101X_{25} + 17.102X_{26} + 14.2X_{27} + 12.4X_{28} + 17.103X_{29} + 26.2X_{30} + 22.044X_{153} + 4.033X_{154}$

Table 52. Continued

		$+ 3.0X_{155} + 5.54X_{156} + 5.512X_{157} + 5.513X_{158} + 4.52X_{159} + 4.011$ $X_{160} + 5.514X_{161} + 11.044X_{162} + 11.022X_{164} + 25.8X_{190} + 8.066X_{194}$ $+ 4.0331X_{216} + 3.01X_{217}$
Aftermath grazing	$124 \geq$	$1.0X_{31}$
Good range	$301 \geq$	$22.02X_{32} + 4.0X_{33} + 3.0X_{34} + 5.5X_{35} + 5.501X_{36} + 5.502X_{37} + 4.5X_{38}$ $+ 4.01X_{39} + 5.522X_{40} + 8.0X_{41} + 8.0X_{191}$
Fair range	$624 \geq$	$34.203X_{42} + 7.5X_{43} + 5.6X_{44} + 10.1X_{45} + 10.101X_{46} + 10.102X_{47} +$ $8.4X_{48} + 7.3X_{49} + 10.103X_{50} + 26.201X_{51} + 15.0X_{192}$
Poor range	$1387 \geq$	$73.6X_{52} + 26.8X_{53} + 19.9X_{54} + 35.8X_{55} + 35.801X_{56} + 35.802X_{57} +$ $29.8X_{58} + 25.9X_{59} + 35.803X_{60} + 55.601X_{61} + 53.6X_{193}$
Alfalfa land	$49 \geq$	$1.0X_{62} + .25X_{127} + .25X_{128} + 1.0X_{221}$
Irrigated pasture	$75 \geq$	$1.0X_{63} + 1.0X_{64} + 1.0X_{222} + 1.0X_{225}$
Barley land	$37 \geq$	$1.0X_{65} + 1.0X_{223} + 1.0X_{224}$
Pvt. capital	$2.00 \geq$	$13.84X_{131} + 4.84X_{132} + 3.42X_{133} + 6.88X_{134} + 7.30X_{135} + 2.56X_{136}$ $+ 1.82X_{137} + 4.94X_{138} + 4.94X_{139} + 4.94X_{140} + 2.92X_{141} + 2.56$ $X_{142} + 3.65X_{143} + 1.82X_{144} + 2.65X_{145} + 1.82X_{146} + 3.65X_{147} +$

Table 52. Continued

	$3.65X_{148} + 3.65X_{149} + 3.28X_{150} + 2.92X_{151} + 3.65X_{152} + 8.58X_{153}$
	$+ 1.56X_{154} + 1.17X_{155} + 2.14X_{156} + 2.14X_{157} + 2.14X_{158} + 1.76$
	$X_{159} + 1.56X_{160} + 2.14X_{161} + 4.29X_{162} + 3.65X_{163} + 4.29X_{164} +$
	$3.12X_{194} + 2.56X_{207} + 1.82X_{208} + 2.65X_{209} + 1.82X_{210} + 1.56X_{216}$
	$+ 1.17X_{217}$
Public capital	$0.25 \geq 1.75X_{165} + 1.09X_{166} + 7.30X_{167} + 2.56X_{168} + 1.82X_{169} + 2.92X_{170}$
	$+ 2.56X_{171} + 3.65X_{172} + 1.82X_{173} + 2.65X_{174} + 1.82X_{175} + 3.28$
	$X_{176} + 2.92X_{177} + 3.65X_{178} + 8.58X_{179} + 1.56X_{180} + 1.17X_{181} +$
	$1.76X_{182} + 1.56X_{183} + 2.14X_{184} + 4.29X_{185} + 3.65X_{186} + 3.28X_{187}$
	$+ 3.65X_{202} + 4.29X_{203} + 3.12X_{204} + 3.65X_{205} + 2.56X_{211} + 1.82$
	$X_{212} + 2.65X_{213} + 1.82X_{214} + 1.56X_{218} + 1.17X_{219}$
Hay	$0.10 \geq -4.0X_{62} - 2.0X_{63} - 3.0X_{65} + .755X_{206} + .755X_{215} + .755X_{220}$
F.S. land	
Seedable	$52.0 \geq 10.6X_{66} + 2.4X_{165}$
Sprayable	$471 \geq 9.0X_{67} + 2.8X_{166}$
Good range	$301 \leq 2.4X_{68}$

Table 52. Continued

Fair range	$624 \leq 4.3X_{69}$
Poor range	$1387 \leq 12.3X_{70}$
BLM land	
Seedable (CW)	$846 \geq 40.0011X_{71} + 15.71X_{72} + 12.51X_{73} + 19.01X_{74} + 17.51X_{75} + 20.0141 X_{76} + 30.0081X_{77} + 10.01X_{167} + 3.5X_{168} + 2.51X_{169} + 4.01X_{170} + 3.5011X_{171} + 5.0041X_{172} + 2.50171X_{173} + 31.4X_{19} + 5.01X_{202} + 3.511X_{211} + 2.511X_{212}$
Seedable (IW or RW)	$846 \geq 40.0111X_{78} + 15.701X_{79} + 12.5011X_{80} + 19.0011X_{81} + 17.5011X_{82} + 20.0111X_{83} + 30.0211X_{84} + 3.50121X_{174} + 2.50131X_{175} + 4.51X_{176} + 4.011X_{177} + 5.051X_{178} + 31.4X_{196} + 3.501211X_{213} + 2.501311X_{214}$
Sprayable	$231 \geq 34.2011X_{85} + 12.91X_{86} + 9.51X_{87} + 14.21X_{88} + 12.41X_{89} + 17.1031 X_{90} + 26.21X_{91} + 22.0441X_{179} + 4.0331X_{180} + 3.01X_{181} + 1.5051X_{182} + 4.0111X_{183} + 5.5141X_{184} + 11.0441X_{185} + 25.8X_{197} + 11.0221X_{203} + 8.0661X_{204} + 4.0337X_{218} + 3.02X_{219}$
6" - 12" precip. belt	
Good range	$564 \geq 11.0X_{92} + 5.5X_{93}$
Fair range	$5750 \geq 21.65X_{94} + 10.82X_{95}$

Table 52. Continued

Poor range	$4961 \geq 37.8X_{96} + 18.9X_{97}$
12" - 16" precip. belt	
Good range	$141 \geq 22.021X_{98} + 4.01X_{99} + 3.01X_{100} + 4.51X_{101} + 4.011X_{102} + 5.5221 X_{103} + 8.01X_{104} + 8.0X_{198}$
Fair range	$1438 \geq 34.2031X_{105} + 7.51X_{106} + 5.61X_{107} + 8.41X_{108} + 7.31X_{109} + 10.1031X_{110} + 26.2011X_{111} + 15.0X_{199}$
Poor range	$1240 \geq 73.61X_{112} + 26.81X_{113} + 19.91X_{114} + 29.81X_{115} + 25.91X_{116} + 35.8031X_{117} + 55.6011X_{118} + 53.6X_{200}$
State land	
Seedable (IW or RW)	$158 \geq 23.401X_{119} + 18.2X_{120} + 5.05X_{186} + 4.5X_{187} + 31.4X_{201} + 5.002X_{205}$
Good range	$159 \geq 6.3X_{121} + 5.6X_{122}$
Fair range	$796 \geq 11.3X_{123} + 10.1X_{124}$
Poor range	$637 \geq 36.0X_{125} + 32.0X_{126}$
January	$.0001 \geq -.167X_{92} - .2X_{93} - .167X_{94} - .2X_{95} - .167X_{96} - .2X_{97} + .872X_{206} + .872X_{215} + .872X_{220}$
February	$.0002 \geq -.167X_{92} - .2X_{93} - .167X_{94} - .2X_{95} - .167X_{96} - .2X_{97} + .872X_{206} + .872X_{215} + .872X_{220}$

Table 52. Continued

March	$.0003 \geq -.167X_{92} - .2X_{93} - .167X_{94} - .2X_{95} - .167X_{96} - .2X_{97} + .872X_{206} + .872X_{215} + .872X_{220}$
April 1 - 15	$.0004 \geq -.5X_{1} - .5X_{11} - .5X_{21} - .125X_{31} - .5X_{32} - .5X_{42} - .5X_{52} - .5X_{71} - .5X_{78} - .5X_{85} - .0835X_{92} - .0835X_{94} - .0835X_{96} - .5X_{98} - .5X_{105} - .5X_{112} - 1.25X_{127} - 1.25X_{129} - .5X_{131} - .5X_{135} - .5X_{153} - .25X_{162} - .5X_{167} - .5X_{179} + .707X_{206} + .707X_{215} + .707X_{220}$
April 16 - 30	$.0005 \geq - .5X_{1} - .25X_{10} - .5X_{11} - .25X_{20} - .5X_{21} - .25X_{30} - .125X_{31} - .5X_{32} - .25X_{41} - .5X_{42} - .25X_{51} - .5X_{52} - .25X_{61} - .5X_{71} - .25X_{77} - .5X_{78} - .25X_{84} - .5X_{85} - .25X_{91} - .0835X_{92} - .0835X_{94} - .0835X_{96} - .5X_{98} - .25X_{104} - .5X_{105} - .25X_{111} - .5X_{112} - .25X_{118} - 1.25X_{127} - 1.25X_{129} - .5X_{131} - .5X_{135} - .25X_{144} - .5X_{153} - .25X_{162} - 1.0X_{163} - 1.0X_{164} - .5X_{167} - .25X_{173} - .5X_{179} - .25X_{185} - [illegible]188 - .5X_{189} - .5X_{190} - .5X_{191} - .5X_{192} - .5X_{193} - .5X_{194} - .5X_{195} - .5X_{196} - .5X_{197} - .5X_{198} - .5X_{199} - .5X_{200} - .5X_{201} - 1.0X_{202} - 1.0X_{203} - .5X_{204} - 1.0X_{205} + .707X_{206} + .707X_{215} + .707X_{220}$
May 1 - 15	$.0006 \geq - .5X_{2} - .25X_{10} - .5X_{12} - .25X_{20} - .5X_{22} - .25X_{30} - .125X_{31} - .5$

Table 52. Continued

		$X_{33} - .25X_{41} - .5X_{43} - .25X_{51} - .5X_{53} - .25X_{61} - .083X_{64} - .5X_{72}$ $- .25X_{77} - .5X_{79} - .25X_{84} - .5X_{86} - .25X_{91} - .5X_{99} - .25X_{104} -$ $.5X_{106} - .25X_{111} - .5X_{113} - .25X_{118} - 1.25X_{128} - 1.25X_{130} - .5$ $X_{132} - .5X_{136} - .25X_{144} - .5X_{145} - .5X_{154} - .5X_{168} - .25X_{173} -$ $.5X_{174} - .5X_{180} - .25X_{185} - .5X_{188} - .5X_{189} - .5X_{190} - .5X_{191} -$ $.5X_{192} - .5X_{193} - .5X_{194} - .5X_{195} - .5X_{196} - .5X_{197} - .5X_{198} - .5$ $X_{199} - .5X_{200} - .5X_{201} - .5X_{204} + .629X_{206}$
May 16 - 31	$.0007 \geq$	$- .5X_{2} - .5X_{12} - .5X_{22} - .125X_{31} - .5X_{33} - .5X_{43} - .5X_{53} - .083X_{64}$ $- .5X_{72} - .5X_{79} - .5X_{86} - .5X_{99} - .5X_{106} - .5X_{113} - 1.25X_{128} -$ $1.25X_{130} - .5X_{132} - .5X_{136} - .5X_{145} - .5X_{154} - .5X_{168} - .5X_{174} -$ $.5X_{180} + .629X_{206} - .5X_{225}$
June	$.0008 \geq$	$- 1.0X_{3} - 1.0X_{13} - 1.0X_{23} - 1.0X_{34} - 1.0X_{44} - 1.0X_{54} - .166X_{64} -$ $.142X_{66} - .142X_{67} - .142X_{68} - .142X_{69} - .142X_{70} - 1.0X_{73} - 1.0X_{80}$ $- 1.0X_{87} - 1.0X_{100} - 1.0X_{107} - 1.0X_{114} - 1.0X_{133} - 1.0X_{137} - 1.0$ $X_{146} - 1.0X_{155} - 1.0X_{169} - 1.0X_{175} - 1.0X_{181} + 1.259X_{206} - 1.0X_{225}$
July	$.0009 \geq$	$- 1.0X_{4} - 1.0X_{14} - 1.0X_{24} - 1.0X_{35} - 1.0X_{45} - 1.0X_{55} - .167X_{64} -$

Table 52. Continued

	$.286X_{66} - .286X_{67} - .286X_{68} - .286X_{69} - .286X_{70} - .33X_{119} - .33$ $X_{121} - .33X_{123} - .33X_{125} - 1.0X_{134} - 1.0X_{138} - 1.0X_{147} - 1.0X_{156}$ $- .34X_{165} - .34X_{166} - .34X_{186} + 1.614X_{206} + 1.614X_{215} + 1.614$ $X_{220} - 1.0X_{225}$
August	$.0010 \geq - 1.0X_{5} - 1.0X_{15} - 1.0X_{25} - 1.0X_{36} - 1.0X_{46} - 1.0X_{56} - .167X_{64}$ $- .286X_{66} - .286X_{67} - .286X_{68} - .286X_{69} - .286X_{70} - .33X_{119} - .33$ $X_{121} - .33X_{123} - .33X_{125} - 1.0X_{139} - 1.0X_{148} - 1.0X_{157} - .33X_{165}$ $- .33X_{166} - .33X_{186} + 1.976X_{206} + 1.976X_{215} + 1.976X_{220} - 1.0X_{225}$
September	$.0011 \geq - 1.0X_{6} - 1.0X_{16} - 1.0X_{26} - 1.0X_{37} - 1.0X_{47} - 1.0X_{57} - .167X_{64} -$ $.286X_{66} - .286X_{67} - .286X_{68} - .286X_{69} - .286X_{70} - .34X_{119} - .34$ $X_{121} - .34X_{123} - .34X_{125} - 1.0X_{140} - 1.0X_{149} - 10X_{158} - .33X_{165}$ $- .33X_{166} - .33X_{186} + 1.976X_{206} + 1.976X_{215} + 1.976X_{220} - .5X_{225}$
October	$.0012 \geq - 1.0X_{7} - .5X_{10} - 1.0X_{17} - .5X_{20} - 1.0X_{27} - .5X_{30} - .25X_{31} - 1.0$ $X_{38} - .5X_{41} - 1.0X_{48} - .5X_{51} - 1.0X_{52} - .5X_{61} - .167X_{64} - 1.0X_{74}$ $- .5X_{77} - 1.0X_{81} - .05X_{84} - 1.0X_{88} - .5X_{91} - 1.0X_{101} - .5X_{104} -$ $1.0X_{108} - .5X_{111} - 1.0X_{115} - .5X_{118} - 1.0X_{120} - 1.0X_{122} - 1.0X_{124}$

Table 52. Continued

	$- 1.0X_{126} - 1.0X_{141} - .5X_{144} - 1.0X_{150} - 1.0X_{159} - .5X_{162} - 1.0$ $X_{170} - .5X_{173} - 1.0X_{176} - 1.0X_{182} - .5X_{185} - 1.0X_{187} + 1.414X_{206}$ $+ 1.414X_{215} + 1.414X_{220}$
November	$.0013 \geq - 1.0X_{8} - 1.0X_{18} - 1.0X_{28} - .25X_{31} - 1.0X_{39} - 1.0X_{49} - 1.0X_{59} -$ $1.0X_{75} - 1.0X_{82} - 1.0X_{89} - .166X_{92} - .2X_{93} - .166X_{94} - .2X_{95} -$ $.166X_{96} - .2X_{97} - 1.0X_{102} - 1.0X_{109} - 1.0X_{166} - 1.0X_{142} - 1.0$ $X_{151} - 1.0X_{160} - 1.0X_{171} - 1.0X_{177} - 1.0X_{188} + 1.414X_{206} + 1.414$ $X_{215} + 1.414X_{220}$
December	$.0014 \geq - 1.0X_{9} - 1.0X_{19} - 1.0X_{29} - 1.0X_{40} - 1.0X_{50} - 1.0X_{60} - 1.0X_{76} -$ $1.0X_{83} - 1.0X_{90} - .166X_{92} - .2X_{93} - .166X_{94} - .2X_{95} - .166X_{96} -$ $.2X_{97} - 1.0X_{103} - 1.0X_{110} - 1.0X_{117} - 1.0X_{143} - 1.0X_{152} - 1.0X_{161}$ $- 1.0X_{172} - 1.0X_{178} - 1.0X_{184} + 1.414X_{206} + 1414X_{215} + 1.414X_{220}$
May 1 - 15	$.0020 \geq - .5X_{207} - .5X_{209} - .5X_{211} - .5X_{213} + .629X_{215}$
May 16 - 31	$.0021 \geq - .5X_{207} - .5X_{209} - .5X_{211} - .5X_{213} + .629X_{215}$
June	$.0022 \geq - 1.0X_{208} - 1.0X_{210} - 1.0X_{212} - 1.0X_{214} + 1.259X_{215}$
May 1 - 15	$.0034 \geq - .5X_{216} - .5X_{218} + .629X_{220}$

Table 52. Continued

May 16 - 31	$.0035 \geq -.5X_{216} - .5X_{218} + .629X_{220}$
June	$.0036 \geq -1.0X_{217} - 1.0X_{219} + 1.259X_{220}$

Table 53. Equation and inequalities representing large model 2c

Objective function	$= 36.60X_{167} + 56.15X_{174} + 46.38X_{178} + 32.13X_{179} + 21.93X_{180} + 32.13 X_{181} + 21.42X_{182}$
Pvt. land + pvt. leased	
Seedable range (CW)	$555 \geq 40.001X_1 + 15.7X_2 + 12.5X_3 + 20.001X_4 + 20.002X_5 + 20.013X_6 + 19.0X_7 + 17.5X_8 + 20.014X_9 + 30.008X_{10} + 10.0X_{109} + 3.5X_{110} + 2.5X_{111} + 5.001X_{112} + 5.002X_{113} + 5.003X_{114} + 4.0X_{115} + 3.501X_{116} + 5.004X_{117} + 2.5017X_{118} + 5.0X_{137} + 31.4X_{160} + 3.5X_{168} + 2.5X_{169}$
Seedable range (IW or RW)	$555 \geq 40.011X_{11} + 15.701X_{12} + 12.501X_{13} + 20.003X_{14} + 20.004X_{15} + 20.005X_{16} + 19.001X_{17} + 1750.X_{18} + 20.011X_{19} + 30.021X_{20} + 3.5012 X_{119} + 2.5013X_{120} + 5.02X_{121} + 5.03X_{122} + 5.04X_{123} + 4.5X_{124} + 4.01X_{125} + 5.05X_{126} + 31.402X_{161} + 3.5013X_{170} + 2.5014X_{171}$
Sprayable	$696 \geq 34.201X_{21} + 12.9X_{22} + 9.5X_{23} + 17.0X_{24} + 17.101X_{25} + 17.102X_{26} + 14.2X_{27} + 12.4X_{28} + 17.103X_{29} + 26.2X_{30} + 22.044X_{127} + 4.033X_{128} + 3.0X_{129} + 5.511X_{130} + 5.512X_{131} + 5.513X_{132} + 4.525X_{133} + 4.011 X_{134} + 5.514X_{135} + 11.044X_{136} + 11.022X_{138} + 25.8X_{162} + 8.066X_{166} + 4.033X_{175} + 3.001X_{176}$
Aftermath grazing	$155 \geq 1.0X_{31}$

Table 53. Continued

Good range	$961 \geq 22.02X_{32} + 4.0X_{33} + 3.0X_{34} + 5.5X_{35} + 5.501X_{36} + 5.502X_{37} + 4.5X_{38} + 4.01X_{39} + 5.522X_{40} + 8.0X_{41} + 8.0X_{163}$
Fair range	$1299 \geq 34.203X_{42} + 7.5X_{43} + 5.6X_{44} + 10.1X_{45} + 10.101X_{46} + 10.102X_{47} + 8.4X_{48} + 7.3X_{49} + 10.103X_{50} + 26.201X_{51} + 15.0X_{164}$
Poor range	$3325 \geq 73.6X_{52} + 26.8X_{53} + 19.9X_{54} + 35.8X_{55} + 35.801X_{56} + 35.802X_{57} + 29.8X_{58} + 25.9X_{59} + 35.803X_{60} + 55.601X_{61} + 53.6X_{165}$
Alfalfa land	$73 \geq 1.0X_{62} + 1.0X_{179}$
Irrigated pasture	$99 \geq 1.0X_{64} + 1.0X_{65} + 1.0X_{66} + 1.0X_{67} + 1.0X_{68} + 1.0X_{69} + 1.0X_{182} + 1.0X_{183}$
Pvt. capital	$10.0 \geq 7.3X_{109} + 2.56X_{110} + 1.82X_{111} + 4.94\ (+\ supp)X_{112} + 4.94(+\ supp)X_{113} + 4.94(+\ supp)X_{114} + 2.92X_{115} + 2.56X_{116} + 3.65X_{117} + 1.82X_{118} + 2.65X_{119} + 1.82X_{120} + 3.65X_{121} + 3.65X_{122} + 3.65X_{123} + 3.28X_{124} + 2.92X_{125} + 3.65X_{126} + 8.58X_{127} + 1.56X_{128} + 1.17X_{129} + 2.14X_{130} + 2.14X_{131} + 2.14X_{132} + 1.76X_{133} + 1.56X_{134} + 2.14X_{135} + 4.29X_{136} + 3.65X_{137} + 4.29X_{138} + 3.12X_{166} + 2.56X_{168} + 1.82X_{169} + 2.65X_{170} + 1.82X_{171} + 1.56X_{175} + 1.17X_{176}$
Public capital	$0.0 \geq 1.75X_{139} + 1.09X_{140} + 2.56X_{141} + 7.30X_{142} + 3.65X_{143} + 3.65X_{144} +$

Table 53. Continued

		$1.56X_{145} + 4.29X_{146} + 2.14X_{147} + 2.04X_{148} + 4.94X_{149} + 2.92X_{150} +$
		$2.56X_{151} + 2.04X_{152} + 3.65X_{153} + 3.28X_{154} + 2.92X_{155} + 1.36X_{156} +$
		$2.46X_{157} + 2.18X_{158} + 1.91X_{149} + 2.04X_{172} + 2.04X_{173} + 1.36X_{177}$
Hay	$1.0 \geq$	$- 3.0X_{62} - 3.01X_{63} - 2.0X_{64} + .35X_{167} + .35X_{174} + .35X_{178}$
Barley land	$34 \geq$	$1.0X_{63}$
F.S. land		
Seedable (mtn. mix)	$216 \geq$	$2.4X_{139}$
Sprayable	$763 \geq$	$9.0X_{71} + 2.8X_{140}$
Good range	$1168 \geq$	$2.4X_{72}$
Fair range	$795 \geq$	$4.3X_{73}$
Poor range	$952 \geq$	$12.3X_{74}$
BLM land		
Seedable (CW)	$2981 \geq$	$16.0X_{75} + 10.0X_{76} + 3.5X_{141} + 10.0X_{142} + 5.07X_{143} + 5.06X_{144}$
Sprayable	$406 \geq$	$10.001X_{77} + 5.0X_{78} + 4.0X_{145} + 22.001X_{146} + 5.521X_{147}$
Good range	$1411 \geq$	$7.5X_{79} + 4.0X_{80}$
Fair range	$13,989 \geq$	$19.8X_{81} + 7.0X_{82}$
Poor range	$9,439 \geq$	$30.1X_{83} + 15.0X_{84}$
State land		
Seedable (CW)	$161 \geq$	$13.0X_{85} + 23.4X_{86} + 18.2X_{87} + 15.6X_{88} + 2.8X_{148} + 5.008(+ \text{supp})X_{149}$

Table 53. Continued

	$+ 4.0X_{150} + 3.502X_{151} + 2.8X_{172}$
Seedable (IW or RW)	$161 \geq 13.001X_{89} + 23.401X_{90} + 18.201X_{91} + 15.601X_{92} + 2.802X_{152} +$
	$5.014X_{153} + 4.518X_{154} + 4.001X_{155} + 2.804X_{173}$
Sprayable	$44 \geq 11.0X_{93} + 19.8X_{94} + 17.6X_{95} + 15.4X_{96} + 3.504X_{156} + 6.3X_{157} +$
	$5.6X_{158} + 4.9X_{159} + 3.504X_{177}$
Good range	$407 \geq 3.5X_{97} + 6.3X_{98} + 5.6X_{99} + 4.9X_{100}$
Fair range	$1989 \geq 6.301X_{101} + 11.3X_{102} + 10.1X_{103} + 8.8X_{104}$
Poor range	$1305 \geq 20.0X_{105} + 36.0X_{106} + 32.0X_{107} + 28.0X_{108}$
January	$.0001 \geq - .167X_{75} - .20X_{76} - .167X_{77} - .20X_{78} - .167X_{79} - .20X_{80} - .167$
	$X_{81} - .20X_{82} - .167X_{83} - .20X_{84} + 1.34X_{167} + 1.34X_{174} + 1.34X_{178}$
February	$.0002 \geq - .167X_{75} - .20X_{76} - .167X_{77} - .20X_{78} - .167X_{79} - .20X_{80} - .167$
	$X_{81} - .20X_{82} - .167X_{83} - .20X_{84} + 1.34X_{167} + 1.34X_{174} + 1.34X_{178}$
March	$.0003 \geq - .167X_{75} - .20X_{96} - .167X_{77} - .20X_{78} - .167X_{79} - .20X_{80} - .167$
	$X_{81} - .20X_{82} - .167X_{83} - .20X_{84} + 1.34X_{167} + 1.34X_{174} + 1.34X_{178}$
April 1 - 15	$.0004 \geq - .5X_{1} - .5X_{11} - .5X_{21} - .5X_{32} - .5X_{42} - .5X_{52} - .83X_{75} - .083X_{77}$
	$- .083X_{79} - .083X_{81} - .083X_{83} - .5X_{109} - .5X_{127} - .5X_{142} - .5X_{146}$

Table 53. Continued

	$+ .67X_{167} + .67X_{174} + .67X_{178}$
April 16 - 30	$.0005 \geq - .5X_{1} - .25X_{10} - .5X_{11} - .25X_{20} - .5X_{21} - .25X_{30} - .5X_{32} - .25X_{41} - .5X_{42} - .25X_{51} - .5X_{52} - .25X_{61} - .083X_{75} - .083X_{77} - .083X_{79} - .083X_{81} - .083X_{83} - .5X_{109} - .25X_{118} - .5X_{127} - .25X_{136} - 1.0X_{137} - 1.0X_{138} - .5X_{142} - 1.0X_{144} - .5X_{146} - .5X_{160} - .5X_{161} - .5X_{162} - .5X_{163} - .5X_{164} - .5X_{165} - .5X_{166} + .67X_{167} + .67X_{174} + .67X_{178}$
May 1 - 15	$.0006 \geq - .5X_{2} - .25X_{10} - .5X_{12} - .25X_{20} - .5X_{22} - .25X_{30} - .5X_{33} - .25X_{41} - .5X_{43} - .25X_{51} - .5X_{53} - .25X_{61} - .5X_{65} - .25X_{85} - .25X_{89} - .25X_{93} - .25X_{97} - .25X_{101} - .25X_{105} - .5X_{110} - .25X_{118} - .5X_{119} - .5X_{128} - .25X_{136} - .5X_{160} - .5X_{161} - .5X_{162} - .5X_{163} - .5X_{164} - .5X_{165} - .5X_{166} + .33X_{167}$
May 16-31	$.0007 \geq - .5X_{2} - .5X_{12} - .5X_{22} - .5X_{33} - .5X_{43} - .5X_{53} - .5X_{65} - .25X_{85} - .25X_{89} - .25X_{93} - .25X_{97} - .25X_{101} - .25X_{105} - .5X_{110} - .5X_{119} - .5X_{128} - .33X_{148} - .33X_{152} - .33X_{156} + .33X_{167} - .5X_{183}$
June	$.0008 \geq - 1.0X_{3} - 1.0X_{13} - 1.0X_{23} - 1.0X_{34} - 1.0X_{44} - 1.0X_{54} - 1.0X_{66} -$

Table 53. Continued

		$.50X_{85} - .50X_{89} - .50X_{93} - .50X_{97} - .50X_{101} - .50X_{105} - 1.0X_{111} - 1.0X_{120} - 1.0X_{129} - .66X_{148} - .66X_{152} - .66X_{156} + 1.23X_{167} - 1.0X_{183}$
July	$.0009 \geq$	$- 1.0X_{4} - 1.0X_{14} - 1.0X_{24} - 1.0X_{35} - 1.0X_{45} - 1.0X_{55} - 1.0X_{67} - .33X_{70} - .33X_{71} - .33X_{72} - .33X_{73} - .33X_{74} - .33X_{86} - .33X_{90} - .33X_{94} - .33X_{98} - .33X_{102} - .33X_{106} - 1.0X_{112} - 1.0X_{121} - 1.0X_{130} - .33X_{139} - .33X_{140} - .33X_{149} - .33X_{153} - .33X_{157} + 1.60X_{167} + 1.60X_{174} + 1.60X_{178} - 1.0X_{183}$
August	$.0021 \geq$	$- 1.0X_{5} - 1.0X_{15} - 1.0X_{25} - 1.0X_{36} - 1.0X_{46} - 1.0X_{56} - 1.0X_{68} - .33X_{70} - .33X_{71} - .33X_{72} - .33X_{73} - .33X_{74}\ 0\ .33X_{86} - .33X_{90} - .33X_{94} - .33X_{98} - .33X_{102} - .33X_{106} - 1.0X_{113} - 1.0X_{122} - 1.0\ X_{131} - .33X_{139} - .33X_{140} - .33X_{149} - .33X_{153} - .33X_{157} + 1.97\ X_{167} + 1.97X_{174} + 1.97X_{178} - 1.0X_{183}$
September	$.0022 \geq$	$- 1.0X_{6} - 1.0X_{16} - 1.0X_{26} - .187X_{31} - 1.0X_{37} - 1.0X_{47} - 1.0X_{57} - 1.0X_{69} - .33X_{70} - .33X_{71} - .33X_{72} - .33X_{73} - .33X_{74} - .33X_{86} - .33X_{90} - .33X_{94} - .33X_{98} - .33X_{102} - .33X_{106} - 1.0X_{114} - 1.0X_{123} - 1.0X_{132} - .33X_{139} - .33X_{140} - .33X_{149} - .33X_{153} - .33X_{157} +$

Table 53. Continued

		$1.97X_{167} + 1.97X_{174} + 1.97X_{178} - .5X_{183}$
October	$.0023 \geq$	$- 1.0X_{7} - .5X_{10} - 1.0X_{17} - .5X_{20} - 1.0X_{27} - .5X_{30} - .813X_{31} - 1.0X_{38} - .5X_{41} - 1.0X_{48} - .5X_{51} - 1.0X_{58} - .5X_{61} - 1.0X_{87} - 1.0 X_{91} - 1.0X_{95} - 1.0X_{99} - 1.0X_{103} - 1.0X_{107} - 1.0X_{115} - .5X_{118} - 1.0X_{124} - 1.0X_{133} - .5X_{136} - 1.0X_{150} - 1.0X_{154} - 1.0X_{158} + 1.38X_{167} + 1.38X_{174} + 1.38X_{178}$
November	$.0024 \geq$	$- 1.0X_{8} - 1.0X_{18} - 1.0X_{28} - 1.0X_{39} - 1.0X_{49} - 1.0X_{59} - .167X_{75} - .20X_{76} - .167X_{77} - .20X_{78} - .167X_{79} - .20X_{80} - .167X_{81} - .20X_{82} - .167X_{83} - .20X_{84} - 1.0X_{88} - 1.0X_{92} - 1.0X_{96} - 1.0X_{100} - 1.0X_{104} - 1.0X_{108} - 1.0X_{116} - 1.0X_{125} - 1.0X_{134} - 1.0X_{141} - 1.0X_{145} - 1.0 X_{151} - 1.0X_{155} - 1.0X_{159} + 1.38X_{167} + 1.38X_{174} + 1.38X_{178}$
December	$.0025 \geq$	$-1.0X_{9} - 1.0X_{19} -1.0X_{29} -1.0X_{40} - 1.0X_{50} - 1.0X_{60} - .167X_{75} - .20X_{76} - .167X_{77} - .20X_{78} - .167X_{79} - .20X_{80} - .167X_{81} - .20 X_{82} - .167X_{83} - .20X_{84} - 1.0X_{117} - 1.0X_{118} - 1.0X_{135} - 1.0X_{143} - 1.0X_{147} + 1.34X_{167} + 1.34X_{174} + 1.34X_{178}$
May 1 - 15	$.0012 \geq$	$- .5X_{168} - .5X_{170} + .33X_{174}$

Table 53. Continued

May 16 - 31	$.0013 \geq -.5X_{168} - .5X_{170} - .33X_{172} - .33X_{173} + .33X_{174}$
June	$.0014 \geq -1.0X_{169} - 1.0X_{171} - .66X_{172} - .66X_{173} + 1.23X_{174}$
May 1 - 15	$.0037 \geq -.5X_{175} + .33X_{178}$
May 16 - 31	$.0038 \geq -.5X_{175} - .33X_{177} + .33X_{178}$
June	$.0039 \geq -1.0X_{176} - .66X_{177} + 1.23X_{178}$

Table 54. Equation and inequalities representing model 3c

Objective function	$= -10.96X_{112} - 21.67X_{115} + 28.20X_{174} + 47.75X_{181} + 37.98X_{185} + 186X_{186} + 21.42X_{187}$
Pvt. and pvt. leased	
Seedable (CW)	$1351 \geq 40.001X_1 + 15.7X_2 + 12.5X_3 + 20.001X_4 + 20.002X_5 + 20.013X_6 + 19.0X_7 + 17.5X_8 + 20.014X_9 + 30.008X_{10} + 1.4X_{116} + 4.0X_{117} + 10.0X_{118} + 3.5X_{119} + 2.5X_{120} + 5.001(+\text{ supp})X_{121} + 5.002(+\text{ supp})X_{122} + 5.003(+\text{ supp})X_{123} + 4.0X_{124} + 3.501X_{125} + 5.004X_{126} + 2.5017X_{127} + 5.0X_{146} + 31.4X_{166} + 3.5X_{175} + 2.5X_{176}$
Seedable (IW or RW)	$1351 \geq 40.011X_{11} + 15.701X_{12} + 12.501X_{13} + 20.003X_{14} + 20.004X_{15} + 20.005X_{16} + 19.001X_{17} + 17.501X_{18} + 20.011X_{19} + 30.021X_{20} + .99X_{113} + 1.9901X_{114} + 3.5012X_{128} + 2.5013X_{129} + 5.02X_{130} + 5.03X_{131} + 5.04X_{132} + 4.5X_{133} + 4.01X_{134} + 5.05X_{135} + 31.402X_{167} + 3.5013X_{177} + 2.5014X_{178}$
Sprayable	$1699 \geq 34.201X_{21} + 12.9X_{22} + 9.5X_{23} + 17.0X_{24} + 17.101X_{25} + 17.102X_{26} + 14.2X_{27} + 12.4X_{28} + 17.103X_{29} + 26.2X_{30} + 22.044X_{136} + 4.033X_{137} + 3.0X_{138} + 5.511X_{139} + 5.512X_{140} + 5.513X_{141} + 4.525X_{142} + 4.011X_{143} + 5.514X_{144} + 11.044X_{145} + 11.022X_{147} + 25.8X_{168} +$

Table 54. Continued

		$8.066X_{172} + 4.033X_{182} + 3.001X_{183}$
Aftermath grazing	$353 \geq$	$1.0X_{31}$
Good range	$1770 \geq$	$22.02X_{32} + 4.0X_{33} + 3.0X_{34} + 5.5X_{35} + 5.501X_{36} + 5.502X_{37} + 4.5$ $X_{38} + 4.01X_{39} + 5.522X_{40} + 8.0X_{41} + 8.0X_{169}$
Fair range	$3676 \geq$	$34.203X_{42} + 7.5X_{43} + 5.6X_{44} + 10.1X_{45} + 10.101X_{46} + 10.102X_{47} +$ $8.4X_{48} + 7.3X_{49} + 10.103X_{50} + 26.201X_{51} + 15.0X_{170}$
Poor range	$8168 \geq$	$73.6X_{52} + 26.8X_{53} + 19.9X_{54} + 35.8X_{55} + 35.801X_{56} + 35.802X_{57} +$ $25.8X_{58} + 25.9X_{59} + 35.803X_{60} + 55.601X_{61} + 53.6X_{171}$
Alfalfa land	$153 \geq$	$1.0X_{62} + .3X_{112} + 1.0X_{186}$
Irrigated pasture	$92 \geq$	$1.0X_{63} + 1.0X_{64} + 1.0X_{187} + 1.0X_{188}$
Pvt. capital	$2.0 \geq$	$9.10X_{95} + 3.42X_{113} + 6.88_{114} + 4.84X_{116} + 13.84X_{117} + 7.30X_{118}$ $+ 2.56X_{119} + 1.82X_{120} + 4.94X_{121} + 4.94X_{122} + 4.94X_{123} + 2.92X_{124}$ $+ 2.56X_{125} + 3.65X_{126} + 1.82X_{127} + 2.65X_{128} + 1.82X_{129} + 3.65X_{130}$ $+ 3.65X_{131} + 3.65X_{132} + 3.28X_{133} + 2.92X_{134} + 3.65X_{135} + 8.58X_{136}$ $+ 1.56X_{137} + 1.17X_{138} + 2.14X_{139} + 2.14X_{140} + 2.14X_{141} + 1.76X_{142}$ $+ 1.56X_{143} + 2.14X_{144} + 4.29X_{145} + 3.65X_{146} + 4.29X_{147} + 3.12X_{172}$

Table 54. Continued

	$+ 2.56X_{175} + 1.82X_{176} + 2.65X_{177} + 1.82X_{178} + 1.56X_{182} + 1.17X_{183}$
Public capital	$0.25 \geq 1.75X_{148} + 1.09X_{149} + 2.56X_{150} + 7.30X_{151} + 3.65X_{152} + 3.65X_{153}$
	$+ 1.56X_{154} + 4.29X_{155} + 2.14X_{156} + 2.04X_{157} + 4.94X_{158} + 2.92X_{159}$
	$+ 2.04X_{160} + 3.65X_{161} + 3.28X_{162} + 1.36X_{163} + 2.46X_{164} + 2.18X_{165}$
	$+ 3.87X_{173} + 2.04X_{179} + 2.04X_{180} + 1.36X_{184}$
Hay	$1.0 \geq - 3.0X_{62} - 2.0X_{63} + .34X_{174} + .34X_{181} + .34X_{185}$
F.S. land	
Seedable	$158 \geq 10.6X_{65} + 2.4X_{148}$
Sprayable	$1427 \geq 9.0X_{66} + 2.8X_{149}$
Good range	$1902 \geq 2.4X_{67}$
Pair range	$2536 \geq 4.3X_{68}$
Poor range	$1902 \geq 12.3X_{69}$
BLM land	
Seedable (CW)	$4703 \geq 40.001X_{70} + 18.757X_{71} + 3.5X_{150} + 10.0X_{151} + 5.07X_{152} + 5.06X_{153}$
Sprayable	$641 \geq 34.201X_{72} + 14.751X_{73} + 4.0X_{154} + 22.00X_{155} + 5.521X_{156}$
Needs chaining	$600 \geq 40.001X_{74} + 18.757X_{75} + 10.0X_{95} + 4.25X_{173}$
6" - 12" precip.	
Good range	$1559 \geq 11.0X_{76} + 5.5X_{77}$

Table 54. Continued

Fair range	$15{,}898 \geq 21.65X_{78} + 10.82X_{79}$
Poor range	$13{,}716 \geq 37.8X_{80} + 18.9X_{81}$
12" - 16" precip.	
Good range	$390 \geq 22.02X_{82} + 4.766X_{83}$
Fair range	$3974 \geq 34.203X_{84} + 8.701X_{85}$
Poor range	$3429 \geq 73.6X_{86} + 30.851X_{87}$
State land	
Seedable (CW)	$274 \geq 13.0X_{88} + 23.4X_{89} + 18.2X_{90} + 15.6X_{91} + 2.8X_{157} + 5.008$(+ supp) $X_{158} + 4.0X_{159} + 2.8X_{179}$
Seedable (IW or RW)	$274 \geq 13.001X_{92} + 23.401X_{93} + 18.201X_{94} + 2.804X_{160} + 5.014X_{161} + 4.518X_{162} + 2.804X_{180}$
Sprayable	$75 \geq 11.0X_{96} + 19.8X_{97} + 17.6X_{98} + 15.4X_{99} + 3.504X_{163} + 6.3X_{164} + 5.6X_{165} + 3.504X_{184}$
Good range	$630 \geq 3.5X_{100} + 6.3X_{101} + 5.6X_{102} + 4.9X_{103}$
Fair range	$3150 \geq 6.301X_{104} + 11.3X_{105} + 10.1X_{106} + 8.8X_{107}$
Poor range	$2520 \geq 20.0X_{108} + 36.0X_{109} + 32.0X_{110} + 28.0X_{111}$
January	$.0001 \geq - .167X_{76} - .20X_{77} - .167X_{78} - .20X_{79} - .167X_{80} - .20X_{81} + 1.25X_{174} + 1.25X_{181} + 1.25X_{185}$

Table 54. Continued

February	$.0002 \geq -.167X_{76} - .20X_{77} - .167X_{78} - .20X_{79} - .167X_{80} - .20X_{81} + 1.25X_{174} + 1.25X_{181} + 1.25X_{185}$
March	$.0003 \geq -.167X_{76} - .20X_{77} - .167X_{78} - .20X_{79} - .167X_{80} - .20X_{81} + 1.25X_{174} + 1.25X_{181} + 1.25X_{185}$
April 1 - 15	$.0004 \geq -.5X_{1} - .5X_{11} - .5X_{21} - .5X_{32} - .5X_{42} - .5X_{52} - .5X_{70} - .5X_{72} - .5X_{74} - .083X_{76} - .083X_{78} - .083X_{80} - .5X_{82} - .5X_{84} - .5X_{86} - .5X_{95} - 1.25X_{112} - 1.25X_{115} - .5X_{117} - .5X_{118} - .5X_{128} - .5X_{136} - .5X_{151} - .5X_{155} + .62X_{174} + .62X_{181} + .62X_{185}$
April 16 - 31	$.0005 \geq -.5X_{1} - .25X_{10} - .5X_{11} - .25X_{20} - .5X_{21} - .25X_{30} - .5X_{32} - .25X_{41} - .5X_{42} - .25X_{51} - .5X_{52} - .25X_{61} - .5X_{70} - .5X_{72} - .5X_{74} - .083X_{76} - .083X_{78} - .083X_{80} - .5X_{82} - .5X_{84} - .5X_{86} - .5X_{95} - 1.25X_{112} - 1.25X_{115} - .5X_{117} - .5X_{118} - .25X_{127} - .5X_{128} - .5X_{136} - .25X_{145} - 1.0X_{146} - 1.0X_{147} - .5X_{151} - 1.0X_{153} - .5X_{155} - .5X_{166} - .5X_{167} - .5X_{168} - .5X_{169} - .5X_{170} - .5X_{171} - .5X_{172} + .62X_{181} + .62X_{185}$
May 1 - 15	$.0006 \geq -.5X_{2} - .25X_{10} - .5X_{12} - .25X_{20} - .5X_{22} - .25X_{30} - .065X_{31} - .5$

Table 54. Continued

		$X_{33} - .25X_{41} - .5X_{43} - .25X_{51} - .5X_{53} - .25X_{61} - .125X_{64} - .25X_{88} - .25X_{92} - .25X_{96} - .25X_{100} - .25X_{104} - .25X_{108} - .5X_{116} - .5X_{119} - .25X_{127} - .5X_{137} - .25X_{145} - .25X_{157} - .25X_{160} - .25X_{163} - .5X_{166} - .5X_{167} - .5X_{168} - .5X_{169} - .5X_{170} - .5X_{171} - .5X_{172} - .595X_{174}$
May 16 - 31	$.0007 \geq 0$	$.5X_{2} - .5X_{12} - .5X_{22} - .065X_{31} - .5X_{33} - .5X_{43} - .5X_{53} - .125X_{64} - .25X_{88} - .25X_{92} - .25X_{96} - .25X_{100} - .25X_{104} - .25X_{108} - .5X_{116} - .5X_{119} - .5X_{137} - .25X_{157} - .25X_{160} - .25X_{163} + .595X_{174} - .5X_{188}$
June	$.0008 \geq$	$- 1.0X_{3} - 1.0X_{13} - 1.0X_{23} - .13X_{31} - 1.0X_{34} - 1.0X_{44} - 1.0X_{54} - .25X_{64} - .50X_{88} - .5X_{92} - .5X_{96} - .5X_{100} - .5X_{104} - .5X_{108} - 1.0X_{113} - 1.0X_{120} - 1.0X_{129} - 1.0X_{138} - .5X_{157} - .5X_{160} - .5X_{163} + 1.12X_{174} - 1.0X_{185}$
July	$.0009 \geq$	$- 1.0X_{4} - 1.0X_{14} - 1.0X_{24} - 1.0X_{35} - 1.0X_{45} - 1.0X_{55} - .25X_{64} - .33X_{65} - .33X_{66} - .33X_{67} - .33X_{68} - .33X_{69} - .33X_{89} - .33X_{93} - .33X_{97} - .33X_{101} - .33X_{105} - .33X_{109} - 1.0X_{114} - 1.0X_{121} - 1.0X_{130} -$

Table 54. Continued

		$1.0X_{139} - .33X_{148} - .33X_{149} - .33X_{158} - .33X_{161} - .33X_{164} + 1.50$ $X_{174} + 1.50X_{181} + 1.50X_{185} - 1.0X_{188}$
August	$.0010 \geq$	$- 1.0X_{5} - 1.0X_{15} - 1.0X_{25} - 1.0X_{36} - 1.0X_{46} - 1.0X_{56} - .25X_{64} -$ $.33X_{65} - .33X_{66} - .33X_{67} - .33X_{68} - .33X_{69} - .33X_{89} - .33X_{93} -$ $.33X_{97} - .33X_{101} - .33X_{105} - .33X_{109} - 1.0X_{122} - 1.0X_{131} - 1.0$ $X_{140} - .33X_{148} - .33X_{149} - .33X_{158} - .33X_{161} - .33X_{164} + 1.80X_{174}$ $+ 1.80X_{181} + 1.80X_{185} - 1.0X_{188}$
September	$.0011 \geq$	$- 1.0X_{6} - 1.0X_{16} - 1.0X_{26} - .44X_{31} - 1.0X_{37} - 1.0X_{47} - 1.0X_{57} -$ $.33X_{65} - .33X_{66} - .33X_{67} - .33X_{68} - .33X_{69} - .33X_{89} - .33X_{93} - .33$ $X_{97} - .33X_{101} - .33X_{105} - .33X_{109} - 1.0X_{123} - 1.0X_{132} - 1.0X_{141} -$ $.33X_{148} - .33X_{149} - .33X_{158} - .33X_{161} - .33X_{164} + 1.80X_{174} + 1.80$ $X_{181} + 1.80X_{185} - .5X_{188}$
October	$.0012 \geq$	$- 1.0X_{7} - .5X_{10} - 1.0X_{17} - .5X_{20} - 1.0X_{27} - .5X_{30} - .15X_{31} - 1.0$ $X_{38} - .5X_{41} - 1.0X_{48} - .5X_{51} - 1.0X_{58} - .5X_{61} - 1.0X_{90} - 1.0X_{94} -$ $1.0X_{98} - 1.0X_{102} - 1.0X_{106} - 1.0X_{110} - 1.0X_{124} - .5X_{127} - 1.0X_{133}$ $- 1.0X_{142} - .5X_{145} - 1.0X_{159} - 1.0X_{162} - 1.0X_{165} + 1.32X_{174} + 1.32$

Table 54. Continued

	$X_{181} + 1.32X_{185}$
November	$.0013 \geq - 1.0X_{8} - 1.0X_{18} - 1.0X_{28} - .15X_{31} - 1.0X_{39} - 1.0X_{49} - 1.0X_{59} - .5$ $X_{71} - .5X_{73} - .5X_{75} - .167X_{76} - .20X_{77} - .167X_{78} - .20X_{79} - .167$ $X_{80} - .20X_{81} - .5X_{83} - .5X_{85} - .5X_{87} - 1.0X_{91} - 1.0X_{99} - 1.0X_{103}$ $- 1.0X_{107} - 1.0X_{111} - 1.0X_{125} - 1.0X_{134} - 1.0X_{143} - 1.0X_{150} -$ $1.0X_{154} - .5X_{173} + 1.32X_{174} + 1.32X_{181} + 1.32X_{185}$
December	$.0014 \geq - 1.0X_{9} - 1.0X_{19} - 1.0X_{29} - 1.0X_{40} - 1.0X_{50} - 1.0X_{60} - .5X_{71} -$ $.5X_{73} - .5X_{75} - .167X_{76} - .20X_{77} - .167X_{78} - .20X_{79} - .167X_{80} -$ $.20X_{81} - .5X_{83} - .5X_{85} - .5X_{87} - 1.0X_{126} - 1.0X_{135} - 1.0X_{144} -$ $1.0X_{152} - 1.0X_{156} - .5X_{173} + 1.22X_{174} + 1.22X_{181} + 1.22X_{185}$
May 1 - 15	$.0020 \geq - .5X_{175} - .5X_{177} - .25X_{179} - .25X_{180} - .595X_{181}$
May 16 - 31	$.0021 \geq - .5X_{175} - .5X_{177} - .25X_{179} - .25X_{180} - .595X_{181}$
June	$.0022 \geq - 1.0X_{176} - 1.0X_{178} - .5X_{179} - .5X_{180} + 1.12X_{181}$
May 1 - 15	$.0034 \geq - .5X_{182} - .25X_{184} + .595X_{185}$
May 16 - 31	$.0035 \geq - .5X_{182} - .25X_{184} + .595X_{185}$
June	$.0036 \geq - 1.0X_{183} - .50X_{184} + 1.12X_{185}$