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Optimum Plans for a 1600 Acre Ranch on Williams-Tetonka-Cavour Soil Association in Central South Dakota Including an Analysis of Pasture Improvement Work Done by Ranchers

Herbert R. Allen

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OPTIMUM PLANS FOR A 1600 ACRE RANCH ON WILLIAMS-TETONKA-CAVOUR SOIL ASSOCIATION IN CENTRAL SOUTH DAKOTA INCLUDING AN ANALYSIS OF PASTURE IMPROVEMENT WORK DONE BY RANCHERS

BY

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OPTIMUM PLANS FOR A 1600 ACRE RANCH ON WILLIAMS-TETONKA-CAVOUR SOIL ASSOCIATION IN CENTRAL SOUTH DAKOTA INCLUDING AN ANALYSIS OF PASTURE IMPROVEMENT WORK DONE BY RANCHERS

Abstract

HERBERT RAYMOND ALLEN

Under the supervision of Professor Rex D. Helfinstine

A profit maximizing linear programming model was used to arrive at optimum plans for a typical ranch in the Williams-Tetonka-Cavour soil association area of central South Dakota. The typical ranch used for this analysis had 500 acres of cropland and 1,056 acres of native grass.

Low, medium, and high levels of efficiency were assumed in grain crop and livestock production. Forage production was obtained from different management systems on tame grasses and native grasses. Tame grasses included brome-alfalfa, crested wheatgrass, Russian wild rye, and sudan grass. Native grass production was obtained from alternative management systems including renovated pasture, fertilized pasture, continuous grazed, or deferred grazing systems. Optimum plans, under five different levels of capital restriction, were developed for various combinations of the efficiency levels in crop and livestock production.

It was found in this study that crop production had priority on the use of capital at all levels of efficiency. When capital was very limited, profits were maximized by limiting the size of the beef cow herd and permitting pasture land to go idle. As capital became available it was profitable to place it first into crop production through

the use of fertilizer, weed and pest control, and improved crop varieties.

The optimum plans, obtained when efficiency levels were permitted to vary, added capital beyond the cropping program by first investing in low efficiency livestock. This permitted a larger volume livestock program and more acres of native pasture to be utilized. As capital became more available, livestock numbers were expanded and livestock efficiency was increased by investing in better breeding stock and improved management programs. Livestock fattening activities were also added as more capital became available. The typical program, when capital was not limited, maintained a cow herd under a $5\frac{1}{2}$ months grazing program. The calves were wintered on pasture and hay, grazed the following summer and then placed in a drylot fattening activity.

The most profitable crop program was highly dependent upon the relative crop production efficiencies and the assumed price relationships. Individual operators must evaluate their own production efficiency in the various crops and determine which crops to produce through the budgeting procedure.

In this study, it was only under a high efficiency level in both crops and livestock that it became profitable to interseed the 25 per cent condition rangeland. In all other situations this rangeland was utilized through a deferred grazing program. The results of this study indicate that the renovation of native pastures in central South Dakota is not profitable unless there is a high efficiency in both crop and livestock production and capital is not a limiting factor. As the efficiency in crop production increased it became more profitable to use cropland to produce cash crops. Forage production for livestock then came from native grassland. It was not profitable to invest in range improvement unless the efficiency in livestock production was relatively high. It must be recognized, however, that this study has placed no value upon the risk and uncertainty involved in crop production.

The second part of this study used a multiple correlation analysis to relate various factors to the amount of pasture improvement work done by ranchers.

Those factors that contributed most significantly to variation in the amount of pasture improvement work done were (1) innovativeness of the rancher, (2) his expectations regarding a satisfactory stand from a new seeding, and (3) his opinion regarding the profitability of range improvement relative to other alternatives.

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Doctor of Philosophy, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Adviser

Head, Economics Department Date

ACKNOWLEDGEMENTS

It is difficult to render proper recognition to all those persons who have assisted in the preparation of this study. Much preliminary work, beginning with a survey of ranchers in the summer of 1965, was necessary and important to the development of a completed study. I owe a special thanks to Dr. Rex Helfinstine for his counsel, patience, and understanding help along the way. To fellow graduate students who worked in the survey, or assisted in other material ways, I wish to express my thanks.

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PART ONE

ANALYSIS OF RANCH ORGANIZATION

CHAPTER I

THE PROBLEM AND OBJECTIVES

A fundamental economic problem facing ranchers of central South Dakota concerns the allocation and use of scarce resources in such a way as to maximize profits. More specifically how to organize the resources on a typical ranch in central South Dakota (Hyde County) under a given set of prices and conditions is the problem with which Part One of this study is concerned.

I. SOUTH DAKOTA AGRICULTURE

Grassland has been one of the major resources of the state of South Dakota. Data from the 1964 census of agriculture show that 58.3 per cent of total farmland in the state was used as pasture. This included 934,280 acres of cropland used only for pasture. Hyde County, the area with which this study is concerned, had 60.3 per cent of the total farmland in pasture. Fifty-nine per cent of the land in Hyde County was in native grassland.

Grass has been marketed primarily through livestock. As a result, beef has been the major product of our grasslands. Cash farm income from cattle and calves accounted for 47.1 per cent of total cash farm income in the state of South Dakota in 1965.[1] This compared with 18.1 per cent of cash farm income from hog production, 3.8 per cent

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[1]Crop and Livestock Reporting Service, South Dakota Agriculture, South Dakota Department of Agriculture, 1966, p. 90.

from sheep and wool, 3.8 per cent from poultry and eggs, 5.7 per cent from dairy products, and 0.5 per cent from other sources.

Cash income from crop production represented 21 per cent of total cash farm income. Crops included were corn, sorghum, oats, wheat, barley, flaxseed, soybeans, and rye. Many of these crops were also processed through livestock. Consequently, it is helpful to look at the farm value of crop production relative to cash receipts in order to understand the role that farm crops have played in producing income on farms and ranches. Table 1 presents the cash farm income and farm value of crop production for major crops in South Dakota.[2]

The table shows that wheat was the largest cash crop. However, corn, hay, and oats all ranked ahead of wheat in terms of farm value. These data also reveal that South Dakota has a variety of crops and livestock production. Rainfall limits the yields that may be obtained from these crops throughout most of the state. The thirty year average growing season precipitation (1931-60) for the central rainfall belt was 12.5 to 15 inches. This included the area with which this study is concerned. Under this situation, we find that grass has become very competitive with cash crops for the use of tillable land.

II. STATEMENT OF THE PROBLEM

The many alternative crop and livestock enterprises present a problem of how to best organize the ranch business to maximize profits.

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[2]Ibid, pp. 87-90.

Table 1. Cash Farm Income From Various Crops and Value of Crop Production in South Dakota, 1965*

Crop	Cash Farm Receipts	Value of Crop Production
	-Thousand Dollars-	-Thousand Dollars-
Wheat	48,734	53,395
Corn	34,684	102,208
Oats	21,505	64,747
Flaxseed	20,333	22,544
Soybeans	11,881	13,983
Hay	6,100	95,598
Barley	3,760	7,446
Rye	3,462	4,180
Sorghum	3,452	10,609

*Crop and Livestock Reporting Service, South Dakota Agriculture, South Dakota Department of Agriculture, 1966, pp. 87-90.

Under a limited capital situation the individual rancher is faced with the problem of allocating each unit of capital into its most productive area. With unlimited capital it would be possible to expand in all areas of opportunity to the optimum level of production. However, capital has been a scarce resource on many ranches.

There are many alternative uses of capital on ranches in central South Dakota. In addition, the various enterprises differ as to their returns to labor, capital, and management. Beef production has been a major enterprise, but many alternative beef producing programs may be followed. Likewise, there are many systems of pasture production and utilization that may be followed in producing beef. Beef cow and calf programs and steer grazing, or some combination of the two, are the most common enterprises.

Native grassland has been a scarce resource on many ranches. This is evident from the fact that our range conditions have been depleted as ranchers yield to pressures to produce more cattle from a given land area. Lewis states that "...the average range condition in the West River area has dropped one half of a range condition class or more since 1957 . . . . In the Northern Great Plains, about 10 per cent of the ranges are reported in excellent, 20 per cent in good, 40 per cent in fair, and 30 per cent in poor condition."[3]

While pastures and rangeland have been at less than optimum

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[3]J. K. Lewis, "Can South Dakota Ranches Run More Cattle," Talk presented at Third Annual West River Beef Cattle Days, 1963.

conditions, the number of cattle has been steadily increasing. Likewise, there has been an increasing demand for use of grazing lands from expansion of towns and cities, irrigation canals, highways, new airports, military reservations, and recreational sites.

III. PURPOSE AND OBJECTIVES

The objectives of this study were:

1. To present alternative ranch plans for maximizing net returns under varied capital levels and efficiency levels.
2. To determine a profit maximizing land use program from among the many pasture improvement programs and pasture management systems for beef production on a typical ranch.
3. To estimate optimum adjustment in ranch organization while undertaking a pasture renovation program.

IV. NATURE AND SCOPE OF THE STUDY

Part One of this study was a profit maximizing study making use of linear programming as an analytical tool. The analysis was applied to a typical ranch unit in central South Dakota as determined by a survey made in the summer of 1965.

The analysis of ranch organization was limited to a study of alternative land use patterns and beef production strategies on 1,056 acres of native grassland and 500 acres of cropland. Alternative grassland grazing programs and tame forage production programs were considered as activities.

All beef production activities were those originating from a beef cow herd on the ranch. The purchase of feeder steers off the farm or the introduction of non-beef enterprises was not considered. The livestock and crop production activities were developed under three assumed levels of efficiency. Emphasis was placed upon the effect of capital restrictions and efficiency levels on ranch organization.

CHAPTER II

REVIEW OF LITERATURE

Woods and Buddemeier[1] completed a study in 1959 to determine the economics of beef cow herds in the unglaciated area of Southern Illinois. The study included a survey of farms on which beef cow herds were kept. Data obtained in the survey were used to determine currently used organization and production practices. A budgeting procedure was used to develop alternative plans for farms with given sets of resources. The researchers found that the highest returns from capital used would be obtained by investing in fertilizer for increasing production of grain crops. The next highest returns was from hogs to utilize the increase in feed grains. Hogs were followed by fertilizer to increase roughage production, and finally enlargement of the beef cow herd.

Nielsen[2] used the linear programming technique to estimate the economic value of the range resource as measured through livestock production. The programming was applied to a block of public rangeland to illustrate the close relationship between public and private decision

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[1]H. S. Woods and W. D. Buddemeier, Increasing Production and Earnings on Farms with Beef-cow Herds in the Unglaciated Area of Southern Illinois, School of Agriculture Publication No. 6, Southern Illinois University, Carbondale, 1959.

[2]Darwin B. Nielsen, "Estimating the Economic Value of the Range Resource from Livestock Production," Economic Research in the Use and Development of Range Resources, conference proceedings of the Committee on Economics of Range Use and Development, Western Agricultural Economics Research Council, Reno, Nevada, June 16-17, 1964, pp. 83-111.

making and to portray how these resources ought to be used. No specific conclusions were drawn (at the date of writing) regarding a range improvement plan. However, the article illustrates the manner in which linear programming may be applied to range management problems. The author points out the need for further refinement of input-output data in range production as well as the methodology employed.

A study of pasture production and improvement in Southern Iowa was made by Heady, Olson, and Scholl.[3] The objectives of this study were:

1. To set forth some fundamental principles which are useful in answering questions of economy in pasture production.
2. To provide information on costs and returns for different systems of pasture improvement and to relate these to different farm situations with respect to limitations of capital.
3. To analyze the attitudes, viewpoints, and reasoning of farmers regarding pasture management.

Pasture costs were calculated for birdsfoot trefoil-orchardgrass (20 years)[4], alfalfa-brome-ladino (5 years), reed canary grass-ladino (5 years), phosphate and lespedeza (20 years), bluegrass nitrogen

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[3]Earl O. Heady, Russell O. Olson, and J. M. Scholl, Economic Efficiency in Pasture Production and Improvement in Southern Iowa, Agricultural Experiment Station Bulletin 419, Iowa State University, Ames, December, 1954.

[4]Figures in parentheses represent the period of time over which all costs were amortized.

fertilizer (1 year), and rented bluegrass pasture. The authors found that when all of the costs over a twenty year period were taken into account the two systems lasting twenty years appeared least costly. The researchers also found that about 85 per cent of the farmers felt that some improvement of their permanent pastures would pay. The most frequent reasons given for not having made such improvements were lack of capital and lack of sufficient livestock to utilize more pasture. Of those who gave lack of capital as their main obstacle less than 20 per cent of them were unable to borrow funds. Of those farmers who did not have enough livestock to utilize the pasture a large number of them did not increase livestock numbers because they felt it was too risky. Thus the authors concluded that uncertainty is a big factor restraining many farmers from the adoption of pasture improvement practices.

McKee,[5] Heady, and Scholl used linear programming to examine the optimum investment in pasture improvement in the southern pasture area of Iowa from the aspect of the farm as a whole. Crop activities in the model included four different rotations. Livestock activities included the beef cow-calf enterprise, yearlings fed on drylot, yearlings full fed on pasture, deferred feeding of yearlings, spring farrowed hogs, and fall farrowed hogs. Four alternative pasture improvement systems were provided along with pasture rental. A supplementary poultry enterprise also was included. The authors concluded from this study

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[5]Dean E. McKee, Earl O. Heady, and J. M. Scholl, Optimum Allocation of Resources Between Pasture Improvement and Other Opportunities on Southern Iowa Farms, Agricultural Experiment Station Research Bulletin 435, Iowa State University, Ames, January 1956.

that investment in permanent pasture improvement will be consistent with the objectives of maximizing farm profits if (a) resources are available to invest in enterprises that can profitably use the increased production of pasture forage and (b) alternatives more profitable than those enterprises using permanent pasture have been fully exploited. Unless the above two conditions are met, farm profits will be greater if the permanent pasture is left unimproved and the resources are used in some other alternative.

Loftsgard[6] and Griffing used linear programming to determine optimum plans for farms in central North Dakota. They found that for all farm situations considered, the first increments of capital returned highest total profits when used for a high fertilization cropping program. Livestock was not included in the maximum profit plan until the supply of operating capital was greater than required for intensive crop production.

Kluckman[7] made a study of the role of pasture improvement in producing beef in eastern South Dakota. This study used the budgeting procedure to develop whole farm plans and compare net returns from improved pastures versus native pastures. Gains made by yearling steers were used as a unit of measurement in order to determine gross

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[6]Laurel D. Loftsgard and Milton E. Griffing, Farm Planning Guides for Central North Dakota, Bulletin No. 425, North Dakota Agricultural Experiment Station, Fargo, August, 1960.

[7]Duane D. Kluckman, Economic Comparison of Improved and Unimproved Pastures in Producing Beef in Eastern South Dakota, Masters Thesis, Economics Department, South Dakota State University, Brookings, 1964.

income. Kluckman found that an operator having very limited capital would spend his first $235 on flax, the next $172 on oats, and the next $336 on corn. Additional capital would allow the operator to buy fertilizer for the cropping program, which returns higher dividends than any of the pasture projects. Total capital, beyond $1,192, would be invested in yearling beef steers to be grazed on the native pasture. With capital of $10,666 available, $1,192 is allocated to pasture production and $9,474 used for the purpose of grazing the native pasture.

Helfinstine[8] developed plans, using the budgeting technique, for the spring wheat area of north central South Dakota. The study was intended to find answers to some of the questions that face farmers concerning their most profitable production plans under wheat-acreage restrictions. Helfinstine's analysis brought out that a grain system of farming, using commercial fertilizer, was more profitable than one using alfalfa or sweet clover. Either feeder cattle and hog raising enterprises or lamb and hog raising enterprises were combined profitably with this system.

Umberger[9] completed a linear programming analysis for Faulk County (central South Dakota) in 1967. This study was for the purpose

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[8]Rex D. Helfinstine, Farm Plans for Wheat Farmers in North Central South Dakota, Bulletin 488, Agricultural Experiment Station, Cooperative with Agricultural Research Service, U.S.D.A., South Dakota State University, Brookings, 1960.

[9]Dwaine Edward Umberger, Minimum Resource Requirements for Specified Levels of Income in Faulk County, South Dakota, Masters Thesis, Economics Department, South Dakota State University, Brookings, 1967.

of developing and evaluating estimates of future farm sizes and organization in Faulk County, South Dakota. A minimum resource model was employed to determine the minimum combination of resources required to obtain specified levels of operator earnings. Crop activities in the model included corn, wheat, flax, oats, barley, and alfalfa in various rotations. Beef cow herds were allowed in all model formulations, including feeder calf systems, stocker enterprises, and hog enterprises. The results of the study indicated that for all operator earning levels, enterprise combinations allowing calves to be purchased and fed required the smallest amount of resources in terms of land, labor, and capital. The largest resource requirements were noted when the only enterprise included in the model was a beef-cow herd requiring 430 pound calves to be sold in the fall. It required 11,164 acres of land at current prices to earn a 5,000 dollar return to labor and management.

Aanderud[10] employed linear programming to study income variability on selected farm and ranch situations of northwest Oklahoma. He also analyzed the probable effect of this variability on capital accumulation and survival of the farm firm. The programming model included continuous wheat, barley, and grain sorghum as activities. Cropland grazing activities included forage sorghum, sudan grass, Johnson grass, weeping love grass, sandy land mix, wheat to graze out, and "go-back"

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[10]Wallace G. Aanderud, James S. Plaxico, and William F. Lagrone, Income Variability of Alternative Plans, Selected Farm and Ranch Situations, Rolling Plains of Northwest Oklahoma, Bulletin B-646, Agricultural Experiment Station and U.S.D.A., Oklahoma State University.

grass. Livestock enterprises in the model were buy-sell steer grazing and cow-calf activities. It was found in this study that the highest income plan was the one which included heavy-graze steers with a high capital level assumed. These plans also showed the most variability. The plans producing the lowest income and the least variability were those that included cow-calf units as the basic livestock enterprise. Lowering the level of capital for a given planning situation resulted in both lower and less variable income because of a reduction in the quantity of livestock produced and a shift from continuous wheat to a wheat-grain sorghum-fallow rotation.

CHAPTER III

METHOD AND PROCEDURE

Linear programming, as a tool for planning, has been applied to problems of management ever since World War II. In recent years, through the use of high speed computers, it has been applied quite extensively to problems of farm and ranch management. A brief description of linear programming is presented in this chapter, along with economic concepts and principles underlying its application to the problem described in Chapter I. Also discussed in this chapter is the source of data used in the linear programming analysis.

I. LINEAR PROGRAMMING

Linear programming is a tool for planning. As such, it is similar to budgeting analysis. However, linear programming differs from budgeting in two important ways:

1. It is able to consider a very large number of alternative activities.
2. From among the many alternatives it is able to select the "best" plan rather than just a better one.[1]

The term process or activity is used frequently in linear programming. They may be thought of in the same context as an enterprise, but the concept of an enterprise has a broader connotation than either

[1]John A. Hopkins, E. O. Heady, Farm Records and Accounting, Iowa State University Press, Ames, Iowa, 1962, pp. 342-343.

process or activity. Hog production may be thought of as an enterprise. But spring farrowing is a different activity from that of fall farrowing.[2] Further, whenever we have a different proportion between inputs, we have a different process. Spring farrowed pigs, using $120 in capital, would be a different process from spring farrowed pigs using $130 in capital. Brome-alfalfa hay, using fertilizer, is a different process from that using no fertilizer.

The mathematical model for linear programming employs a set of linear equations. A simplified set using only two variables would be:

$$(2.0) \qquad a_1x_1 + b_1x_2 = y$$

$$a_2x_1 + b_2x_2 = m$$

In this model y and m represent the supply of two different resources. The variables x_1 and x_2 represent the number of units of different activities or processes and the coefficients a and b represent the quantity of the resources used per unit of the x_1 and x_2 activities. It will be noted that such a model assumes divisibility of inputs and products. For example, if x_1 represents the number of head of cattle in a beef fattening activity, the solution equation will probably contain an x_1 value in "fractions of a head." This, however, presents no handicap for practical application or interpretation since the solution may be rounded to the nearest head. Such a model also assumes a linear function for each process. If the inputs to any process are doubled, the output will be doubled and income will be doubled. Thus,

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[2]E. O. Heady, W. Candler, Linear Programming Methods, Iowa State University Press, Ames, Iowa, 1964, p. 11.

the magnitude of any process or activity is increased by increasing the scale of the process. All inputs vary in the same proportion.

A solution to the example set of equations previously presented will completely exhaust the resources y and m. However, in ranch planning we do not want to force a system to use every unit of each resource. This could be unprofitable. Consequently, the example set of equations may be modified to the following, which permit resources to go unused.

$$(2.1) \qquad a_1x_1 + b_1x_2 + 1x_3 + 0x_4 = y$$
$$a_1x_1 + b_1x_2 + 0x_3 + 1x_4 = m$$

The variables x_3 and x_4 represent disposal activities (resources placed in idleness). Resources may be placed in a real activity, such as x_1 or x_2, or placed in the disposal activity for that resource. The disposal activity for the resource y is x_3. Its coefficient is one, since it takes one unit of resource y to place one unit of resource y in disposal. The same is true for the resource m and its disposal activity, x_4--- and all the other resources that may be included in any model.

It is not possible to produce beef cattle, corn, or any other activity in a negative quantity. Therefore, a further restriction upon the model is that:

$$(2.3) \qquad x_1 \geqq 0 \text{ and } x_2 \geqq 0$$

The objective of a linear programming problem for a ranch may be to either maximize profit or minimize cost. An example objective function of the following form is therefore set forth as:

(2.4) $z = cx_1 + dx_2$

In this function z = profit, c = income per unit of the x_1 variable, and d = income per unit of the x_2 variable.

A profit maximizing linear programming problem, such as used in this study, may now be described as one which maximizes an objective function (2.4) within the limitations placed upon it by the set of equations (2.1) and the non-negative restrictions (2.3).[3]

II. ECONOMIC CONCEPTS AND PRINCIPLES

The linear programming solution to a problem of resource allocation employs the techniques of marginal analysis. The mathematical solution incorporates the economic principle of substitution and opportunity cost. "Shadow price" represents the decrease in returns if one additional unit of an activity is brought into the plan. This is a marginal value. The "shadow price", for disposal activities, represents the marginal value product (MVP) of the resource. It may also be looked upon as the "opportunity cost" of one unit of input. If, for example, one acre of land is placed in idleness it may decrease returns by five dollars. Conversely, one acre of additional land will increase returns by five dollars. Whenever the MVP is zero for a disposal activity it means that this is a free resource. It does not limit production. Scarce resources, are those resources that do limit

[3]It is not the author's intent to present a detailed explanation of the linear programming method. For additional information the reader may consult any of several well known texts on the subject.

production.[4]

Diminishing returns may also be taken into account in the linear programming model. It has been mentioned that linearity is assumed for each process. However, by using a separate process or activity for each different level of resource input it is possible to apply the principle of diminishing returns. Oats produced using twenty pounds of fertilizer would be one activity and oats produced using thirty pounds of fertilizer would be another activity.

The straight line process using twenty pounds of fertilizer may be represented by the line OA in Figure I. Another straight line process using thirty pounds of fertilizer may be represented by the line OR. Activities of this nature are included in this study where forages may be produced by either of two activities. One activity uses fertilizer and the other uses no fertilizer.

The theoretical framework for the efficiency concepts used in this study are presented in Figure II. Curves I, II, and III are production functions assumed to be lying within the relevant range of production. They represent three different levels of efficiency. Efficiency, for this analysis, is measured by output per unit of input.

The different production functions are the result of assumed efficiencies in labor use, machine time and fuel consumption, quality of product, and feed conversion rates. A low efficiency level in any one process may be represented by the point A, lying on Curve I with

[4]For detailed discussion of these concepts consult E. O. Heady, and W. Candler, op. cit. pp. 85-91.

Figure I. Production Processes Showing Diminishing Returns

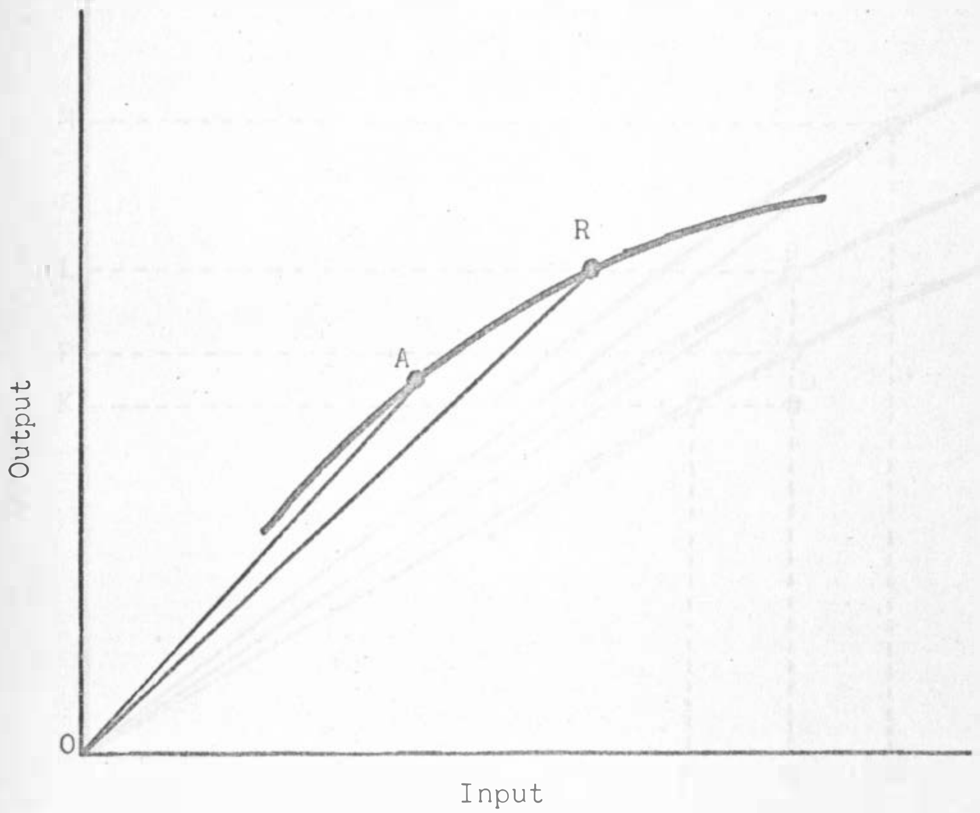
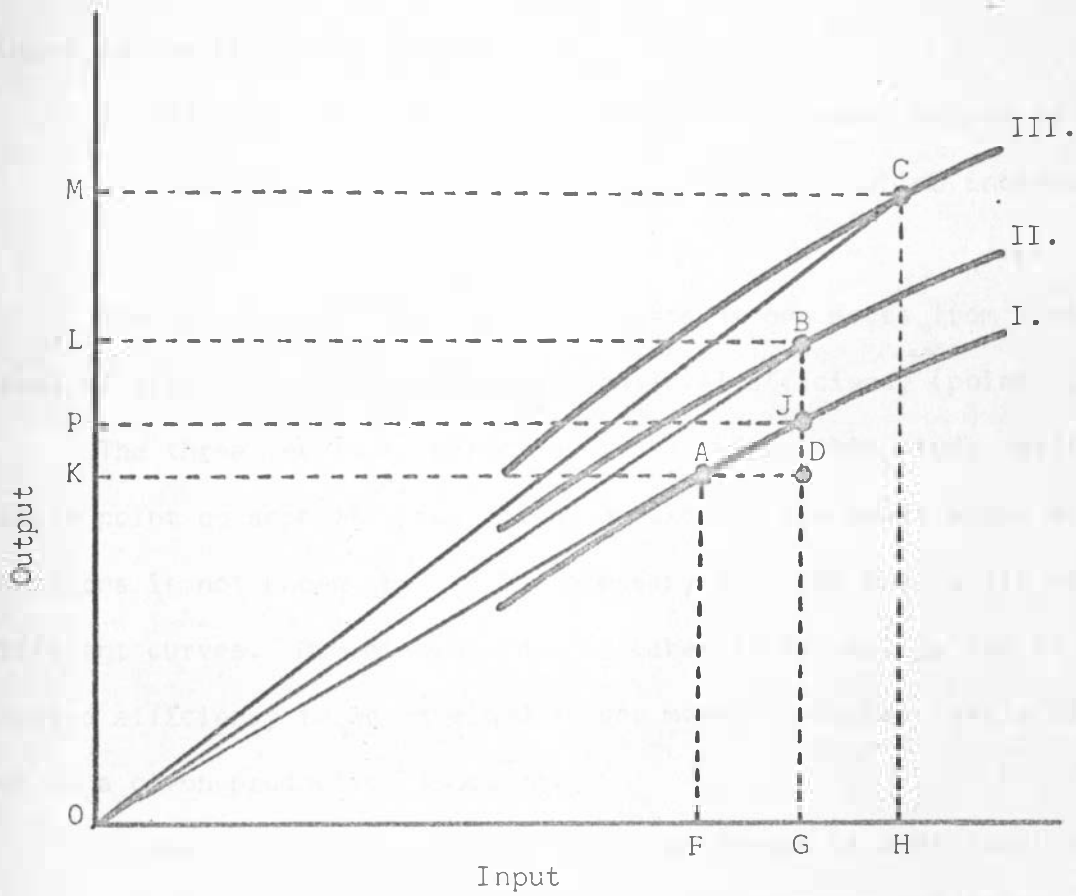


Figure II. Theoretical Framework for Efficiency Concepts



output OK. It is assumed to have a linear function represented by the line OA. A medium level of efficiency may be represented by the point B, lying on Curve II with output OL. Likewise, a high level of efficiency is represented by point C on Curve III with output OM. When moving from a low level efficiency to a medium level efficiency, output as shown in Figure II, increases by the amount KL. This increase in output is the result of two factors:

1. Added inputs in the amount FG which increases output by PK.
2. Assumed differences in level of efficiency which increases output by the amount PL.

The same kind of relationship exists as one moves from a medium level of efficiency (point B) to a high level efficiency (point C).

The three levels of efficiency, assumed in this study, define a single point on separate production functions. The exact shape of the functions is not known, but it is necessary that the points lie on different curves. Diminishing returns makes it impossible for an increased efficiency to be attained as one moves to higher levels of output on a given production function.

It may be possible to move to higher levels of efficiency and greater levels of input but the question of whether or not it is profitable to do so needs to be answered. The linear programming method, under a given set of assumptions and using a profit maximizing model, is able to answer this question.

III. SOURCE OF DATA

In the summer of 1965 a survey was taken in Faulk, Hyde, Aurora, and Gregory Counties in South Dakota. A personal interview was made of all those drawn in a random sample of farm operators.[5] Data from this survey have been used in a variety of ways throughout this study. It should be mentioned that, henceforth, whenever the survey is mentioned it is in reference to the one described above. Data from the survey have been used in determining labor requirements for beef cow herds, practices carried out by ranch operators, and in developing activity budgets. Survey data from Hyde County have been the source of information for defining a typical farm, as used in this study. Table 2 presents the average crop acres per farm for the forty farms included in the survey. Wheat, oats, corn, and alfalfa hay are the predominant crops. Eighty-one acres of the 446.7 acres of cropland is fallow land or land in government programs. The average ranch contains 1,683.6 acres of land, of which 1,151.78 acres is native hay and range.

Much information on machine operations has been obtained from work completed by Sanderson.[6] Data prepared by Aanderud[7] has also been

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[5]See page 105 of this study for further information on the survey.

[6]John T. Sanderson, Assistant Professor, S.D.S.U., unpublished work on North Central Regional Project Number 54 involving central South Dakota.

[7]Wallace G. Aanderud, Guidebook for Planning a Farm or Ranch Business, Extension Circular 633, Cooperative Extension Service, South Dakota State University, Brookings, 1965.

Table 2. Average Crop Acres Owned and Rented Per Farm, Forty Farms, Hyde County Survey, 1965

Crop	Owned	Rented	Total
Spring wheat	36.58	8.13	44.71
Winter wheat	23.85	7.25	31.10
Oats	35.18	12.04	47.22
Barley	0.60	1.13	1.73
Rye	5.50	0.00	5.50
Corn grain	27.28	7.75	35.03
Corn silage	25.85	11.53	37.38
Sorghum grain	0.11	0.00	0.11
Sorghum silage	6.78	1.35	8.13
Alfalfa hay	95.75	24.62	120.37
Mixed tame hay	20.98	8.63	29.61
Sudan grass pasture	0.76	0.00	0.76
Annual pasture	1.95	0.55	2.50
Soil bank	21.08	9.75	30.83
Idle ground	35.20	15.40	50.60
Legume seed*	0.00	0.00	0.00
Flax	0.00	0.75	0.75
Millet	0.38	0.00	0.38
TOTAL CROPLAND	337.83	108.88	446.71
Native hay	145.69	107.63	253.32
Native range	672.22	226.24	898.46
Introduced pasture**	35.72	4.00	39.72
Other land	25.54	4.26	29.80
Farmstead	13.99	1.60	15.59
TOTAL LAND	1230.99	452.61	1683.60

*Legume seed acres are not added into total acres. They are included in mixed tame hay.

**All perennial tame grass pastures.

helpful in developing activity budgets.

Research publications by the Agronomy and Animal Science Departments of South Dakota State University were also used extensively in developing activity budgets. Likewise, research reports from the Great Plains Pasture Research Station at Mandan, North Dakota were a source of data.

CHAPTER IV

THE PROGRAMMING MODEL

A static linear programming model was used in this analysis to estimate maximum income under a given set of resource restrictions. A dynamic analysis is employed in Chapter X to estimate the adjustments through time when a pasture improvement program is undertaken. A description of the activities and resource restrictions, as well as the assumptions underlying these models, is presented in this chapter.

I. LIVESTOCK ACTIVITIES

Livestock activities in this study were limited to beef production originating from cow herds established on the ranch. This was done since a major consideration of this study was centered around efficiencies in beef production from the natural grasslands and supplemental tame forages as produced in central South Dakota. Survey results also revealed that 90 per cent of the ranches surveyed had a beef cow herd as a basic enterprise. Therefore, no attempt was made to estimate the effect upon income by introducing livestock activities other than beef. The purchase of feeder cattle was not permitted in this model. The use of pasture and forage production through beef, within the limits described above, presents many alternative management strategies to the individual rancher. This is the managerial framework common to ranchers in central South Dakota. It is also the framework within which this study is conducted.

Cow-calf Herds

Two basic cow-calf activities were considered. One activity produces feeder calves for sale on October 30 and the other produces calves to be held longer and sold in January. Each of the two activities may be carried out under either a 10 month grazing program or a $5\frac{1}{2}$ month grazing program. A 10 month grazing program requires $3\frac{1}{2}$ months of grazing during the winter, a crested wheat pasture for grazing between April 15 and May 15 plus adequate pastures for grazing from May 15 to November 1. A $5\frac{1}{2}$ month grazing program provides grazing between May 15 and November 1.

Budgets were developed at three assumed levels of efficiency for each of the four cow-calf programs described above. This results in a total of twelve activities to be included in the model for the cow-calf herd. Differences in level of efficiency are assumed to be due to:

1. Quality of herd as reflected in weight of calf sold, price received, and breeding charge.
2. General herd management as reflected in per cent calf crop.
3. Labor efficiency as reflected in hours per cow unit.

Table 3 presents the assumed input-output data in cow-calf activities contributing to differences in level of efficiency. The table reflects assumed differences between grazing programs and date of calf sales, as well as between levels of efficiency. Per cent calf crop is 88 per cent for low efficiency, 90 per cent for medium, and 92 per cent for high efficiency. Breeding charge per cow unit is \$5.00, \$7.00, and \$9.00 respectively for low, medium, and high levels of

Table 3. Assumed Input-Output Data in Cow-Calf Activities Which Contribute to Differences in Level of Efficiency

	10 Month Grazing		$5\frac{1}{2}$ Month Grazing	
	Sell in Oct.	Sell in Jan.	Sell in Oct.	Sell in Jan.
Low Level Efficiency				
Weight of calf sold, lbs.	415	480	415	480
Calf price per cwt.	$26.00	$25.50	$26.00	$25.50
Breeding charge per cow unit	$ 5.00	$ 5.00	$ 5.00	$ 5.00
Per cent calf crop	88	88	88	88
Hours of labor per cow unit	10	11	12	13
Medium Level Efficiency				
Weight of calf sold, lbs.	425	500	425	500
Calf price per cwt.	$27.50	$27.00	$27.50	$27.00
Breeding charge per cow unit	$ 7.00	$ 7.00	$ 7.00	$ 7.00
Per cent calf crop	90	90	90	90
Hours of labor per cow unit	8	9	10	11
High Level Efficiency				
Weight of calf sold, lbs.	435	520	435	520
Calf price per cwt.	$29.00	$28.50	$29.00	$28.50
Breeding charge per cow unit	$ 9.00	$ 9.00	$ 9.00	$ 9.00
Per cent calf crop	92	92	92	92
Hours of labor per cow unit	6	7	8	9

efficiency. Inputs, other than those presented in Table 3, do not change with efficiency levels.

Labor requirements were based upon data obtained in the survey. These data are presented in Appendix Table 51 and Appendix Figure IV.

Calf Wintering

Calves produced by the cow herd for sale in October may either be sold on the market, enter a fattening activity, or be wintered for the period from November 1 to April 15. Per cent calf crop, which changes with level of efficiency, affects the number of calves going into the wintering programs as well as succeeding programs. The programming model employs calf transfer units in "head" of livestock. Calves are either sold, or carried through for continuing livestock activities. The calf units (head of livestock) are composed of both heifers and steers. For example, a low efficiency beef cow herd of one hundred cows would produce eighty-eight calves. A 16 per cent replacement rate is assumed; therefore, sixteen of the eighty-eight calves would be held back for replacements. This leaves seventy-two calves (.72 of a calf on a per cow basis) to be sold or transferred to other activities. These seventy-two calves are composed of forty-four steers and twenty-eight heifers. Each calf unit in a transfer row represents 61 per cent steer and 39 per cent heifer. This same relationship was held throughout as calves were transferred into succeeding activities or sold. Sale price and sale weights represent those for 61 per cent steer and 39 per cent heifer.

Assumed differences in level of efficiency for calves in the wintering program are the result of:

1. Quality of livestock as reflected in rate of gain, grade, and animal value. Calves are assumed to grade low good, good, and choice for low, medium, and high levels of efficiency respectively.
2. Feed input changes as differing rates of gain result in differing animal weights.
3. Labor requirements vary by 10 per cent above and below the medium level of efficiency.

Calf Fattening

Calves produced by the cow herd may enter a fattening program on November 1 to be fattened for sale on a high roughage feeding program. Assumed differences in levels of efficiency are the result of the same factors described for the calf wintering program. Descriptions of the fattening programs for the three levels of efficiency are as follows:

1. Low level efficiency: Calves grading low good are fed a high roughage ration using hay and grain. They gain 1.8 pounds per day for a total gain of 600 pounds. They are fed 334 days and are sold on August 31 weighing 1,015 pounds, grading high good, for $23 per hundredweight.
2. Medium level efficiency: Calves grading good are fed a high roughage ration using hay and grain. They gain 1.9 pounds per day for a total gain of 600 pounds. They are on feed 316 days and are sold on August 13 weighing 1,025 pounds, grading low choice, for $24 per hundredweight.

3. <u>High level efficiency:</u> Calves grading choice are fed a high roughage ration using hay and grain. They gain 2.0 pounds per day for a total gain of 600 pounds. They are on feed 300 days and sold July 28 weighing 1,035 pounds, grading choice, for $25.00 per hundredweight.

Summer Grazing Activities

On April 15, at the end of a calf wintering program, yearling cattle may enter either a summer grazing program of 6.5 months or one of 4.5 months.

The longer grazing program utilizes an early spring pasture of crested wheat grass between April 15 and May 15. The shorter grazing program uses hay, rather than pasture, during this same period.

Summer graze yearlings, 6.5 months

1. <u>Low efficiency:</u> Yearlings grading low good enter at 547 pounds. They use 4.38 AUM's of grazing and gain 1.3 pounds per day for 195 days. They are sold November 1 weighing 800 pounds, grading low good, for $23.50 per hundredweight.
2. <u>Medium efficiency:</u> Yearlings grading good enter at 574 pounds. They use 4.65 AUM's of grazing and gain 1.45 pounds per day for 195 days. They are sold November 1 weighing 857 pounds, grading good, for $23.75 per hundredweight.
3. <u>High efficiency:</u> Yearlings grading choice enter at 600 pounds. They use 4.91 AUM's of grazing and gain 1.6 pounds per day for 195 days. They are sold November 1 weighing

912 pounds, grading choice, for $24 per hundredweight.

Summer graze yearlings, 4.5 months

1. Low efficiency: Yearlings go on pasture May 15 weighing 586 pounds. They use 3.03 AUM's of grazing and 0.2 tons of hay. Rate of gain is 1.3 pounds per day for 135 days. They may either be sold or enter a fattening activity on October 1 weighing 762 pounds, grading good. If they are sold, they sell for $23.75 per hundredweight.

2. Medium efficiency: Yearlings go on pasture May 15 weighing 617 pounds. They use 3.22 AUM's of grazing and 0.22 tons of hay. Rate of gain is 1.45 pounds per day for 135 days. They may either be sold or enter a fattening activity on October 1 weighing 813 pounds, grading good. If they are sold, they sell for $24.00 per hundredweight.

3. High efficiency: Yearlings go on pasture May 15 weighing 648 pounds. They use 2.56 AUM's of pasture and 0.23 tons of hay. Rate of gain is 1.6 pounds per day for 105 days. They may either be sold or enter a fattening activity on September 1 weighing 816 pounds, grading choice. If they are sold, they sell for $24.25 per hundredweight.

Fatten Heavy Yearlings

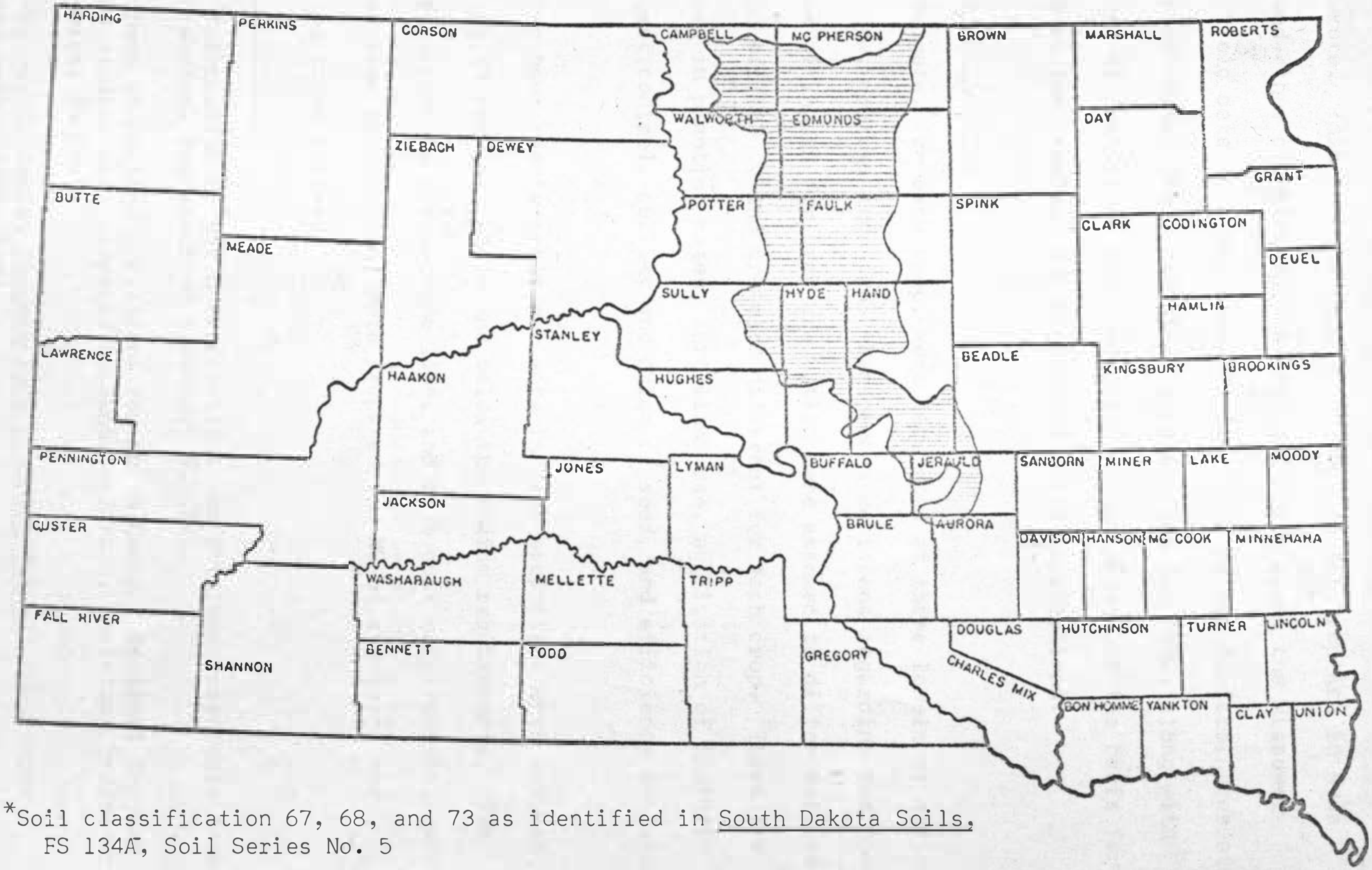
Cattle coming out of the shortest summer grazing program may either be sold or enter a fattening activity. They are fattened on a corn silage, hay, and grain ration in drylot.

1. Low efficiency: Cattle enter the drylot on October 1, weighing 762 pounds. Rate of gain is 2.2 pounds per day for 154 days. They are sold March 3 weighing 1,100 pounds, grading high good, for $23.75 per hundredweight.
2. Medium efficiency: Cattle enter the drylot on October 1, weighing 813 pounds. Rate of gain is 2.35 pounds per day for 122 days. They are sold February 2 weighing 1,100 pounds, grading low choice for $24.00 per hundredweight.
3. High efficiency: Cattle enter the drylot on September 1, weighing 816 pounds. Rate of gain is 2.5 pounds per day for 114 days. They are sold December 23 weighing 1,100 pounds, grading choice for $24.50 per hundredweight.

II. CROP ACTIVITIES

The average size ranch in the survey of Hyde County was 1,684 acres. The linear programming analysis in this study was therefore, applied to an assumed 1,600 acre unit. The unit consisted of 500 acres of cropland, 1056 acres of native range, and 44 acres in roads, farmstead, and wasteland. It was further assumed that the ranch was within the Williams-Tetonka-Cavour soil association of central South Dakota. Figure III identifies the area represented by this soil series. Crop production in this area predominates on a Williams soil. Yield expectations are representative of the cropland soils in soil resource group 102 within land resource area 53. This is a deep, friable, well drained loam soil in the semi-arid grassland country of

Figure III. Location of Williams-Tetonka-Cavour Soil Association*



*Soil classification 67, 68, and 73 as identified in South Dakota Soils, FS 134A, Soil Series No. 5

South Dakota. This land is typical of much of the cropland in Hyde County and other counties to the west and north along the Missouri River. Yield data for this area, as developed by agronomists, presents the current normal yield and yield expectations for 1980, along with the necessary fertilizer requirements.[1] These data were the basis for arriving at low, medium, and high level yield expectations.

Levels of Efficiency

Budgets, for each crop, were developed at three levels of efficiency--low, medium, and high. Management decisions regarding the combinations of inputs for crop production were assumed to differ between levels of efficiency and are also different for each crop. There are variations in planting rates, fertilizer use, application of insecticides, pest control, quality and price of seed, and efficiency in labor use.

Man hour requirements per acre in crop production were assumed to vary by 10 per cent above and below the medium requirements. The medium requirements for machine time, and also cost requirements, were developed from survey data, data prepared for NC-54 studies[2], and studies by other states[3].

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[1]Information on yield expectations was obtained personally from Dr. Fred Weston, Professor of Agronomy, S.D.S.U.

[2]Data on machine operations for North Central Regional Project Number 54 studies were prepared by John Sanderson, Assistant Professor of Economics, S.D.S.U.

[3]Sydney C. James, Midwest Farm Planning Manual, Iowa State University Press, Ames, Iowa

Table 4. Five Year Average Yields for Hyde County and Yield Assumptions for Low, Medium, and High Level of Production Efficiency

Crop	Five Year Average*	Efficiency Level Low	Medium	High
			-Bushels-	
Corn following corn	24.4	23	32	41
Corn following legume		28	34	41
Spring wheat following row crop	15.3	15	21	27
Spring wheat following small grain		12	18	24
Spring wheat following fallow or alfalfa		18	24	30
Oats	31.6	35	47	59
Barley	23.7	26	36	46
Sorghum grain	26.4	25	35	45
Flax	7.4	6	11	16

*Average for all rotations. Data reported by the South Dakota Crop and Livestock Reporting Service, 1961-65.

land is in 25 per cent condition. In this condition "red group plants or the short grasses of the yellow group make up most of the vegetation. Unpalatable shrubs may become more abundant. Water runoff and soil erosion is high."[6] A deferred grazing activity was provided as one system of pasture production on grassland in this condition. Five acres of such a system provided for one acre of winter grazing, one acre of spring and summer pasture, one for late summer and fall grazing, one for hay, and one acre to be rested. Production is estimated per acre of the system.

A pasture renovation activity was provided as an alternative method of using the 25 per cent condition grassland. In this activity the pasture is interseeded with a mixture of blue grama, western wheatgrass, big bluestem, and green needlegrass. Costs were amortized over a ten year period. The renovation activity, when it comes into the plan, uses one acre of 25 per cent condition pasture and produces one acre of 75 per cent condition pasture. Another activity provided the alternative of using the 25 per cent condition pasture as it is. This was a continuous grazing program with relatively low production.

There are 896 acres of native pasture land assumed to be in 75 per cent condition. In this condition the range is made up of a large proportion of palatable vegetation. Many green group and yellow group plants are present. "Slight erosion may be evident. The ground cover

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[6]James K. Lewis, L. R. Albee, and P. L. Howard, South Dakota Range Its Nature and Use, Cooperative Extension Service and Agricultural Experiment Station, Extension Circular 605, January 1963, pp. 20-22.

is still good and some mulch is present."[7] Three activities were provided as alternative uses of this pasture. One activity was a continuous grazing program with no fertilizer and the other was a fertilized pasture. The third activity was making of native hay.

All production of tame pastures or forage was taken out of cropland use. This included crested wheatgrass, brome-alfalfa, sudan grass, and Russian wild rye. Crested wheatgrass pastures provided grazing for a one month period in early spring between April 15 and May 15. Three activities were included for crested wheatgrass production. One was for crested wheatgrass not fertilized, a second was for fertilized crested wheatgrass, and a third was crested wheatgrass-alfalfa mixture.

Brome-alfalfa may be produced under two different management programs. In one program the pasture is rotation grazed and fertilized. This program also produces .37 tons of hay per acre by taking the first cutting from one-half the pasture land at the beginning of the season. The second brome-alfalfa program is continuous grazed and not fertilized.

Sudan grass was included as an activity and it produces 5 AUM's of grazing in the period from July 16 to August 31.

The Russian wild rye activity is only for fall grazing. It produces 2 AUM's per acre from September 1 to October 31.

Brome-alfalfa hay production may be carried out under two

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[7] Ibid

activities. One uses fertilizer and the other uses no fertilizer.

Aftermath grazing is produced by the use of corn stubble, small grain stubble, and alfalfa hay ground. A complete list of the activities included in the model for forage production is presented in Appendix Table 58.

Pasture production was measured in animal unit months (AUM's) according to the formula:[8]

$$\frac{\text{(Animal Units) (Months)}}{\text{Acres}} = \text{AUM's per acre}$$

Forage production was estimated on a seasonal basis. Likewise, the forage requirements for livestock were distributed on a seasonal basis. AUM's of pasture production by seasons served as intermediate products in this model. Table 5 presents the estimated seasonal production of forage by the several alternative pasture programs.

Level of Efficiency

All forage activities described in Table 5 were included in the model with all three levels of crop production efficiency. Variations in management of the forage programs, are the result of fertilization, rotation grazing, or seeding mixtures. However, no attempt was made to estimate input-output data for forage activities to correspond to the three levels of efficiency as established in crop production.

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[8]An animal unit represents 1,000 pounds of liveweight. A 580 pound steer grazing for one month would therefore require .58 AUM's. A pasture that would carry a 1,000 pound cow for one month on one acre would produce 1 AUM per acre.

Table 5. Seasonal Distribution of Forage Production Per Acre from Various Forage Crops Under Different Management Programs, Hyde County

Item	Hay Production*	Pasture Production: Apr. 16– May 15	May 16– July 15	July 16– Aug. 31	Sept. 1– Oct. 31	Nov. 1– Apr. 15	Season Total
	–Tons	–Animal Units Per Month–					
Crested wheatgrass, not fertilized		1.0					1.0
Crested wheatgrass, fertilized		1.52					1.52
Crested wheatgrass and alfalfa		1.11					1.11
Brome-alfalfa, rotation grazed, fertilized	.37		1.667	.308	.417		2.392
Brome-alfalfa, continuous grazing, no fertilizer			1.0	.75	.5		2.25
Sudan grass				5.0			5.0
Russian wild rye					2.0		2.0
Native grass, 75% condition, no fertilizer			.21	.16	.1		.47
Native grass, 75% condition, fertilized			.41	.31	.21		.93
Native grass for winter grazing, (Western wheatgrass)						.57	.57
Native grass, 25% condition, continuous grazing			.07	.05	.03		.15
Native grass, 25% condition, deferred grazing	.16		.1	.06	.08	.12	.36
System production and grazing	.083	.275	.418	.195	.604		1.492
Native grass for hay	.8						
Aftermath grazing							
Corn stubble:							
Low efficiency						.3	.3
Medium efficiency						.35	.35
High efficiency						.4	.4
Small grain stubble, all levels of efficiency				.1			.1
Alfalfa hay ground, not fertilized					.2		.2
Alfalfa hay ground, fertilized					.5		.5

*Hay production in grass hay equivalent tons

IV. RESOURCE RESTRICTIONS

Resource restrictions at the non-zero level in this model were the basic resources of land, labor, and capital. A listing of resource restrictions is presented in Appendix Table 58.

Cropland Restrictions

Cropland restrictions were 69 acres of land with 3 to 6 per cent slope and 431 acres of land with less than 3 per cent slope. Native grassland was restricted to 160 acres in 25 per cent condition and 896 acres in 75 per cent condition.

Labor Restrictions

Labor restrictions were established on a monthly basis for the period of April through October. This was assumed to be the critical period for labor requirements and an activity could not enter the program if it required labor in any month beyond that available. The supply of labor by periods is given in Table 6. It was assumed that one full time operator would put in a ten hour day, twenty-five days per month, during the period November through March. Five days would be taken for vacation during this same period. The operator also puts in a twelve hour day (300 hours per month) for the period April through October. Housewife labor is available in the amount of twenty-five hours per month for the months of April through September. Hired labor may be employed up to two hundred hours per month for the period April through September. Labor hired by any optimum plan was subtracted from the functional value of the plan in the same manner as fixed costs.

Table 6. Hours of Labor Supply By Periods

Labor Period	Operator Labor	Housewife Labor	Hired Labor	Total Labor
April	300	25	200	525
May	300	25	200	525
June	300	25	200	525
July	300	25	200	525
August	300	25	200	525
September	300	25	200	525
October	300	--	--	300
November-March	1200	--	--	1200
TOTAL	3275	175	1200	4650

The amount of labor hired varies between levels of efficiency and capital limitations.

Capital Restrictions

Capital restrictions were imposed in the amounts of $5,000, $10,000, $15,000, $20,000, and an unlimited amount. In situations with capital unlimited, a capital borrowing activity was employed with a 6 per cent annual rate charged on all capital used. Therefore, wherever the term "unlimited capital" is employed, it shall be taken to mean that capital will be employed as long as the marginal return is greater than 6 per cent.

Capital used by activities includes total variable costs in crop and livestock production plus annual investment capital in livestock production.

V. GENERAL ASSUMPTIONS

This model assumed an owner operated ranch unit. No analysis was made of the effect of tenure upon resource use. Acreage allotments for participation in government programs were not assumed in this model. Government program restrictions and their effect upon ranch plans are left for further study and investigation.

The purchase of feed grain, pasture, or hay was not permitted in this model. Corn, oats, barley, and grain sorghum activities produce corn equivalent bushels of grain, which may be either fed to livestock or sold. Livestock activities were limited to feed produced on the ranch.

Price Levels

Price levels in this study reflect current market prices for inputs and products. The set of price assumptions is presented in Appendix Table 52.[9]

Agricultural Conservation Program cost sharing was assumed for the pasture renovation activity. Payments of $6.00 per acre were subtracted from the total cost of pasture renovation.

A given complement of machinery was assumed to be owned by the operator and it is as presented in Appendix Table 57. Combining of small grain is custom hired. It was anticipated that some plans may have large acreages of small grain, some may have no small grain production, and the feasibility of owning a combine would vary with the crop production program. It was, therefore, decided to make a harvesting charge under a custom hire situation for all activities.

Fixed Costs

Fixed costs were assumed to be the same for all optimum plans developed for the 1,600 acre ranch unit. Depreciation on a given set of permanent improvements adequate to handle a maximum volume operation was assumed in this model. A listing of these improvements is presented in Appendix Table 49. Fixed costs include taxes, housing, insurance, interest on investment, and depreciation for machinery. Other fixed costs include land tax, liability insurance, fencing costs,

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[9]Price differentiation by grades and season for slaughter cattle is based upon five year average prices at Sioux Falls, South Dakota as given by the Crop and Livestock Reporting Service.

telephone, electricity, professional services, building depreciation, and interest on land capital. Fixed costs are presented in Appendix Table 48.

CHAPTER V

OPTIMUM RANCH PLANS UNDER LOW LEVEL OF PRODUCTION EFFICIENCY AND VARYING CAPITAL RESTRICTIONS

Optimum ranch plans, under a low efficiency level of production, were developed for five different levels of restriction on operating capital. The results of the linear programming are presented in this chapter.

I. LAND USE PROGRAM

Table 7 presents the optimum land use program under five, ten, fifteen, and twenty thousand dollars of operating capital and under unlimited capital. It can be observed in Table 7 that all land (69 acres) with a 3-6 per cent slope is utilized by a corn-wheat rotation. This situation is true for sloping land under all capital situations.

Cropland under 3 per cent slope was shifted out of pasture production and into grain production as capital was reduced. At a capital level of $15,000, 2.9 acres of cropland was used to provide a fall pasture of Russian wild rye. At levels of $10,000 or less, no cropland was used for pasture production, but with unlimited capital, 173.2 acres of cropland was used for pasture. If adequate capital is available it is possible to make the investment in livestock which is needed if pasture is to be utilized. However, crop production has priority on capital use when capital limits production.

Brome-alfalfa, not rotated or fertilized (P_{79}), provided most of

Table 7. Optimum Land Use Program Under Restricted Capital Situations, Low Efficiency Level

	Capital Limits (Dollars)				
Item	5,000	10,000	15,000	20,000	Unlimited
			-Acres-		
Cropland in grain, 3-6% slope					
Corn grain	34.5	34.5	34.5	34.5	34.5
Wheat	34.5	34.5	34.5	34.5	34.5
Cropland in grain, under 3% slope					
Corn grain	263.3	258.8	246.2	230.8	183.1
Corn silage	0.0	0.0	3.1	7.0	11.4
Barley	153.4	169.8	178.8	172.6	63.3
Sorghum	14.3	2.4	0.0	0.0	0.0
Total cropland in grain	500.0	500.0	497.1	479.4	326.8
Cropland in pasture					
Brome-alfalfa, rotated and fertilized	0.0	0.0	0.0	0.0	4.4
Brome-alfalfa, not rotated or fertilized	0.0	0.0	0.0	0.0	116.6
Russian wild rye	0.0	0.0	2.9	20.6	52.2
Total cropland in pasture	0.0	0.0	2.9	20.6	173.2
TOTAL CROPLAND	500.0	500.0	500.0	500.0	500.0
Native pasture land					
75% condition, not fertilized	103.9	527.2	790.2	744.2	572.8
25% condition, deferred grazing	145.0	160.0	160.0	160.0	160.0
Native hay	0.0	57.3	105.8	151.8	323.2
Unused pasture	807.1	311.5	0.0	0.0	0.0
TOTAL NATIVE PASTURE LAND	1056.0	1056.0	1056.0	1056.0	1056.0

the tame pasture. Only 4.4 acres of brome-alfalfa would be fertilized and rotation grazed at low levels of efficiency in crop and livestock production. Russian wild rye for late fall grazing uses 52.2 acres of cropland when capital is unlimited.

The shift to more corn and sorghum at low levels of capital was also due to the pattern of labor use. With fewer numbers of livestock included in the plan there was more labor available for corn and sorghum. Both of these crops require more labor than barley production.

Native pasture land in 25 per cent condition was utilized in every instance through a deferred grazing system. There were the alternatives of grazing the pasture continously or renovating it by interseeding. At the five thousand dollar capital limit, there was a portion of the pasture left unused. There was a total of 807 acres of native grassland going unused at the five thousand dollar capital limit and 311.5 acres unused at a ten thousand dollar capital limit. The obvious course of action under such a situation is to rent out the unused pasture land. However, a rental activity and income from rent was not included in this model. At very low levels of capital availability the more profitable investments are in crop production rather than livestock.

There was no crested wheatgrass production for early spring grazing included in the optimum plan. The model provided for three alternative management programs in crested wheat production and longer grazing periods for livestock to utilize the early spring pasture.

II. LIVESTOCK PROGRAM

The optimum beef production program at a low efficiency level of production is presented in Table 8. With unlimited capital an eighty-five cow herd, under a 5.5 month grazing program (P_{35}), was the basic enterprise. Fifty calves, from a 72 per cent calf crop, were wintered on pasture and hay (P_{47}) and eleven calves were put into a drylot fattening program (P_{59}). The fifty calves go into a summer grazing program the following spring (P_{49}). They were grazed for 4.5 months and then placed in a drylot fattening program (P_{58}). Total operating capital employed in an unlimited capital situation is $34,579.

When operating capital was restricted to twenty thousand dollars, the beef cow herd was reduced to forty-five cows. All of the thirty-two calves were placed in a wintering program and grazed the following summer for 4.5 months. At the end of the period one calf was sold and the remaining thirty-one were placed in a drylot fattening program.

When capital was restricted to fifteen thousand dollars, the cow herd was further reduced to thirty-five cows. All of the twenty-five calves were wintered and then grazed the following summer. However, at the end of the grazing period, eleven of the calves were sold directly off grass and fourteen were placed in a drylot fattening program.

With a capital restriction of ten thousand dollars, the cow herd was reduced to twenty-three and all the calves were wintered and grazed the following summer. All calves were sold at the end of the grazing period.

A capital restriction of five thousand dollars reduced the cow

Table 8. Optimum Beef Production Program Under Several Restricted Capital Situations, Low Efficiency Level

Item	Unit*	Capital Limits (Dollars) 5,000	10,000	15,000	20,000	Unlimited
Cow-calf herd, 5½ month grazing	Head	7	23	35	45	85
Winter calf on pasture and hay	Head	6	17	25	32	50
Summer graze yearlings, 4½ months	Head	6	17	25	32	50
Fatten yearlings	Head	0	0	14	31	50
Calf fattening	Head	0	0	0	0	11

*Livestock numbers have been rounded to the nearest whole unit.

herd to seven. All calves were wintered, grazed the following summer for 4.5 months, and then sold off grass.

III. PASTURE PRODUCTION AND UTILIZATION

The pattern of pasture production and utilization changed each time the livestock program was changed as a result of changing capital restrictions. Total acres of pasture under each of the different capital situations was presented in Table 7, page 47. Pasture production, in this study, has been broken down into a seasonal pattern. The seasonal pattern for a low efficiency level is presented in Table 9 only for the unlimited capital situation.

Eighty-five cows in the cow herd plus fifty calves from the previous year's calf crop required 260.2 AUM's of grazing between May 16 and July 15. This was supplied by a brome-alfalfa pasture, a deferred grazing system on 160 acres of 25 per cent condition pasture, and also 573 acres of native grassland in 75 per cent condition. There were 323.2 acres of native grassland used only for hay production. Only 1.6 tons of the required 285.7 tons of hay were supplied by tame forages.

During the July 16 to August 31 grazing period, the pasture system remained unchanged. All required production was still supplied by the brome-alfalfa and native grasses except that 9.7 AUM's of aftermath grazing was obtained from small grain stubble.

During the period September 1 to October 31, a Russian wild rye pasture supplied 104.3 AUM's of fall grazing. The balance of the

Table 9. Pasture Production and Utilization with Low Level Efficiency in Crop and Livestock Production, Capital Unlimited

Item	Acre	Hay Production	Pasture Production: May 16-July 15	July 16-Aug. 31	Sept. 1-Oct. 31	Nov. 1-April 15	Season Total
		-Tons-	-A.U.M.-	-A.U.M.-	-A.U.M.-	-A.U.M.-	-A.U.M.-
Tame pasture							
Brome-alfalfa rotated and fertilized	4.4	1.6	7.3	1.4	1.8		10.5
Brome-alfalfa not rotated or fertilized	116.6		116.6	87.4	58.2		262.2
Russian wild rye	52.2				104.3		104.3
Native grass							
75% condition not fertilized	572.8		120.3	91.6	57.2		269.1
25% condition deferred grazing	160.0	25.6	16.0	9.6	12.7	19.2	57.5
Hay	323.2	258.5					
Crop aftermath							
Corn stubble	217.6					65.3	65.3
Small grain stubble	97.0			9.7			9.7
TOTAL		285.7	260.2	199.7	234.2	84.5	778.6
Livestock enterprises	Head						
Cow-calf, 5½ month grazing	85	230.7	197.4	147.7	197.1		542.2
Winter calf, pasture and hay	50	17.6				84.5	84.5
Summer graze yearlings, 4½ months	50	10.0	62.8	52.0	37.1		151.9
Fatten yearlings	50	11.6					
Fatten October calf	11	15.8					
TOTAL		285.7	260.2	199.7	234.2	84.5	778.6

grazing during this period was from brome-alfalfa and native grassland.

Calves to be wintered from November 1 to April 15 required 84.5 AUM's of pasture. This was supplied by winter pasture on native grass and aftermath grazing of the corn stubble. The cow herd was wintered on hay from November 1 to May 16.

IV. OPERATING STATEMENT

A net farm operating statement, for optimum ranch plans under each of the five different levels of capital restriction, is presented in Table 10. This table shows that gross receipts declined from $22,497 with unlimited capital to $13,227 when capital was restricted to five thousand dollars. Operating expenses and fixed expenses were subtracted from gross receipts. The remaining amount represents the return to operator's land, labor, capital, and management. This is also the figure commonly referred to as net ranch income. Net ranch income ranges from $6,008 under a capital restriction of five thousand dollars to $11,296 when capital is unlimited.

A charge on the resources used in the business was subtracted from net ranch income. A 6 per cent charge was made on operating capital. This included all variable costs of production (including any labor hired).[1] A 4 per cent charge was made on all land capital.

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[1]Operating expenses, as presented in Table 10, equals gross receipts less functional value of the program less interest (when P_{99} is included as an activity) plus value of labor hired. The P_{99} activity is a capital borrowing activity. Functional value is the program value as solved and printed out by the computer.

Table 10. Operating Statement for Optimum Ranch Plans with Low Efficiency in Crop and Livestock Production Under Several Capital Limiting Situations

Item	Capital Limits (Dollars)				
	5,000	10,000	15,000	20,000	34,579
Corn sold	$ 7,500	$ 7,321	$ 6,412	$ 5,300	$ 2,468
Barley sold	3,246	3,593	3,766	3,634	1,332
Sorghum sold	336	46	0	0	0
Wheat sold	942	942	942	942	942
Yearlings sold off grass	1,023	3,001	2,033	303	0
Sale of fattened yearlings	0	0	3,562	8,059	13,128
Sale of fattened calves	0	0	0	0	2,636
Cull cow sales	180	537	805	1,053	1,991
Gross receipts	$13,227	$15,440	$17,520	$19,291	$22,497
Operating expenses[a]	$ 3,121	$ 3,793	$ 4,522	$ 5,257	$ 7,103
Fixed expenses	4,098	4,098	4,098	4,098	4,098
Return to operator's land, labor, capital & mgt.	$ 6,008	$ 7,549	$ 8,900	$ 9,936	$11,296
Interest on operating capital[b] @ 6%	$ 300	$ 600	$ 900	$ 1,200	$ 2,075
Interest on land capital ($95,408 @ 4%)	3,816	3,816	3,816	3,816	3,816
Value of operator labor[c]	2,036	2,543	3,000	3,393	4,196
Return to management	$ -144	$ 590	$ 1,184	$ 1,527	$ 1,209
MVP on operating capital[d]	0.31	0.31	0.21	0.21	0.06
Hours of labor used	1,557	1,895	2,201	2,478	3,197
Acres of cropland in use	500	500	500	500	500
Acres of native pasture land in use	249	745	1,056	1,056	1,056

[a]Hired labor included

[b]Operating capital included all variable costs in crop and livestock production plus annual investment capital in livestock. (Excluding feed produced and fed)

[c]Hours of operator labor used by the plan @ $1.50 per hour.

[d]Shadow price

Operator labor, as used by the plan, was charged at the rate of $1.50 per hour. After subtracting these charges the residual return is identified as a return to management.

The return to management was negative at a five thousand dollar capital restriction. This means that the operator earned a rate of return on his resources which was somewhat less than that previously described as a charge for the use of these resources. Management return was greatest at a capital limit of twenty thousand dollars. It declined from $1,527 to $1,209 as the capital limit moved from $20,000 to $34,579.

The higher level of capital use would not be undertaken unless one is willing to accept a lower rate of return on resources than is received at the twenty thousand dollar capital level. Management return would be greater at an unlimited capital level if a charge of $1.39 (or less) per hour is made for labor.

It is also shown in Table 10 that the MVP declined as more and more capital was made available.[2] With unlimited capital the MVP declined to six cents. This was the charge made on the use of capital by the capital borrowing activity.

Pastureland and labor resources in use declined as capital became more limiting. However, as shown in Table 7, page 47 all crop land was fully employed at all levels of capital restriction.

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[2]See discussion on MVP, page 17 of this study.

V. SUMMARY

A low level of efficiency produces corn yielding 23 bushels per acre. Oats yield 35 bushels, spring wheat 15 bushels, barley 26 bushels, sorghum 25 bushels, flax 6 bushels, and brome-alfalfa pasture produces 2.25 AUM's of grazing per acre. Beef production assumes an 88 per cent calf crop. Under these efficiency levels crop production had priority on use of capital when capital became limiting. Cropland was shifted out of pasture production and into production of corn, sorghum, and barley as capital became more limited. Land with 3 to 6 per cent slope was maintained in a corn-wheat rotation.

If adequate capital is available it is possible to make investments in livestock which permit pasture to be utilized. This study showed that with unlimited capital an optimum plan would include an eighty-five cow herd under a $5\frac{1}{2}$ month grazing program. Calves were wintered, grazed the following summer, and then finished in a drylot fattening program. As capital became more limited, the size of the cow herd was reduced and fattening activities were curtailed. The calf fattening activity was first to be reduced and eliminated. The fattening of yearlings off grass was next to be reduced. It was eliminated entirely at low levels of capital availability.

Forage production was supplied by native grass and brome-alfalfa pasture. Almost all of the required hay production was native grass hay. Pasture land in poor condition was utilized through a deferred grazing system. The optimum plan did not include any tame grasses for early spring grazing but a Russian wild rye pasture for fall grazing was part of the plan. When capital became very limited, native grassland was left idle.

Net ranch income was $6,008 when operating capital was limited to five thousand dollars. With unlimited capital, net ranch income was $11,296.

CHAPTER VI

OPTIMUM RANCH PLANS UNDER MEDIUM LEVEL OF PRODUCTION EFFICIENCY AND VARYING CAPITAL RESTRICTIONS

Ranch operators differ in their level of management skills and in their decision making regarding the application of technology to their ranch operations. This results in some ranchers receiving a greater total product from an equivalent set of basic resources. A separate set of activity budgets for crop and livestock production was developed under an assumption of a medium level of efficiency, as described in Chapter IV.

It is the purpose of this chapter to discuss the optimum farm plans obtained when the medium level of efficiency is assumed.

I. LAND USE PROGRAM

The optimum land use program under five different levels of capital restriction is presented in Table 11. The table shows that all land with a 3 to 6 per cent slope was maintained in a corn-wheat rotation (P_{19}) at all levels of capital restriction. When capital was unlimited, 104.2 acres of level cropland were used in barley production (P_{14}), 201.3 acres in sorghum (P_{17}), and 125.5 acres in tame pasture. The optimum plan included fertilizing the brome-alfalfa pasture (P_{78}) and using rotation grazing. Eight acres of sudan grass (P_{80}) for a supplemental pasture were also brought into the plan and 62.3 acres of cropland were put into Russian wild rye (P_{81}) for late fall grazing.

Table 11. Optimum Land Use Program Under Restricted Capital Situations, Medium Efficiency Level

Item	Capital Limits (Dollars) 5,000	10,000	15,000	20,000	Unlimited
			-Acres-		
Cropland in grain, 3-6% slope					
Corn grain	34.5	34.5	34.5	31.2	32.2
Corn silage	0.0	0.0	0.0	3.3	2.3
Wheat	34.5	34.5	34.5	34.5	34.5
Cropland in grain, under 3% slope					
Barley	0.0	0.0	0.0	0.0	104.2
Flax	0.0	125.2	138.6	153.7	0.0
Sorghum	278.0	302.2	284.8	272.3	201.3
Wheat	102.0	0.0	0.0	0.0	0.0
Fallow	51.0	0.0	0.0	0.0	0.0
Total cropland in grain	500.0	496.4	492.4	495.0	374.5
Cropland in pasture					
Brome-alfalfa, rotated and fertilized	0.0	0.0	0.0	0.0	55.1
Crested wheat, fertilized	0.0	3.6	7.6	0.0	0.0
Russian wild rye	0.0	0.0	0.0	5.0	62.3
Sudan grass	0.0	0.0	0.0	0.0	8.1
Total cropland in pasture	0.0	3.6	7.6	5.0	125.5
TOTAL CROPLAND	500.0	500.0	500.0	500.0	500.0
Native pasture land					
75% condition, not fertilized	0.0	300.9	777.4	763.9	558.6
25% condition, deferred grazing	0.0	160.0	160.0	160.0	160.0
Winter grazing	0.0	0.0	3.5	24.6	0.0
Native hay	0.0	13.3	63.8	107.5	337.4
Unused pasture	1056.0	581.8	51.3	0.0	0.0
TOTAL NATIVE PASTURE LAND	1056.0	1056.0	1056.0	1056.0	1056.0

The unlimited capital situation was the only case where cropland was used in any significant amount for pasture production. The most cropland used at any of the other capital levels was at the fifteen thousand dollar level where 7.6 acres of cropland was put into crested wheatgrass for early spring grazing. At the ten, fifteen, and twenty thousand dollar capital limits practically all level cropland was used in flax (P_{16}) and sorghum production. Flax yields, at the medium level of efficiency, were assumed to be eleven bushels per acre and sorghum yields were thirty-five bushels per acre. At a five thousand dollar capital limit, flax was dropped from the optimum plan and all level land was used in sorghum and wheat production. There are 278 acres in continuous sorghum and 153 acres in a wheat-wheat-fallow rotation.

It is observed in Table 11 that the 160 acres of pastureland in 25 per cent condition was utilized through a deferred grazing program (P_{95}) in every instance except at the five thousand dollar capital limit. At this low limit no livestock was produced and so all pasture land was idle.

II. LIVESTOCK PROGRAM

Table 12 shows that a cow-calf herd under a $5\frac{1}{2}$ month grazing program (P_{39}) is the basic enterprise at a medium level of efficiency just as it was at the low level of efficiency. When capital was unlimited, eighty-eight cows, producing sixty-five calves, were brought into the optimum plan under the medium level of efficiency. Forty-seven of these calves were put into a drylot fattening program (P_{61}) in October.

Table 12. Optimum Beef Production Program Under Several Restricted Capital Situations, Medium Efficiency Level

Item	Unit*	Capital Limits (Dollars)				
		5,000	10,000	15,000	20,000	Unlimited
Cow-calf herd, $5\frac{1}{2}$ month grazing	Head	0	12	26	34	88
Winter calf on pasture and hay	Head	0	9	19	25	18
Summer graze yearlings, $6\frac{1}{2}$ months	Head	0	9	19	0	0
Summer graze yearlings, $4\frac{1}{2}$ months	Head	0	0	0	25	18
Fatten yearlings	Head	0	0	0	25	18
Calf fattening	Head	0	0	0	0	47

*Livestock numbers have been rounded to the nearest whole unit.

The other eighteen were wintered on pasture and hay (P_{51}), grazed the following summer for 4½ months (P_{53}), and then finished in a drylot fattening program (P_{60}).

When operating capital was limited to twenty thousand dollars, the cow herd was reduced to thirty-four and the calf fattening activity was dropped. All of the twenty-five calves were wintered on pasture and hay, grazed the following summer for 4½ months, and then finished in a drylot fattening program.

At a fifteen thousand dollar capital restriction, the cow herd was reduced to twenty-six cows. No fattening activities were carried out. All of the nineteen calves were wintered on pasture and hay. They were grazed the following summer in a 6½ month grazing program, rather than a 4½ months program, and sold. This required the production of some crested wheatgrass for early spring grazing.

At a ten thousand dollar capital restriction, a twelve cow herd was maintained. All of the calves were wintered on pasture and hay, grazed the following summer in a 6½ month grazing program, and sold.

No livestock was produced at a five thousand dollar restriction on operating capital.

III. PASTURE PRODUCTION AND UTILIZATION

The seasonal pattern of forage production and utilization for an unlimited capital situation is presented in Table 13.

Hay production was primarily from native grassland. Brome-alfalfa hay was made at the start of the season on one-half of the

Table 13. Pasture Production and Utilization with Medium Level Efficiency in Crop and Livestock Production, Capital Unlimited

Item	Acre	Hay Production	Pasture Production May 16-July 15	July 16-Aug. 31	Sept. 1-Oct. 31	Nov. 1-April 15	Season Total
		-Tons-	-A.U.M.-	-A.U.M.-	-A.U.M.-	-A.U.M.-	-A.U.M.-
Tame pasture							
Brome-alfalfa, rotated and fertilized	55.1	20.4	91.8	17.0	23.0		131.8
Sudan grass	8.1			40.5			40.5
Russian wild rye	62.3				124.6		124.6
Native grass							
75% condition, not fertilized	558.6		117.3	89.4	55.8		262.5
25% condition, deferred grazing	160.0	25.6	16.0	9.6	12.8	19.2	57.6
Hay	337.4	269.9					
Crop aftermath							
Corn stubble	32.2					11.3	11.3
Small grain stubble	138.7			13.9			13.9
TOTAL		315.9	225.1	170.4	216.2	30.5	642.2
Livestock enterprises	Head						
Cow-calf, 5½ month grazing	88	236.4	202.1	151.3	202.3		555.7
Winter calf, pasture and hay	17	6.3				30.5	30.5
Summer graze yearlings, 4½ months	17	3.8	23.0	19.1	13.9		56.0
Fatten yearlings	17	3.1					
Fatten October calf	48	66.3					
TOTAL		315.9	225.1	170.4	216.2	30.5	642.2

fifty-five acres that was used for pasture (P_{78}). This pasture was under a rotational grazing system and cattle grazed one-half of the pasture at a time.

Eight acres of sudan grass (P_{80}) provided 40.5 AUM's of supplemental grazing from July 16 to August 31. There was also 13.9 AUM's of aftermath grazing on small grain stubble during this same period. Sixty-two acres of Russian wild rye pasture (P_{81}) furnished over half of the required grazing during September and October. After October 1 the cow herd was wintered on hay. Winter grazing was needed only for the current calf crop and this was supplied by a winter pasture on the 25 per cent condition pastureland (P_{95}) and by grazing the corn stubble.

IV. OPERATING STATEMENT

The operating statement for a medium level of efficiency in crop and livestock production is presented in Table 14.

Gross receipts ranged from $15,649, under a five thousand dollar capital restriction, to $26,744 when capital was unlimited. The range in net ranch income was from $6,296 to $12,749 for the corresponding capital restriction situations. It will be noted here that net ranch income was 40.2 per cent of gross receipts under a five thousand dollar capital restriction compared to 47.7 per cent when capital was unlimited. This is because fixed expenses do not decline as capital becomes more limited.

The return to management was greatest at a twenty thousand

Table 14. Operating Statement for Optimum Ranch Plans with Medium Efficiency in Crop and Livestock Production Under Several Capital Limiting Situations

Item	Capital Limits (Dollars)				
	5,000	10,000	15,000	20,000	39,233
Corn sold	$ 1,214	$ 1,156	$ 1,087	$ 154	$ 0
Barley sold	0	0	0	0	3,052
Sorghum sold	9,218	10,005	9,428	9,017	4,082
Wheat sold	5,217	1,319	1,319	1,319	1,319
Flax sold	0	3,788	4,191	4,649	0
Yearlings sold off grass	0	1,839	3,873	0	0
Cull cow sales	0	285	601	797	2,039
Sale of fattened yearlings	0	0	0	6,661	4,599
Sale of fattened calves	0	0	0	0	11,653
Gross receipts	$15,649	$18,392	$20,499	$22,597	$26,744
Operating expenses[a]	$ 5,255	$ 6,345	$ 6,885	$ 7,757	$ 9,897
Fixed expenses	4,098	4,098	4,098	4,098	4,098
Return to operator's land, labor, capital, & mgt.	$ 6,296	$ 7,949	$ 9,516	$10,742	$12,749
Interest on operating capital[b] @ 6%	$ 300	$ 600	$ 900	$ 1,200	$ 2,354
Interest on land capital ($95,408 @ 4%)	3,816	3,816	3,816	3,816	3,816
Value of operator's labor[c]	1,487	1,877	2,300	2,603	3,540
Return to management	$ 693	$ 1,656	$ 2,500	$ 3,123	$ 3,039
MVP on operating capital[d]	1.14	0.31	0.31	0.21	0.06
Hours of labor used	1,159	1,475	1,744	1,989	2,799
Acres of cropland in use	500	500	500	500	500
Acres of native pasture land in use	0	474	1,005	1,056	1,056

[a]Hired labor included

[b]Operating capital included all variable costs in crop and livestock production plus annual investment capital in livestock. (Excluding feed produced and fed)

[c]Hours of operator labor used by the plan @ $1.50 per hour.

[d]Shadow price

dollar capital limit. This is similar to the situation in Chapter V where a low level of efficiency in crop and livestock production was assumed. The return to management, at a medium level of efficiency, as shown in Table 14, would be greatest at an unlimited capital restriction if $1.46 per hour (or less) were charged for the use of labor. Management return, at a medium level of production efficiency, was positive at all five of the capital limiting situations. Under a low level of efficiency the return to management was negative at a five thousand dollar capital restriction.

The pastureland and labor resources in use declined as capital became more limiting. However, all cropland was fully employed at all capital levels.

V. SUMMARY

When capital was unlimited, level cropland was used to produce barley, sorghum, and tame pastures.

Cropland with a 3 to 6 per cent slope was maintained in a corn-wheat rotation at all capital levels. This is the same as was arrived at in the optimum plan under a low efficiency level for sloping land. At a medium level of production efficiency, the unlimited capital situation was the only case where cropland was used in any significant amount for forage production. At the ten, fifteen, and twenty thousand dollar capital restrictions practically all of the level cropland was used for flax and sorghum production. The same capital situations, under a low level of production efficiency, used the land to produce corn and barley.

When capital was limited to five thousand dollars, all level cropland was used to produce sorghum and wheat. Some crested wheatgrass was brought into the plans at ten and fifteen thousand dollar capital restrictions to provide early grazing for yearling cattle.

Native grassland in poor condition was utilized through a deferred grazing system at all levels of capital restriction.

A cow-calf herd, under a $5\frac{1}{2}$ month grazing program was the basic livestock enterprise. When capital was unlimited, more of the calves were placed into a fattening program at a medium level of efficiency than was fattened under a low level of efficiency. As capital became limited the fattening programs were curtailed and the size of the cow herd was reduced. No livestock was produced at a five thousand dollar level of capital restriction.

Net ranch income ranged from $6,296 with a five thousand dollar capital limit to $12,749 when capital was unlimited.

CHAPTER VII

OPTIMUM RANCH PLANS UNDER HIGH LEVEL OF PRODUCTION EFFICIENCY AND VARYING CAPITAL RESTRICTIONS

The levels of production efficiency assumed in this chapter are considerably above current normal levels. It was assumed that corn yielded forty-one bushels per acre, flax yielded fifteen bushels, and spring wheat yielded twenty-seven bushels per acre. These yields approximate the estimate of normal yields by agronomy specialists for the year 1980. A 92 per cent calf crop was assumed in beef production.

While these levels may seem somewhat high, they are not unrealistic. Future production potential may be estimated by assuming these efficiency levels. Also, reports from individual ranchers and results of the survey indicate that many of the top ranchers in the area are currently attaining these production levels.

It is the purpose of this chapter to present the optimum ranch plans obtained when high levels of production efficiency were assumed.

I. LAND USE PROGRAM

Less cropland was used for production of forage crops when a high level of production efficiency was assumed than when a medium or a low level was assumed. Table 15 shows that land with a 3 to 6 per cent slope was put into a corn-wheat rotation (P_{30}) at all capital levels. However, at a five thousand dollar capital limit, thirty-seven acres of sloping land was left idle. The capital investment per

Table 15. Optimum Land Use Program Under Restricted Capital Situations, High Efficiency Level

Item	Capital Limits (Dollars) 5,000	10,000	15,000	20,000	Unlimited
			-Acres-		
Cropland in grain, 3-6% slope					
Corn grain	16.0	34.5	34.5	34.5	34.5
Wheat	16.0	34.5	34.5	34.5	34.5
Unused cropland	37.0	0.0	0.0	0.0	0.0
Cropland in grain, Under 3% slope					
Corn grain	0.0	328.0	320.9	313.3	289.6
Corn silage	0.0	0.3	2.1	2.8	4.2
Flax	0.0	102.7	108.0	114.9	117.3
Wheat	287.2	0.0	0.0	0.0	0.0
Fallow	143.8	0.0	0.0	0.0	0.0
Total cropland in grain	500.0	500.0	500.0	500.0	480.1
Cropland in pasture					
Brome-alfalfa, rotated and fertilized	0.0	0.0	0.0	0.0	1.0
Russian wild rye	0.0	0.0	0.0	0.0	18.9
Total cropland in pasture	0.0	0.0	0.0	0.0	19.9
TOTAL CROPLAND	500.0	500.0	500.0	500.0	500.0
Native pasture land					
75% condition, not fertilized	0.0	32.0	222.8	470.7	679.5
25% condition, deferred grazing	0.0	98.5	160.0	160.0	0.0
25% condition, renovated	0.0	0.0	0.0	0.0	160.0
Native hay	0.0	0.0	30.7	74.7	216.5
Unused pasture	1056.0	925.5	642.5	350.6	0.0
TOTAL NATIVE PASTURE LAND	1056.0	1056.0	1056.0	1056.0	1056.0

acre in fertilizer, and other inputs, was greater at high levels of efficiency. All available capital was used in crop production and sloping land was the first to come out of production when capital was limited.

When capital was not limited, the optimum plan called for nineteen acres of Russian wild rye (P_{81}) and one acre of brome-alfalfa pasture (P_{78}) to be produced on cropland. The 411 acres of level cropland were used to produce 294 acres of corn (P_{23}) and 117 acres of flax (P_{27}). As operating capital limits were reduced to twenty, fifteen, and ten thousand dollars, the land continued to be used for producing corn and flax. Corn acreage increased and flax acreage decreased as capital became more limiting. At a five thousand dollar capital limit, crop production on level land shifted to wheat production. A wheat-wheat-fallow rotation was used (P_{24}).

II. LIVESTOCK PRODUCTION

Table 16 presents the optimum beef production plan for the high efficiency level program. A cow calf herd, under a $5\frac{1}{2}$ month grazing program (P_{43}), was the basic livestock enterprise. However, the size of the cow herd was smaller at a high level of production efficiency than at either the medium or low levels of efficiency. At high levels of efficiency, crop production became more competitive with livestock and forage for the use of cropland. The livestock activity was limited to that which could be supported by native grassland.

When capital was unlimited, a cow herd of fifty-three cows was

Table 16. Optimum Beef Production Under Several Restricted Capital Situations, High Efficiency Level

Item	Unit*	Capital Limits (Dollars)				
		5,000	10,000	15,000	20,000	Unlimited
Cow-calf herd, 5½ month grazing	Head	0	5	15	26	53
Winter calf on pasture and hay	Head	0	4	12	20	40
Summer graze yearlings, 4½ months	Head	0	4	12	20	40
Fatten yearlings	Head	0	4	12	20	40

*Livestock numbers have been rounded to the nearest whole unit.

brought into the optimum plan. All calves were wintered on pasture and hay (P_{55}) and grazed the following summer (P_{57}) from May 15 to September 1. Summer grazed yearlings came off grass September 1 under a high efficiency program. This compared to October 1 for a low and a medium level efficiency program. At the end of the summer grazing period, the calves were put into a dry lot fattening program (P_{62}).

When the capital restriction was reduced to twenty thousand dollars, the cow herd was reduced to twenty-six cows. All of the calves were wintered, summer grazed, and fattened at the end of the summer grazing period.

The cow herd was reduced to fifteen cows when capital was restricted to fifteen thousand dollars. A ten thousand dollar capital limit further reduced the cow herd to five cows. In each case the calves were wintered on pasture and hay, grazed for $3\frac{1}{2}$ months in the summer, and then placed into a drylot fattening program.

At a five thousand dollar capital limit there was no livestock production.

III. PASTURE PRODUCTION AND UTILIZATION

Pasture production and utilization for an unlimited capital situation are presented in Table 17. Practically all forage production was from native grassland. One acre of brome-alfalfa (P_{78}) and 18.9 acres of Russian wild rye (P_{81}) were produced on cropland.

Native grassland in "25 per cent condition" (P_{98}) was renovated under a high level of efficiency in crop and livestock production.

Table 17. Pasture Production and Utilization with High Level Efficiency in Crop and Livestock Production, Capital Unlimited

			Pasture Production				
Item	Acre	Hay Production	May 16-July 15	July 16-Aug. 31	Sept. 1-Oct. 31	Nov. 1-April 15	Season Total
		-Tons-	-A.U.M.-	-A.U.M.-	-A.U.M.-	-A.U.M.-	-A.U.M.-
Tame pasture							
Brome-alfalfa, rotated and fertilized	1.0	0.4	1.7	0.3	0.4		2.4
Russian wild rye	18.9				37.8		37.8
Native grass							
75% condition, not fertilized	679.5		142.7	108.7	68.0		319.4
25% condition, renovated	160.0		33.6	25.6	16.0		75.2
Hay	216.5	173.2					
Crop aftermath							
Corn stubble	181.0					72.4	72.4
Small grain stubble	34.5			3.5			3.5
TOTAL		173.6	178.0	138.1	122.2	72.4	510.7
Livestock enterprises	Head						
Cow-calf, 5½ month grazing	53	143.1	122.4	91.6	122.2		336.2
Winter calf, pasture and hay	40	14.6				72.4	72.4
Summer graze yearlings, 4½ months	40	9.2	55.6	46.5			102.1
Fatten yearlings	40	6.7					
TOTAL		173.6	178.0	138.1	122.2	72.4	510.7

This involves interseeding with native grasses. Renovation did not enter the optimum plans at either a low or medium level of efficiency.

Calves, wintered from November 1 to April 15, obtained all of their grazing from corn stubble.

IV. OPERATING STATEMENT

Table 18 shows that gross receipts ranged from $15,620 at a five thousand dollar capital restriction to $32,129 when capital was unlimited. A net ranch income of $16,974, when capital was unlimited, is $5,678 above that obtained under a low level of production efficiency. It is $4,225 above that obtained by a medium level of production efficiency.

The return to management was greatest when capital was unlimited. At low and medium levels of efficiency the return to management was greatest under a capital restriction of twenty thousand dollars. This simply indicates that a high level of efficiency brings a greater return to resources than does a low or a medium level of efficiency.

The land and labor resources in use declined as capital became more limited. At a five thousand dollar capital limit only 747 hours of labor were used. No livestock was produced at this level and, consequently, no pasture land was used. Thirty-seven acres of cropland were also idle when capital was restricted to five thousand dollars.

V. SUMMARY

Less cropland was used for production of forage crops when a

Table 18. Operating Statement for Optimum Ranch Plans with High Efficiency in Crop and Livestock Production Under Several Capital Limiting Situations

Item	Capital Limits (Dollars) 5,000	10,000	15,000	20,000	32,488
Corn sold	$ 723	$16,223	$15,707	$14,866	$13,217
Flax sold	0	4,514	4,751	5,056	5,163
Wheat sold	14,897	1,695	1,695	1,695	1,695
Sale of fattened yearlings	0	986	3,179	5,354	10,823
Cull cow sales	0	112	361	609	1,231
Gross receipts	$15,620	$23,530	$25,693	$27,580	$32,129
Operating expenses[a]	$ 4,813	$ 8,280	$ 8,997	$ 9,372	$11,057
Fixed expenses	4,098	4,098	4,098	4,098	4,098
Return to operator's land, labor, capital, & mgt.	$ 6,709	$11,152	$12,598	$14,110	$16,974
Interest on operating capital[b] @ 6%	$ 300	$ 600	$ 900	$ 1,200	$ 1,949
Interest on land capital ($95,408 @ 4%)	3,816	3,816	3,816	3,816	3,816
Value of operator's labor[c]	1,121	1,746	2,039	2,334	2,967
Return to management	$ 1,472	$ 4,990	$ 5,843	$ 6,760	$ 8,242
MVP on operating capital[d]	2.06	0.30	0.30	0.30	0.06
Hours of labor used	747	1,333	1,536	1,742	2,221
Acres of cropland in use	463	500	500	500	500
Acres of native pasture land in use	0	130	414	705	1,056

[a]Hired labor included

[b]Operating capital included all variable costs in crop and livestock production plus annual investment capital in livestock. (Excluding feed produced and fed)

[c]Hours of operator labor used by the plan @ $1.50 per hour.

[d]Shadow price

high level of production efficiency was assumed than at either a low or a medium level of efficiency. A cow-calf herd under a $5\frac{1}{2}$ month grazing program was the basic livestock enterprise, just as it was for a low and a medium efficiency level. However, the size of the herd at a high efficiency level was smaller than the herd at either the medium or low efficiency level. Calves were wintered, summer grazed, and then placed in a fattening program at all levels of capital restrictions except the five thousand dollar level. At this level no livestock was produced. The size of the herd increased as more capital became available.

At a high level of production efficiency, it became profitable to renovate the pasture land in "25 per cent condition." However, renovation came into the optimum plan only under an unlimited capital situation.

CHAPTER VIII

OPTIMUM RANCH PLANS UNDER VARIABLE LEVELS OF PRODUCTION EFFICIENCY AND VARYING CAPITAL RESTRICTIONS

It is theoretically possible for an optimum plan to include one enterprise at a high efficiency level and another enterprise at a low efficiency level. This would happen if there are any supplementary or complementary relationships between the enterprises in the use of ranch resources. To determine if any such relationships existed a programming model was prepared which included activities at all levels of efficiency. The efficiency levels were thus permitted to vary and the selection of efficiency levels for the optimum plan was given over to the linear programming procedure.

The results of the linear programming, when all levels of efficiency were permitted to vary, are presented in this chapter.

I. LAND USE PROGRAM

Use of cropland, when efficiency levels were permitted to vary, resulted in the selection of a high level efficiency at all levels of capital restriction, excepting the five thousand dollar level. Table 19 shows that cropland with a 3 to 6 per cent slope was maintained in a corn-wheat rotation (P_{30}). Level cropland was used to produce corn (P_{23}) and flax (P_{27}). When capital was limited to five thousand dollars corn was produced at a medium level of efficiency (P_{12}). One hundred twenty acres were taken out of corn and flax production and put

Table 19. Optimum Land Use Program Under Various Capital Limiting Situations, Efficiency Level Variable

Item	Capital Limits (Dollars)				
	5,000	10,000	15,000	20,000	Unlim-ited
			-Acres-		
Cropland in grain, 3-6% slope					
Corn grain	34.5	34.5	34.5	34.5	34.5
Wheat	34.5	34.5	34.5	34.5	34.5
Cropland in grain, under 3% slope					
Corn grain	298.6*	328.8	323.5	313.4	290.1
Corn silage	0.0	0.0	0.0	0.6	3.8
Flax	12.1	102.2	107.5	117.0	117.4
Wheat	80.2	0.0	0.0	0.0	0.0
Fallow	40.1	0.0	0.0	0.0	0.0
Total cropland in grain	500.0	500.0	500.0	500.0	480.3
Cropland in pasture					
Brome-alfalfa, rotated and fertilized	0.0	0.0	0.0	0.0	0.9
Russian wild rye	0.0	0.0	0.0	0.0	18.8
Total cropland in pasture	0.0	0.0	0.0	0.0	19.7
TOTAL CROPLAND	500.0	500.0	500.0	500.0	500.0
Native pasture land					
75% condition, not fertilized	0.0	89.8	503.6	794.6	679.6
25% condition, deferred grazing	0.0	133.9	160.0	160.0	0.0
25% condition, renovated	0.0	0.0	0.0	0.0	160.0
Native hay	0.0	0.0	54.0	101.4	216.4
Unused pasture	1056.0	832.3	338.4	0.0	0.0
TOTAL NATIVE PASTURE LAND	1056.0	1056.0	1056.0	1056.0	1056.0

*Medium level production efficiency. All other figures are high efficiency level.

into a wheat-wheat-fallow rotation (P_{24}). The wheat was produced at a high level of efficiency. Less capital inputs, in the way of fertilizer and chemicals for corn production, were required at a medium level efficiency than at a high level of efficiency. Consequently, under a very limited capital situation, greater returns to capital were realized by shifting to the medium level efficiency in corn and producing wheat rather than flax. However, 12.1 acres of flax were included in the optimum plan at the five thousand dollar capital level.

II. LIVESTOCK PROGRAM

Livestock production with unlimited capital was carried out at a high level of efficiency when efficiency levels were free to vary. A cow calf herd under a $5\frac{1}{2}$ month grazing program was the basic enterprise (P_{43}). It is the same program as presented for the unlimited capital situation in Chapter VII under a high efficiency level. The calves from fifty-three cows were wintered (P_{55}), grazed the following summer (P_{57}), and then placed in a fattening program (P_{62}). The optimum plan is presented in Table 20.

The cow herd was reduced to thirty-four cows when capital was restricted to twenty thousand dollars. Eight of these cows were at a high level of efficiency (P_{43}) in production and twenty-six were low (P_{35}). The calf crop from the eight high efficiency cows were wintered, summer grazed, and fattened. The calf crop from the twenty-six low ' efficiency cows was sold at the end of the summer grazing period.

When operating capital was restricted to fifteen thousand

Table 20. Optimum Beef Production Program Under Several Restricted Capital Situations, Variable Efficiency Level

Item	Efficiency Level	Capital Limits (Dollars) 5,000	10,000	15,000	20,000	Unlimited
		(Number of Head)*				
Cow-calf herd, 5½ month grazing	Low	0	7	22	26	0
Cow-calf herd, 5½ month grazing	High	0	0	0	8	53
Winter calf on pasture and hay	Low	0	5	16	18	0
Winter calf on pasture and hay	High	0	0	0	6	40
Summer graze yearlings, 4½ months	Low	0	5	16	18	0
Summer graze yearlings, 4½ months	High	0	0	0	6	40
Fatten yearlings	High	0	0	0	6	40

*Livestock numbers have been rounded to the nearest whole unit.

dollars, all livestock production was at a low level of efficiency. The cow herd was reduced to twenty-two cows. The calf crop was wintered on pasture and hay and then sold at the end of a summer grazing period.

The same type of program was carried out when the capital restriction was further reduced to ten thousand dollars. The low efficiency cow herd was reduced to seven cows. The calves were wintered and sold at the end of the summer grazing period.

No livestock production was carried out when capital was restricted to five thousand dollars.

III. PASTURE PRODUCTION AND UTILIZATION

The pasture production program, when efficiency levels in crop and livestock production were permitted to vary, was virtually the same as the program presented in Chapter VII under high efficiency. Under an unlimited capital situation all pasture production was from native grassland except for 0.9 acre of brome-alfalfa (P_{78}) and 18.8 acres of Russian wild rye (P_{81}). Table 21 presents the pasture program under an unlimited capital situation. It was observed in Table 19 that 160 acres of native pasture land were renovated. This renovation resulted in a total of 839.6 acres of native grassland in 75 per cent condition. Another 216.4 acres of native grassland were used for hay.

When the capital restriction is anything less than unlimited, the pasture utilization program differs from that presented in Chapter VII only because of a difference in the livestock program. If

Table 21. Pasture Production and Utilization with Efficiency Level Variable, Capital Unlimited

Item	Acre	Hay Production	Pasture Production: May 16-July 15	July 16-Aug. 31	Sept. 1-Oct. 31	Nov. 1-April 15	Season Total
		-Tons-	-A.U.M.-	-A.U.M.-	-A.U.M.-	-A.U.M.-	-A.U.M.-
Tame pasture							
Brome-alfalfa, rotated and fertilized	0.9	0.3	1.5	0.3	0.4		2.2
Russian wild rye	18.8				37.6		37.6
Native grass							
75% condition, not fertilized	839.6		176.2	134.5	84.0		394.7
Hay	216.4	173.1					
Crop aftermath							
Corn stubble	181.0					72.4	72.4
Small grain stubble	34.5			3.4			3.4
TOTAL		173.4	177.7	138.2	122.0	72.4	510.3
Livestock enterprises	Head						
Cow-calf, $5\frac{1}{2}$ month grazing	53	142.6	122.0	91.5	122.0		335.5
Winter calf, pasture and hay	40	14.8				72.4	72.4
Summer graze yearlings, $4\frac{1}{2}$ months	40	9.2	55.7	46.7			102.4
Fatten yearlings	40	6.8					
TOTAL		173.4	177.7	138.2	122.0	72.4	510.3

efficiency levels are variable and capital is limited, the optimum plan selects low efficiency cows. When capital is limited, a larger herd can be maintained if low efficiency cows are used rather than high efficiency cows and more acres of grassland are utilized.

IV. OPERATING STATEMENT

Table 22 presents the costs and returns obtained in the optimum plans under various capital limiting situations. Net ranch income ranged from $8,868, with a five thousand dollar capital restriction, to $16,974 dollars when capital was unlimited. Management return, under the corresponding capital limits, ranged from $3,126 to $8,246. Land and labor resources in use decreased as capital became more limiting. All native pasture land was left idle at a capital restriction of five thousand dollars.

V. SUMMARY

The optimum plans arrived at in this chapter gave priority to crop production as capital became more limiting. Corn and flax were produced on level land at capital limits of ten thousand dollars and above. They were produced at a high level of production efficiency. At a five thousand dollar capital limit 120 acres of cropland were shifted out of corn and flax production and into a wheat-wheat-fallow rotation. The corn production at this low capital level was carried out at a medium level of efficiency and wheat production was at a high efficiency level. A corn-wheat rotation, at a high efficiency level,

Table 22. Operating Statement for Optimum Ranch Plans with Variable Efficiency in Crop and Livestock Production Under Several Capital Limiting Situations

	Capital Limits (Dollars)				
Item	5,000	10,000	15,000	20,000	32,470
Corn sold	$12,066	$16,357	$16,039	$15,354	$13,237
Flax sold	533	4,501	4,732	5,147	5,166
Wheat sold	5,637	1,695	1,695	1,695	1,695
Sale of fattened yearlings	0	0	0	1,669	10,815
Cull cow sales	0	161	518	793	1,230
Yearlings sold off grass	0	898	2,889	3,360	0
Gross receipts	$18,236	$23,612	$25,873	$28,018	$32,143
Operating expenses[a]	$ 5,270	$ 8,297	$ 8,976	$ 9,645	$11,071
Fixed expenses	4,098	4,098	4,098	4,098	4,098
Return to operator's land, labor, capital, & mgt.	$ 8,868	$11,217	$12,799	$14,275	$16,974
Interest on operating capital[b] @ 6%	$ 300	$ 600	$ 900	$ 1,200	$ 1,948
Interest on land capital ($95,408 @ 4%)	3,816	3,816	3,816	3,816	3,816
Value of operator's labor[c]	1,626	1,836	2,331	2,676	2,964
Return to management	$ 3,126	$ 4,965	$ 5,752	$ 6,583	$ 8,246
MVP on operating capital[d]	0.64	0.32	0.32	0.28	0.06
Hours of labor used	1,263	1,398	1,747	1,984	2,219
Acres of cropland in use	500	500	500	500	500
Acres of native pasture land in use	0	224	718	1,056	1,056

[a]Hired labor included

[b]Operating capital included all variable costs in crop and livestock production plus annual investment capital in livestock. (Excluding feed produced and fed)

[c]Hours of operator labor used by the plan @ $1.50 per hour.

[d]Shadow price

was maintained on sloping land in all instances.

Livestock production was carried out at a high efficiency level when capital was not limited. The returns under these conditions were such that all 25 per cent condition pasture land could be renovated and all native pasture be fully used. A cow-calf herd of fifty-three cows was maintained. The calves were wintered, summer grazed, and then fattened.

Capital was removed first from the livestock program as capital became more limiting. This was done by shifting to low efficiency cows and reducing the size of the herd. Such a procedure permitted more cows to be maintained, than if high efficiency cows were kept, and more grassland was utilized.

Net ranch income at a five thousand dollar capital limit was $8,868. This is $2,159 greater than the net ranch income under a five thousand dollar capital restriction when efficiency levels were preselected at high level, as was done in Chapter VII.

Net ranch income, when capital was unlimited, is $16,974. This is the same as when efficiency levels were preselected at a high efficiency level since, under an unlimited capital situation, the optimum plan selected high efficiency level enterprises in all instances.

CHAPTER IX

OPTIMUM RANCH PLANS UNDER MIXED LEVELS OF PRODUCTION EFFICIENCY

Ranch operators are not necessarily efficient in all enterprises. They may be highly efficient in livestock production and low in crop production, or vice versa. Optimum plans were developed for an unlimited capital situation by mixing the efficiency levels. Two plans were developed. One plan assumed low efficiency in crop production and high efficiency in livestock production. Another plan assumed high efficiency in crop production and low efficiency in livestock production.

This chapter presents the optimum plans obtained when mixed efficiency levels were assumed.

I. LAND USE PROGRAM

The land use program presented in Table 23 shows that a corn-wheat rotation was used on sloping land in both plans. When the efficiency in crop production was low, relative to that in livestock production, more cropland was used for pasture production than when the efficiency relationships were reversed. There were 235.9 acres of cropland in tame pasture under a "low crop-high livestock" efficiency level. This compares to 31.7 acres with a "high crop-low livestock" efficiency level.

With a high efficiency in crop production there were 285.8 acres

Table 23. Optimum Land Use Program with Mixed Efficiency Levels, Capital Unlimited

Item	Efficiency Levels	
	Low Crop High Livestock	High Crop Low Livestock
	-Acres-	
Cropland in grain, 3-6% slope		
Corn grain	34.5	34.5
Wheat	34.5	34.5
Cropland in grain, under 3% slope		
Corn grain	169.2	281.0
Corn silage	13.4	4.8
Barley	12.5	0.0
Flax	0.0	113.5
Total cropland in grain	264.1	468.3
Cropland in pasture		
Brome-alfalfa, rotated & fertilized	145.5	0.0
Sudan grass	28.5	0.2
Russian wild rye	61.9	31.5
Total cropland in pasture	235.9	31.7
TOTAL CROPLAND	500.0	500.0
Native pasture land		
75% condition, not fertilized	452.0	716.5
25% condition, deferred grazing	160.0	160.0
Winter grazing pasture	112.4	0.0
Native hay	331.6	179.5
TOTAL NATIVE PASTURE LAND	1056.0	1056.0

of corn (P_{23}) and 113.5 acres of flax (P_{27}) produced. When crop production efficiency was low there were 182.6 acres of corn (P_1) and 12.5 acres of barley (P_3). However, under a low efficiency in crop production 13.4 acres of corn were harvested as silage compared to 4.8 acres when the crop efficiency was high.

II. LIVESTOCK PROGRAM

Table 24 presents the optimum livestock program for an unlimited capital situation. Under a "low crop-high livestock" efficiency level there were 105 cows maintained in the cow herd (P_{43}). This is a larger cow herd than was arrived at for any other optimum plan. A cow-calf program with $5\frac{1}{2}$ month grazing was included in both of the plans for mixed efficiency levels. With a "high crop-low livestock" situation there were fifty-two cows (P_{35}) maintained in the herd. Table 24 shows that in both plans the calves were wintered on pasture and hay, grazed the following summer, and then placed in a fattening program.

III. PASTURE PRODUCTION AND UTILIZATION

Table 25 presents the pasture production and utilization program under a "high crop-low livestock" efficiency situation. Cattle went on pasture May 16. All grazing through July 15 was from native grassland. During July and August the optimum plan called for one-half AUM of sudan grass (P_{80}). The small grain stubble also provided 3.5 AUMs of grazing during the same period. Russian wild rye (P_{81}) used 31.5 acres of cropland to provide fall grazing in September and October. After

Table 24. Optimum Beef Production Program with Crop and Livestock Efficiency Levels Mixed, Capital Unlimited

Item	Efficiency Levels: Low Crop High Livestock	Efficiency Levels: High Crop Low Livestock
	-Head of Livestock-	
Cow-calf herd, 5½ month grazing	105	52
Winter calf on pasture and hay	80	37
Summer graze yearlings, 4½ months	80	37
Fatten yearlings	80	37

Table 25. Pasture Production and Utilization with High Efficiency in Crop Production, Low Efficiency in Livestock Production, Capital Unlimited

Item	Acre	Hay Production	Pasture Production: May 16-July 15	July 16-Aug. 31	Sept. 1-Oct. 31	Nov. 1-April 15	Season Total
		-Tons-	-A.U.M.-	-A.U.M.-	-A.U.M.-	-A.U.M.-	-A.U.M.-
Tame pasture							
Sudan grass	0.1			0.5			0.5
Russian wild rye	31.5				63.0		63.0
Native grass							
75% condition, not fertilized	716.5		150.5	114.6	71.7		336.8
25% condition, deferred grazing	160.0	25.6	16.0	9.6	12.8	19.2	57.6
Hay	179.5	143.6					
Crop aftermath							
Corn stubble	108.8					43.5	43.5
Small grain stubble	34.5			3.5			3.5
TOTAL		169.2	166.5	128.2	147.5	62.7	504.9
Livestock enterprises	Head						
Cow-calf, 5½ month grazing	52	140.1	119.9	89.7	119.9		329.5
Winter calf, pasture and hay	37	13.1				62.7	62.7
Summer graze yearlings, 4½ months	37	7.5	46.6	38.5	27.6		112.7
Fatten yearlings	37	8.5					
TOTAL		169.2	166.5	128.2	147.5	62.7	504.9

November 1 the cow herd was wintered on hay. This hay was produced entirely from native grassland (P_{97}). Calves required 62.7 AUM's of grazing in the winter. This was supplied from the deferred grazing system (P_{95}) on the 25 per cent condition pasture land and also by grazing the corn stubble.

The pasture program arrived at under a "low crop-high livestock" efficiency situation is presented in Table 26. This program required more brome-alfalfa and sudan grass than did the plan previously described. Cattle went on pasture May 16. Brome-alfalfa, that was fertilized and rotated (P_{78}), provided most of the grazing during this period for 105 cows and 80 yearling calves. During July and August the cow herd and yearling calves obtained about one-half of the required grazing from 28.5 acres of sudan grass (P_{80}). The remainder was supplied by the brome-alfalfa, native grass, and small grain stubble. During September and October grazing was needed only for the cow-calf herd. One-half of this required grazing was from 61.9 acres of Russian wild rye (P_{81}). After November 1 the cow herd was wintered on hay. Winter grazing for the calves was obtained from native grass and corn stubble.

IV. OPERATING STATEMENT

Costs and returns for the optimum plans are presented in Table 27. Net ranch income was approximately one thousand dollars greater under a "high crop-low livestock" efficiency level than under a "low crop-high livestock" efficiency level. Gross receipts, under high

Table 26. Pasture Production and Utilization with Low Efficiency in Crop Production, High Efficiency in Livestock Production, Capital Unlimited

Item	Acre	Hay Production	Pasture Production: May 16-July 15	July 16-Aug. 31	Sept. 1-Oct. 31	Nov. 1-April 15	Season Total
		-Tons-	-A.U.M.-	-A.U.M.-	-A.U.M.-	-A.U.M.-	-A.U.M.-
Tame pasture							
Brome-alfalfa, rotated and fertilized	145.5	53.8	242.5	44.8	60.6		347.9
Sudan grass	28.5			142.5			142.5
Russian wild rye	61.9				123.7		123.7
Native grass							
75% condition, not fertilized	452.0		94.9	72.32	45.2		212.4
25% condition, deferred grazing	160.0	25.6	16.0	9.6	12.8	19.2	57.6
75% condition, winter grazing	112.4					64.1	64.1
Hay	331.6	265.3					
Crop aftermath							
Corn stubble	203.7					61.0	61.0
Small grain stubble	47.0			4.7			4.7
TOTAL		344.7	353.4	273.9	242.3	144.3	1,013.9
Livestock enterprises	Head						
Cow-calf, 5½ month grazing	105	283.4	242.5	181.3	242.3		666.1
Winter calf, pasture and hay	80	29.5				144.3	144.3
Summer graze yearlings, 4½ months	80	18.3	110.9	92.6			203.5
Fatten yearlings	80	13.5					
TOTAL		344.7	353.4	273.9	242.3	144.3	1,013.9

Table 27. Operating Statement for Optimum Ranch Plans with Mixed Efficiency Levels in Crop and Livestock Production, Capital Unlimited

Item	Efficiency Levels: Low Crop High Livestock	Efficiency Levels: High Crop Low Livestock
Corn sold	$ 2,371	$12,516
Flax sold	0	4,995
Wheat sold	942	1,695
Barley sold	263	0
Fattened yearlings sold	21,493	9,755
Cull cow sold	2,445	1,208
Gross receipts	$27,514	$30,169
Operating expenses[a]	$ 9,026	$10,593
Fixed expenses	4,098	4,098
Return to operator's land, labor, capital and management	$14,390	$15,478
Interest on operating capital[b] @ 6%	$ 3,100	$ 1,660
Interest on land capital ($95,408 @ 4%)	3,816	3,816
Value of operator's labor[c]	3,896	3,407
Return to management	$ 3,578	$ 6,595
MVP on operating capital[d]	0.06	0.06
Hours of labor used	2,997	2,512
Acres of cropland in use	500	500
Acres of native pasture land in use	1,056	1,056
Operating capital used	$51,673	$27,666

[a]Hired labor included

[b]Operating capital includes all variable costs in crop and livestock production plus annual investment capital in livestock. (Excluding feed produced and fed)

[c]Hours of operator labor used by the plan @ $1.50 per hour.

[d]Shadow price

efficiency in crops, was $30,169. This compares to $27,514 when crop production efficiency was low.

Return to management was $6,595 under "high crop-low livestock" and $3,578 under "low crop-high livestock." This large difference in management was due primarily to differences in the quantity of resources used by the two plans. The "low crop-high livestock" situation employed $24,007 more capital and 485 hours more labor than did the "high crop-low livestock" situation. All land was fully employed in each plan.

V. SUMMARY

More cropland was used for pasture production under a "low crop-high livestock" efficiency situation than under a "high crop-low livestock" program. Brome-alfalfa, sudan grass, and Russian wild rye were produced on cropland. When the efficiency in crop production was low, relative to that for livestock production, enough cropland was used to produce 182.6 acres of corn and 12.5 acres of barley. When the efficiency in crop production was high, relative to that for livestock production, 285.8 acres of corn and 113.5 acres of flax were produced.

When the production efficiency in livestock was high, relative to that for crop production, a large cow herd was maintained. The cow herd was reduced in size as livestock production efficiency declined relative to that in crop production. Calves were wintered, grazed during the summer, and then fattened in both of the optimum plans developed under mixed efficiency levels.

The "low crop-high livestock" situation employed $24,007 more capital and 485 hours more labor than the "high crop-low livestock" situation. However, the return to management was $3,017 greater when the efficiency in crop production was high.

CHAPTER X

RANCH PLANS THROUGH TIME

Pasture renovation was included in the optimum plan when crop and livestock production efficiency was high and capital was not a limiting factor. However, pasture renovation requires that no grazing be carried out for a period of two years while new seeding is becoming established. This quite often creates difficulties in livestock management. The loss of grazing land for a two year period can reduce income. It creates problems in handling livestock and may even force a reduction in the size of the cow herd if a large amount of pasture is renovated.

To estimate the optimum ranch organization when pasture renovation is undertaken, plans were developed for two different time periods. Time period one represents a two year period during which a new seeding is becoming established. Time period two represents the time period after the seeding is established and all native grassland is in 75 per cent condition.

It was assumed, during time period one, that 160 acres of native grassland in 25 per cent condition would be renovated as a unit. During this time period, a fifty cow herd was forced into the plan under the assumption that a cow herd of this size was to be maintained. It will be recalled that the optimum plan presented in Chapter VIII, under an unlimited capital situation, had fifty-three cows in the herd. This, however, was under a situation where pasture renovation had been carried out and all of the grazing land was in 75 per cent condition. Therefore, it was decided to accept an objective of maintaining a fifty cow herd during time period one. It was also decided that no perennial pasture crops should be permitted to enter the plan if they did not appear in the optimum plan arrived at in Chapter VIII. Therefore, the crested wheatgrass activity was removed from the model. The model for time period one also removed pasture renovation as an activity and reduced the supply of native pasture by 160 acres. All costs of renovation were subtracted from the functional value of the program in the same manner as fixed costs.

The model for time period two did not include pasture renovation as an activity. However, it did include crested wheatgrass. Since all costs of renovation were taken out in time period one only the costs of pasture maintenance were included in time period two. All native pasture (1,056 acres) was assumed to be in 75 per cent condition.

It is the purpose of this chapter to present the optimum plans obtained for time period one and time period two. The two plans were developed under a situation where efficiency levels were variable and capital was unlimited.

I. LAND USE PROGRAM

Table 28 presents the optimum land use programs for time period one and time period two. The table shows that all land with a 3 to 6 per cent slope was maintained in a corn-wheat rotation under both plans. Cropland in grain was reduced during time period one compared to time

Table 28. Optimum Land Use Program When Pasture Renovation is Undertaken, Two Time Period Situations, Efficiency Levels Variable, Capital Unlimited

Item	Efficiency Level	Time Period One	Time Period Two
		-Acres-	
Cropland in grain, 3-6% slope			
Corn grain	High	34.5	34.5
Wheat	High	34.5	34.5
Cropland in grain, under 3% slope			
Corn grain	High	293.7	290.0
Corn silage	High	3.6	3.8
Flax	High	98.4	117.4
Total cropland in grain		464.7	480.2
Cropland in pasture			
Brome-alfalfa, rotated & fertilized	Average	13.0	1.0
Sudan grass	Average	2.3	0.0
Russian wild rye	Average	20.0	18.8
Total cropland in pasture		35.3	19.8
TOTAL CROPLAND		500.0	500.0
Native pasture land			
Renovated pasture, unused		160.0	0.0
75% condition, not fertilized	Average	697.2	839.6
Native hay	Average	198.8	216.4
TOTAL NATIVE PASTURE LAND		1056.0	1056.0

period two. The program during time period two produced 293.8 acres of corn and 117.4 acres of flax on the level land. This compares to 297.3 acres of corn and 98.4 acres of flax during time period one. All activities were carried out at a high level of efficiency.

Table 28 shows that 35.3 acres of cropland were used to produce tame pasture during time period one. This included thirteen acres of brome-alfalfa (P_{78}), 2.3 acres of sudan grass (P_{80}), and twenty acres of Russian wild rye (P_{81}) for fall grazing. During time period two, one acre of brome-alfalfa was produced and 18.8 acres of Russian wild rye.

During time period one 160 acres of native pasture were unused during the period of renovation. There were 697.2 acres of native grassland (P_{92}) used for pasture and 198.8 acres used for hay (P_{97}) during this period. In time period two 839.6 acres were used for pasture and 216.4 acres were used for hay.

II. LIVESTOCK PROGRAM

Table 29 shows that a cow-calf program under a $5\frac{1}{2}$ month grazing program (P_{43}) was the basic enterprise in the optimum plan. Fifty cows were included in the program during time period one and fifty-three were included during time period two. All calves in both plans were wintered on pasture and hay (P_{55}), grazed for $3\frac{1}{2}$ months the following summer (P_{57}), and then placed in a drylot fattening program (P_{62}).

Table 29. Livestock Program During Two Time Periods of Pasture Renovation, Efficiency Level Variable, Capital Unlimited

Livestock Enterprise	Efficiency Level	Unit*	Time Period One	Time Period Two
Cow-calf, $5\frac{1}{2}$ month grazing	High	Head	50	53
Winter calves on pasture and hay	High	Head	38	40
Summer graze yearlings, $3\frac{1}{2}$ months	High	Head	38	40
Fatten yearlings	High	Head	38	40

*Livestock numbers have been rounded to the nearest whole unit.

III. OPERATING STATEMENT

Table 30 presents the costs and returns for time period one and time period two. Operating expenses included all variable costs in crop and livestock production plus labor hired. No interest charge on operating capital was included in operating expenses. Fixed expenses differ between the two plans by the amount of the pasture renovation costs. These costs amount to $3.61 per acre after subtracting $6.00 per acre as an Agricultural Conservation Program payment.

The return to the operator's land, labor, capital, and management (net ranch income) in time period one was $15,698. This compares to $17,157 during time period two. Another comparable net ranch income, $16,974, was presented in Table 22, page 84. This net ranch income was arrived at when efficiency levels were permitted to vary and pasture renovation entered the plan as an activity. However, in the case where pasture renovation entered the plan as an activity, it was assumed that a fifty-three cow herd, as well as more acres of grain production, were maintained through all time periods. The analysis in this chapter indicates that cropland must be shifted to pasture production to maintain a cow herd during the time when pasture is being renovated.

Table 30 shows that the return to management in time period one was $7,036 compared to $8,429 in time period two. More capital and land were used during time period two than time period one but there was very little difference in the amount of labor used.

Table 30. Operating Statement During Two Time Periods of Pasture Renovation, Efficiency Level Variable, Capital Unlimited

Item	Time Period One	Time Period Two
Corn sold	$13,485	$13,237
Flax sold	4,330	5,166
Wheat sold	1,695	1,695
Sale of fattened yearlings	10,210	10,815
Cull cow sales	1,161	1,230
Gross receipts	$30,881	$32,143
Operating expenses[a]	$10,506	$10,888
Fixed expenses	4,677	4,098
Return to operator's land, labor, capital and management	$15,698	$17,157
Interest on operating capital[b] @ 6%	$ 1,861	$ 1,948
Interest on land capital ($95,408 @ 4%)	3,816	3,816
Value of operator's labor[c]	2,985	2,964
Return to management	$ 7,036	$ 8,429
MVP on operating capital[d]	0.06	0.06
Hours of labor used	2,203	2,219
Acres of cropland in use	500	500
Acres of native pasture land in use	896	1,056
Operating capital used	$31,017	$32,467

[a]Hired labor included

[b]Operating capital includes all variable costs in crop and livestock production plus annual investment capital in livestock. (Excluding feed produced and fed)

[c]Hours of operator labor used by the plan @ $1.50 per hour.

[d]Shadow price

IV. SUMMARY

To maintain a fifty cow herd during a period of time in which 160 acres of native grassland was being renovated, the optimum plan converted cropland to tame pasture production. Brome-alfalfa pasture that was rotated and fertilized was the major pasture crop that was added. There were 2.3 acres of sudan grass and twenty acres of Russian wild rye also produced on cropland.

A cow-calf enterprise, under a $5\frac{1}{2}$ month grazing program, was maintained before and after renovation. All calves, in both time periods, were wintered, summer grazed, and then fattened.

Net ranch income was $1,459 lower in time period one than time period two.

PART TWO

FACTORS ASSOCIATED WITH PASTURE IMPROVEMENT WORK BY RANCHERS

CHAPTER XI

PROBLEM AND OBJECTIVES

Part One of this study has employed linear programming as a tool of analysis. Heady and Candler state that "linear programming is mainly a procedure for providing normative answers to problems which are so formulated."[1] The analysis in Part One has been normative in that it has specified the manner in which a ranch ought to be organized under a specified set of conditions and objectives.

Part Two of this study is a positive analysis. It attempts to investigate the activities of ranchers and explain the existing situation in regard to pasture improvement work.

It is the purpose of this chapter to describe the problems and objectives with which the positive analysis is concerned.

I. THE PROBLEM

The analysis in Part One of this study has indicated that tame grass pastures can profitably be included in the land use program of ranches in the Williams-Tetonka-Cavour soil association area. Especially is this shown for situations where capital is not a limiting factor. However, only 29 out of 160 farmers and ranchers, included in a survey of central South Dakota, reported having tame grass pastures as part of their land use program. Fourteen out of the 160 reported

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[1] Earl O. Heady and Wilfred Candler, op. cit., pp. 8-9.

they had pasture improvement experience involving native pastures. The experiences reported included fertilization, resting the range, rotation grazing, new seedings of native grass, and interseeding into native grass pastures. The number of ranchers reporting experience in various types of activities for pasture improvement purposes is shown in Table 31. Sixty-five different farmers and ranchers reported pasture improvement activities. Many of these did pasture improvement work in several of the categories listed in Table 31.

In view of the importance of high producing grassland for beef production purposes, the results of this survey raise questions as to why more ranchers have not engaged in pasture improvement work. Over grazing is reported by Extension Agents as being a major problem in pasture management.

II. OBJECTIVES OF THE STUDY

Linear programming has demonstrated that production efficiency and capital level can affect the profitability of pasture improvement as part of the land use program. It is further hypothesized in this study that many additional factors influence the amount of pasture improvement work done by ranchers.

The objective of this study is to identify some of these factors.

III. METHOD AND PROCEDURE

The Model

A multiple linear correlation model was employed in identifying

Table 31. Number of Ranchers Reporting Pasture Improvement Experience

Type of Pasture Improvements	Number of Ranchers Reporting
Tame grass seeding*	47
Native grass seeding**	6
Native pasture fertilized	6
Tame grass fertilized	13
Range rested	2
Rotation grazing on native grassland	4
Interseeding into rangeland	2
Sprayed for weeds	2
Total number of different ranchers	65

*Tame grass includes: Bromegrass, tame rye, intermediate wheatgrass, crested wheatgrass, Russian wild rye, reed canary, sudan grass, and various mixtures of these grasses with alfalfa.

**Native grass includes: Western wheatgrass, needlegrasses, switchgrass, big bluestem, sideoats grama, and blue grama.

factors associated with the amount of pasture improvement work done by ranchers. Fifteen variables were identified for use in the model. A list of these variables is presented in Table 32. Variable X_{14} represented total acres of pasture improvement work and served as the dependent variable. Variable X_{15} also served as a dependent variable. A detailed discussion of these variables and how they were measured is presented in Chapter XII. The mathematical model may be expressed as:

$$X_{14} = a + b_1X_1 + b_2X_2 + \text{----} + b_{13}X_{13}$$

It was not the intent of this analysis to establish associations for predictive purposes. Consequently, interest was centered in the association between variables and the closeness of this association as measured by the coefficient of determination.

Source of Data

Data for quantifying the variables used in this study were obtained from a survey of 160 farmers and ranchers in Faulk, Hyde, Aurora, and Gregory Counties. This survey was taken during June of 1965 by a staff of five interviewers.

Table 32. Variables Used in Multiple Correlation Model

X_1	= Amount of capital available (net worth)
X_2	= Expectation of a satisfactory stand from a new seeding
X_3	= Risk and uncertainty associated with beef cow herds relative to other enterprises
X_4	= Profitability of range improvement relative to other alternatives
X_5	= Pasture improvement may be done on a small scale
X_6	= Degree to which handling of livestock while seeding is established is observed as a problem
X_7	= Pasture acres per animal unit
X_8	= Per cent of total land operated that is owned
X_9	= Understanding of the technology of pasture improvement
X_{10}	= Innovativeness of the rancher
X_{11}	= Age of the operator in years
X_{12}	= Years of formal education
X_{13}	= Total ranch acres
X_{14}	= Total acres of pasture improvement work done in a recent ten year period
X_{15}	= Did or did not do any pasture improvement work

CHAPTER XII

DESCRIPTION OF THE MODEL

A multiple regression analysis was used to identify factors associated with the amount of pasture improvement work done by ranchers. There are a great many factors that may be considered. A description of the factors used in this study and how they were measured for use in a multiple correlation analysis is presented in this chapter.

I. MODEL VARIABLES

Amount of Capital Available (X_1)

The amount of pasture improvement work done may be a function of the quantity of capital available. Capital available was measured by means of net worth. Net worth for each rancher was arrived at through an inventory of assets and liabilities obtained in the survey.

Expectation of a Satisfactory Stand from a New Seeding (X_2)

Ranchers who have a high expectation for a satisfactory stand from a new seeding may be more likely to do pasture improvement work than those who have a low expectation. Seeding failures add to production costs with no addition to returns. A low expectation of success would deter ranch operators from making this type of investment. Each rancher included in the survey was asked to state the number of years out of five that he would expect to obtain a satisfactory stand from: (a) a new seeding of tame grass, (b) a new seeding of native grass, and (c) interseeding a pasture-type alfalfa into a native grass pasture.

The ranchers' responses to each of the three different types of seeding were totaled for a score. The maximum score attainable was fifteen and the minimum score was zero.

Risk and Uncertainity Associated with Beef Cow Herds Relative to Other Enterprises (X_3)

Beef production is the major livestock enterprise in central South Dakota. There were 149 ranchers out of 160 included in the survey who kept a beef cow herd. This means that a high proportion of grassland production is processed through a beef cow herd. The rancher's beliefs regarding the amount of risk and uncertainty associated with a beef cow herd may influence the amount he is willing to invest in grassland improvement. The risk and uncertainty factor, however, is a relative thing and can be measured only in relation to other alternative enterprises available to the rancher. These would include the more common alternatives of raising sheep or hogs, steer grazing, and crop production. The enterprises listed in Table 33 were presented to the ranchers. They were asked to rank them from one to six on the basis of dependability of income.

Table 33. Enterprise Ranking According to Dependability of Income

Enterprise	Average Ranking
Cow-calf operation	1.5
Sheep raising	2.9
Cow-yearling operation	3.4
Hog raising	3.7
Yearling steer grazing	4.4
Cash crop production	5.0

The ranking which a rancher gave to the cow-calf operation and the cow-yearling operation were added together for a score. The minimum possible score of three would indicate that the rancher rated beef cow herds first in dependability of income. A maximum possible score of eleven would indicate that beef cow herds were ranked last in dependability of income. The average score for each enterprise, as shown in Table 33, indicates that ranchers considered a cow-calf operation less risky than any of the other enterprises. Cash crop production was considered the most risky enterprise by ranchers included in the survey.

<u>Profitability of Range Improvement Relative to Other Alternatives</u> (X_4)

Ranchers were asked to consider the alternative areas of investment presented in Table 34.

Table 34. Profitability Ranking of Various Investment Alternatives

Enterprise	Average Ranking
Increasing size of beef cow herd	1.83
Investing in another livestock enterprise	2.65
Investing in range improvement	3.03
Investing to increase crop production	3.09
Investing in Government bonds	4.48

Each rancher then ranked the alternatives in order of likely profitability per $100 invested. The range in possible score for any one enterprise would be one to five. If ranchers believe that capital earns a smaller return when invested in range improvement, as compared to other alternatives, they may not invest in range improvement work.

The average ranking given to range improvement by 156 ranch operators included in the survey was 3.03. However, investing in crop production was ranked on an equal basis with pasture improvement work as shown in Table 34. Ranchers, on the average, would invest to increase the size of the beef cow herd or invest in some other livestock enterprise before investing for range improvement. Government bonds were rated last in relative profitability.

Degree to Which Range Improvement May Be Done on a Small Scale (X_5)

Enterprises or practices that may be conducted on a small scale are conducive to adoption on a trial basis by ranch operators. The use of fertilizer is an example of such a practice. It may be used on one acre of land as a trial or used on all of the land if the rancher so chooses. Some enterprises are not adapted to trial on a small scale. The adoption of a system for grade A milk production would be an example of this. A farmer could not invest a small amount of money and sell part of his milk on the grade A market. He must make a considerable investment in milking equipment, pipe lines, bulk cooler, etc. A decision to shift to grade A milk production would come slower than a decision to use weed sprays, fertilizer or any other practice that may be adopted on a small scale. The consequences of a decision on a small scale activity are not as great as for those on a large scale. If pasture improvement work must be carried out on a large scale basis it may be likely to deter investment in this area. Those ranchers that believe pasture improvement work must be done on a large scale basis may not be as likely to invest in pasture improvement work as those who do not. Ranchers included in the survey were asked whether or not they could do some range improvement work a few acres at a time each year or whether it would have to be done a whole pasture at a time. A yes or no response was obtained. This variable was therefore fitted into the model as a dummy variable. In the correlation model "1" equals yes and "0" equals no. Out of 156 ranchers included in the survey, 85 answered yes, 61 answered no, and 10 didn't know. Fifty-four and one-half per cent of the ranchers surveyed indicated that they believed range improvement work could be conducted on a small scale basis.

Degree to Which Handling of Livestock is Observed as a Problem (X_6)

When pasture improvement work is being done, it may be necessary to keep livestock off the range for a period of time, which may, in turn, cause problems in handling livestock. Other pastures on which livestock can graze may not be available. Ranchers in the survey were asked the following question: Do you consider that handling your cattle while reseeding rangeland is

1. No problem?
2. Somewhat of a problem?
3. An important problem?
4. A very important problem?

A score of 4 was given to those respondents who felt that handling of livestock was a very important problem. Those who felt that no problem was involved received a score of one. If a rancher felt that a very important problem existed in regard to the handling of livestock while seeding or improving a portion of rangeland he would be less likely to undertake improvement work. There were fifty-six respondents who felt that no problem was involved, forty-one believed it was somewhat of a problem, twenty-six regarded it as an important problem, and thirty-three stated that it was a very important problem.

Current Stocking Rate (X_7)

Those persons who desire to expand the size of their beef herd may endeavor to do so by several means: (1) Rent or buy more pasture land, (2) improve their pasture productivity, or (3) increase the stocking rate. A rancher who is currently overstocking his pasture may be more likely to engage in pasture improvement work than one who is not. Data from the survey permitted the computation of total pasture acres and total animal units on pasture during 1965. Acres per animal unit were calculated for each rancher and used as an independent variable in the model.

Per Cent of Total Land Operated that is Owned (X_8)

Ownership may permit greater security of tenure and greater freedom of management. Under these conditions ranch operators may be in a better position to make long time plans for range improvement. The per cent of land owned was computed for each ranch included in the survey and used as an independent variable in the model.

Understanding of the Technology of Pasture Improvement (X_9)

To obtain satisfactory results from pasture improvement it is necessary that the proper technology be employed. This includes the use of adapted varieties, use of fertilizer, proper planting methods, and many other practices. If a rancher does not understand this technology he may be reluctant to begin any pasture improvement work. With the assistance of agronomists at South Dakota State University, a set of questions was formulated which would measure a persons understanding of pasture improvement technology. Each question was further scored on the basis of the type of response. The set of questions and the technique for scoring is presented in Table 35.

A total score was computed for each rancher by summing the scores on each question. The total score was used as an independent variable.

Innovativeness of the Rancher (X_{10})

It was decided in advance of the survey to measure innovativeness by a technique developed by Rogers, Havens, and Cartano.[1] Their approach involves determining an innovativeness score for each farmer for the purpose of categorizing adopters of farm practices as to their degree of innovativeness. Innovativeness measures the degree to which an individual is early in adopting practices compared to other members of his community. Ranchers who are innovative in nature may do more pasture improvement work than those who are not.

An innovativeness score for each rancher was determined on the

[1] Everett M. Rogers, A. E. Havens, and D. G. Cartano, The Construction of Innovativeness Scales, Mimeo Bulletin A. E. 30, Ohio Agricultural Experiment Station, Department of Agricultural Economics and Rural Sociology, February, 1962.

Table 35. Scoring System on Familiarity with Range Improvement Technology

Question and Response	Score
1. What fertilizer would you use on native range?	
(a) Use phosphorous or don't know	0
(b) Use a mixed fertilizer or above 40 pounds of nitrogen per acre	1
(c) Use 10-40 pounds of nitrogen per acre	2
(d) Use no fertilizer or would take a soil sample	3
2. What plants would be best for interseeding into native range?	
(a) Don't know or none	0
(b) Any type of clover	1
(c) Alfalfa alone or crested wheat alone	2
(d) Only grass plants	3
(e) Both alfalfa and grass	4
3. How can one best control gum weed and pasture thistle?	
(a) Don't know	0
(b) Mowing	1
(c) Use 2,4-D	2
(d) Specifies rate, time, and form of 2,4-D use	3
4. Between what dates are cool season native grasses most productive?	
(a) Don't know or any time previous to May 1	0
(b) May 1 to July 15	1
(c) June 1 to August or September	2
(d) June 1 to July 15	3
5. How can we increase production of green grass early in the season?	
(a) Don't know	0
(b) Apply nitrogen during late fall or in April	1
(c) Use early emerging cool season grass (no species)	2
(d) Refrain from late fall grazing	3
(e) Use crested wheat or Russian wild rye or both c and d are stated	4
(f) Both d and e are stated	5
6. When is supplemental pasture needed with cool season grasses?	
(a) Don't know	0
(b) Other than July 15 to September 15	1 or 2
(c) July 15 to September 15	3

Table 35. (continued)

Question and Response	Score
7. What is the best height for first spring grazing of green needlegrass or western wheat grass?	
(a) Don't know	0
(b) 2 to 4 inches or over 10 inches	1
(c) 8 to 10 inches	3
(d) 5 to 7 inches	4
8. What is the best way to improve alkaline or low spots?	
(a) Don't know	0
(b) Plant reed canary or creeping meadow fescue in low spots	1
(c) Seed tall wheatgrass in alkaline spots	2
(d) Both b and c are mentioned	3

basis of his answers to questions on time of adoption of new practices. Questions were formulated from recommendations of Animal Science and Agronomy Extension Specialists. Nineteen recommended practices, adapted to the area in which the survey was conducted, were selected by using the following criteria:

1. Practices must have been recommended by State University specialists.
2. The practices, or new ideas, should be applicable to the ranchers in the survey area and generally not involve large outlays of capital in order to adopt them.
3. They should be practices most likely to have been adopted within the last ten years so that farmers could recall the adoption date.

Table 36 presents the list of practices and per cent of ranch operators who have adopted each practice. Each rancher was asked to state the year in which he began using the practice. Interviewers did not consider a practice adopted unless it was put into permanent practice. Each practice was then categorized in one of three ways: (a) the year in which it was adopted, (b) not adopted at all, or (c) the practice was not applicable to the rancher's situation. This information was obtained from forty ranchers in each of the four counties previously mentioned by a staff of five interviewers. All five interviewers worked in a single county until the survey was completed.

Analysis of data. The range of adoption dates was determined

Table 36. Adoption of Recommended Practices by 160 Ranchers, to Whom Practices Were Applicable, in Central South Dakota

Practice	Total to Whom Applicable	Number of Adopters	Per Cent Adopted
1. Use 2,4-D for weed control in small grain	151	113	74.8
2. Use treated seed for seeding small grain	151	55	36.4
3. Test soil for fertilizer requirements	160	46	28.8
4. Plant crested wheat for spring pastures	158	45	28.5
5. Grow Ranger or Vernal Alfalfa for hay	160	65	40.6
6. Cut alfalfa for hay in early bloom	156	141	90.4
7. Frequently purchase certified seed	156	87	55.8
8. Plant sudan grass for supplemental pasture	158	53	33.5
9. Practice rotation grazing on tame pasture	135	60	44.4
10. Use stubble mulch tillage	150	62	41.3
11. Use soil sterilants for noxious weed patches	156	48	30.8
12. Participate in beef performance testing	136	8	5.9
13. Use stilbestrol in beef cattle feeding	118	28	23.7
14. Use Ronnel, Co-Ral, or Rulene for grub control	157	50	31.8
15. Use haylage	160	4	2.5
16. Calve heifers as 2-year-olds	154	126	81.8
17. Adopted a range plan	160	25	15.6
18. Computes nutrients in cattle rations	150	42	28.0
19. Use antibiotics in feed	146	51	34.9
TOTAL	2,872	1,109	38.6

for each practice and the dates of adoption were arrayed to show the number of adopters of a practice in each year. When asked for the year in which he first began using a practice, the respondent may have replied that he had always used the practice. When this response was received, the date of adoption was considered to be the year in which he started farming. Table 37 presents data to illustrate the procedure used in arraying the dates of adoption. Only two practices are presented to serve as an example of the method employed.

After establishing the frequency distribution of the time of adoption for each practice, the next step was that of assigning a "sten score." This was done by assigning a score from 0 to 9 based upon the time of adoption and assuming a normal distribution. Past research in the adoption of farm practices indicates that the adoption of a new practice over time will either be normally distributed or else closely approach normality.[2] Table 38 is the guide used for assigning "sten scores" for the year of adoption as presented in Table 37. Table 38 shows that under a normal distribution 2.3 per cent of the adopters should receive a "sten score" of nine. These would be the earliest adopters. Another 4.4 per cent would receive a score of eight. Under a normal distribution 68.2 per cent of the adopters would receive a score ranging from three to six.

In assigning scores for the year of adoption, it was necessary to give the same score to all respondents who adopted a practice in any

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[2]Everett M. Rogers, "Categorizing the Adopters of Agricultural Practices", Rural Sociology 23: 345-354, 1958.

Table 37. Time of Adoption and Sten Scores Assigned for Growing Ranger or Vernal Alfalfa and Using Stilbestrol in Beef Cattle Feeding

	Grow Ranger or Vernal Alfalfa		Use Stilbestrol	
Date of Adoption	Number of Adopters Each Year	Sten Score Assigned	Number of Adopters Each Year	Sten Score Assigned
1945	2	9	3	9
1946	1	9	1	8
1947	1	9	2	8
1948	0	-	1	8
1949	3	8	0	-
1950	5	8	2	8
1951	0	-	0	-
1952	1	7	0	-
1953	3	7	0	-
1954	1	7	0	-
1955	9	7	2	7
1956	1	6	1	7
1957	2	6	0	-
1958	3	6	3	7
1959	2	6	0	-
1960	5	6	2	7
1961	5	6	1	7
1962	5	6	5	6
1963	6	5	1	6
1964	6	5	1	6
1965	4	5	3	6
Never adopted	95	3	90	4
TOTAL	160		118	
Don't apply	0	-	42	-
Total respondents	160		160	

Table 38. Score Guide Used in Converting Time of Adoption to Sten Scores

Sten Score	Per Cent of Respondents Receiving Each Sten Score	Number of Respondents Receiving Each Sten Score When Sample Size is 160	Number of Respondents Receiving Each Sten Score When Sample Size is 118
9	2.3	4	3
8	4.4	7	5
7	9.2	15	11
6	14.9	24	18
5	19.2	30*	22
4	19.2	30*	22
3	14.9	24	18
2	9.2	15	11
1	4.4	7	5
0	2.3	4	3
TOTAL	100.0	160	118

*When rounded to the nearest whole number 19.2 per cent of 160 would be 31. However, the total would then add to 162 so the two largest categories are rounded to 30.

given year. For example, 2.3 per cent, or three of the respondents, to which the practice of using stilbestrol was applicable, are to receive a "sten score" of nine. In Table 37 we see that three respondents adopted the practice in 1945 so all three receive a score of nine. The next five respondents (4.4 per cent) are to receive a score of eight. However, it is noted that in order to assign a score of eight to exactly five respondents only one of the two who adopted the practice in 1950 should receive a score of eight. There is no basis for distinguishing between the two so both are given a score of eight. This leaves one less respondent to receive a score of seven in the succeeding category. Ten respondents are now to receive a score of seven. Table 37 shows that if the next ten respondents are to receive a score of seven, only one of the five who adopted the practice in 1962 should receive a score of seven. Since less than half of those who adopted the practice in 1962 should receive a score of seven, they are all given a score of six. This allocation of scores, according to a normal distribution, is continued for the remaining years. An average score is computed for all the non-adopters. Four (2.3 per cent) of the non-adopters are to receive a low score of zero. The next five are to receive a score of one. The average score for all those who never adopted the practice of using stillbestrol in cattle feeding is four.

Every respondent was next assigned a score for each separate practice according to the date of adoption. An average score was computed for each respondent and this was his innovativeness score as arrived at by the method employed by Rogers, Havens, and Cartano.

It is noted that under this technique an individual's innovativeness score is determined by the number of practices he has adopted as well as how early he adopted the practice. Individuals who started farming in recent years could not possibly receive as high a score as those who started farming earlier since they had no opportunity to adopt a practice. In this survey there were eleven respondents who had started farming since 1960. It, therefore, seemed necessary to make an adjustment in the score for the year in which an individual started farming. To do this, a linear regression analysis was run with the innovativeness score as the dependent variable and the year in which one started farming as the independent variable. The estimating equation obtained was:[3]

$$Y = 4.54176 - .007215X$$

In correcting the scores each score was reduced downward by .007215 for each year that the date of starting farming deviated from 1965 and rounded to three digits. Table 39 presents the adjusted innovativeness score for each farm operator included in the survey. The mean innovativeness score was 4.07 and the range was from 2.85 to 5.75.

Age of the Operator in Years (X_{11})

Older operators may not be interested in making long time investments in range improvements. Many factors, associated with age, may

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[3]In testing the hypothesis that b = 0, a t value of 2.08 was obtained. With 158 degrees of freedom this is significant at the .05 level of probability and the hypothesis is rejected.

Table 39. Innovativeness Scores, Corrected for Year Started Farming, for Farm Operators Included in a Sample Survey of Central South Dakota Farm Operators

Farm Number	Innovativeness Score	Farm Number	Innovativeness Score	Farm Number	Innovativeness Score	Farm Number	Innovativeness Score
101	5.00	201	3.53	301	4.36	401	4.09
102	4.34	202	3.61	302	3.85	402	3.43
103	4.05	203	3.57	303	3.70	403	4.02
104	3.28	204	4.27	304	3.74	404	4.78
105	3.40	205	4.46	305	3.46	405	4.72
106	4.19	206	4.41	306	3.14	406	4.52
107	4.25	207	3.85	307	3.97	407	3.01
108	3.25	208	5.72	308	3.69	408	3.70
109	4.68	209	3.26	309	3.46	409	3.83
110	3.65	210	3.79	310	3.73	410	4.48
111	4.21	211	4.39	311	5.62	411	4.30
112	3.57	212	4.80	312	3.59	412	3.70
113	4.56	213	3.50	313	3.41	413	4.65
114	3.38	214	3.71	314	3.49	414	3.75
115	3.56	215	4.66	315	4.56	415	4.20
116	3.59	216	4.70	316	5.24	416	4.06
117	3.88	217	3.83	317	5.01	417	4.26
118	3.55	218	5.75	318	3.00	418	3.69
119	3.86	219	4.14	319	4.57	419	3.92
120	4.10	220	3.94	320	4.02	420	4.60
121	4.80	221	4.48	321	4.04	421	4.31
122	4.80	222	4.49	322	3.70	422	3.04
123	4.75	223	5.06	323	4.49	423	4.17
124	4.21	224	3.97	324	4.25	424	3.93
125	3.47	225	4.51	325	4.67	425	4.24
126	4.60	226	4.25	326	3.57	426	3.05
127	4.16	227	4.78	327	5.07	427	3.61
128	3.61	228	3.91	328	5.32	428	3.79
129	4.30	229	5.72	329	4.14	429	3.78
130	3.95	230	5.48	330	3.71	430	3.91
131	3.44	231	4.28	331	3.67	431	3.16
132	3.80	232	4.81	332	4.43	432	3.59
133	2.98	233	3.62	333	4.04	433	3.94
134	3.45	234	4.51	334	3.54	434	3.86
135	4.43	235	4.12	335	2.85	435	3.61
136	4.46	236	4.58	336	3.52	436	3.69
137	3.43	237	4.26	337	3.68	437	3.53
138	4.02	238	4.44	338	4.14	438	3.86
139	3.57	239	4.95	339	4.78	439	4.33
140	4.06	240	4.78	340	3.92	440	3.82

Range 2.85 to 5.75 Mean = 4.07

act to cause an individual to avoid investments in range improvement. Age was therefore fitted into the model as an independent variable.

Years of Formal Education (X_{12})

Formal education and training may facilitate an understanding of the value of pasture improvement as well as the methods for pasture improvement. Years of formal education were used as an independent variable.

Ranch Size (X_{13})

Operators of large ranches may be more interested in doing pasture improvement work than operators of small ranches. Many factors such as capital position, personal characteristics of the operators, or adequate land for handling livestock while reseeding may cause ranch size to be a factor related to the amount of pasture improvement work done. Total ranch acres were used as an independent variable in the model.

Acres of Pasture Improvement Work Done (X_{14})

The amount of pasture improvement work done was measured in acres. It was the dependent variable in the model. Interviewers asked each rancher in the survey to list any kind of pasture improvement work which had been done within the last ten years.[4] It included seedings, resting the range, fertilization, weed spraying, and rotation grazing. For purposes of this study, pasture improvement work was defined as

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[4]This would be a ten year period up to and including 1965.

"any activity which had as its objective an increase in pasture production per acre." It included the activities presented in Table 31, page 107.

Pasture acres represents a cumulative total of all improvement activities. For example, if an individual seeded five acres of brome-alfalfa for pasture in 1960, twenty acres in 1962, and fertilized fifty acres of native pasture in 1963, he would have a total of seventy-five acres of pasture improvement work.

Did or Did Not Do Pasture Improvement Work (X_{15})

This was measured by means of a dummy variable. A "1" indicates that pasture improvement work was done and a "0" indicates that no pasture improvement work was done.[5]

[5]For a discussion of dummy variables consult Robert Ferber and P. J. Verdoorn, Research Methods in Economics and Business, Macmillan Company, New York, 1962, pp. 369-372.

CHAPTER XIII

RESULTS OF SIMPLE CORRELATION ANALYSIS

A straight line regression analysis, using the variables discussed in Chapter XII, was run under two situations. Table 40 presents the zero order correlation coefficients when all ranchers (156) included in the survey[1] were included in the correlation analysis. Table 41 presents the zero order correlation coefficients when only those ranchers who had done pasture improvement work were included in the correlation study.

It is the purpose of this chapter to discuss the relationship between variables where the zero order correlation coefficient was found to be significantly different from zero, as presented in Tables 40 and 41.

I. NET WORTH

Per Cent of Total Land Operated that is Owned (X_8)

Net worth was found to be significantly associated with land ownership. This is logical and expected. As the per cent of land owned increased the amount of net worth also increased. It is a positive association.

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[1]Four of the original 160 ranchers in the survey are not included in this analysis because of insufficient information.

Table 40. Simple Correlation Matrix, 156 Observations,
All Farms and Ranches Drawn in Random Sample Survey

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.000	.032	.041	-.003	.031	-.110	.154	.299**	.043	.315**	.205*	.081	.713**	.088	.008
2		1.000	.012	.009	.110	-.034	.022	.084	.177*	.025	-.037	.021	.033	.157	.198*
3			1.000	.039	.081	.126	-.058	.043	-.070	.037	-.073	-.106	-.112	.084	.118
4				1.000	-.165*	.042	.017	-.072	-.113	-.101	.207**	-.059	-.009	-.153	-.183*
5					1.000	-.379**	-.023	-.041	.155	.115	-.099	.080	.068	.109	.187*
6						1.000	-.101	.012	-.172*	-.187*	-.031	-.112	-.160*	-.169*	-.114
7							1.000	.094	-.138	-.054	.182*	-.015	.336**	.063	-.141
8								1.000	-.055	.146	.268**	-.062	.050	.036	.038
9									1.000	.192*	-.245**	.129	-.031	.119	.250**
10										1.000	-.012	.192*	.246**	.241**	.237**
11											1.000	-.255**	.108	-.005	-.236**
12												1.000	.092	.004	.038
13													1.000	.070	.031
14														1.000	.549**
15															1.000

*Significant at .05 level (.157)

** Significant at .01 level (.206)

Table 41. Simple Correlation Matrix, 64 Observations, Farms and Ranches Having Done Pasture Improvement Work

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.000	.233	-.073	.027	.065	-.118	.060	.248*	.000	.377**	.378**	.148	.630**	.180	.000
2		1.000	-.089	.085	-.078	-.118	.113	.056	.219	.099	.122	.168	.290*	.100	.000
3			1.000	.445**	-.047	.080	.024	.094	-.396**	.016	.143	-.154	-.141	.042	.000
4				1.000	-.195	.148	-.096	-.104	-.224	-.162	.190	-.257*	.050	-.098	.000
5					1.000	-.276*	.041	.021	.064	.019	.151	.021	.071	.012	.000
6						1.000	-.285*	.028	-.215	-.090	-.195	-.095	-.132	-.208	.000
7							1.000	-.016	-.125	-.037	.101	.057	.334**	.286*	.000
8								1.000	-.174	.199	.238	-.084	-.053	.031	.000
9									1.000	.151	-.245*	.388**	-.110	-.035	.000
10										1.000	.064	.233	.167	.195	.000
11											1.000	-.300*	.173	.259*	.000
12												1.000	.104	-.068	.000
13													1.000	.098	.000
14														1.000	.000
15															.000

*Significant at .05 level (.246)

**Significant at .01 level (.320)

Innovativeness of the Rancher (X_{10})

Innovativeness was found to vary directly with net worth. The correlation coefficient was significant at the 1 per cent level in Table 40 and also in Table 41. This would indicate that it was the more innovative individual who had a large net worth. However, it must be recognized that no direction of causation can be determined from the correlation analysis. It could also be reasoned that individuals with a large net worth are more innovative.

Age of Operator in Years (X_{11})

A positive association exists between age of the rancher and net worth. This is another logical association that one would expect to find. Net worth increases with age. The correlation coefficient was significant at the 1 per cent level in Table 41 and at the 5 per cent level in Table 40.

Total Ranch Acres (X_{13})

Net worth was more closely associated with the amount of land operated than with any of the other factors. The correlation coefficient was significant at the 1 per cent level in both tables. Ranch size varied directly as the net worth varied and it could be logically argued that there were lines of causation running in both directions.

II. EXPECTATION OF A SATISFACTORY STAND FROM A NEW SEEDING

Understanding of the Technology of Pasture Improvement (X_9)

The expectation of a satisfactory stand from a new seeding was significantly associated with an understanding of the technology of pasture improvement when all ranchers in the survey were a part of the analysis. Among ranchers who had done pasture improvement work the association was significant at slightly greater than the 5 per cent level of probability. The association was positive. It would seem reasonable to assume that a greater understanding of the technology would influence the expectations from a new pasture seeding. An understanding of the technology would, in itself, create a greater degree of confidence in the expected outcome. Such understanding would eliminate many apprehensions as to whether or not the seeding was properly made and leave only the factors beyond control of the rancher as risk elements.

Total Ranch Acres (X_{13})

The expectation of a satisfactory stand from a new seeding was associated with ranch size only among those ranchers who had done pasture improvement work. The correlation coefficient of .29 was significant at a 5 per cent level of probability. After a decision had been made to do pasture improvement work, it was the large ranches that had the most acres of pasture improvement work done. The operators of large ranches had the greatest expectation of success from new seedings.

The correlation coefficient was .033 when all ranchers in the survey were included in the analysis.

Pasture Improvement Experience (X_{15})

Table 40 shows that the expectation of a satisfactory stand from a new seeding was positively associated with a decision to do pasture improvement work. Variable 15 in Table 40 is a dummy variable. A "1" indicates that pasture improvement work was done and a "0" indicates that no pasture improvement work was done. If a "1" is interpreted as also meaning that the decision to do pasture improvement work has been made, then a correlation coefficient of .198 would indicate that ranchers who had made this decision had a higher expectation of success from a new seeding. It might also be interpreted as those with experience in pasture improvement work had a higher expectation of success from a new seeding.

III. RISK AND UNCERTAINTY ASSOCIATED WITH BEEF COW HERDS

Profitability of Range Improvement (X_4)

The profitability of range improvement relative to other alternatives, as viewed by the rancher, was associated with the amount of risk and uncertainty he attached to a beef cow herd. The correlation coefficient of .445 was significant at the 1 per cent level. This association existed only among those ranchers who had done pasture improvement work. Those ranchers who believed that beef cows had a high risk factor also believed that range improvement was not very profitable relative to other alternatives.

Understanding of the Technology of Pasture Improvement (X_9)

For those ranchers who had done pasture improvement work there was a negative association between their understanding of the technology of pasture improvement and the amount of risk they associated with beef cow herds. The correlation coefficient of -.396 was significant at the 1 per cent level. Ranchers who had experience in pasture improvement work and also felt that beef cows were one of the more risky enterprises had a low understanding of the technology of pasture improvement. This cannot necessarily be interpreted to mean that an improvement in their understanding of the technology will change their attitude toward the risk associated with beef cows.

IV. PROFITABILITY OF RANGE IMPROVEMENT

Range Improvement on a Small Scale (X_5)

A correlation coefficient of -.165 between profitability of range improvement and the degree to which range improvement may be done on a small scale was significant at a 5 per cent level of probability. The association was negative and significant only among all ranchers in the survey. However, one should note that the association among ranchers who had done pasture improvement work was also negative and not far from being significant at the five per cent level. The inverse association indicated that those ranchers who felt that range improvement was profitable also believed that it could be carried out on a small scale basis.

<u>Age of Operator in Years</u> (X_{11})

Among all ranchers in the survey there was an association between their age in years and their opinion regarding the profitability of pasture improvement. The association was significant at a 1 per cent level. Older operators ranked range improvement lower in profitability than did younger operators. This association was not significant among ranchers who had done pasture improvement work.

<u>Years of Formal Education</u> (X_{12})

Among ranchers, who had done pasture improvement work, there was a correlation coefficient of -.257 between years of formal education and their profitability ranking of range improvement. Ranchers with more formal years of education had a higher profitability ranking for range improvement.

<u>Pasture Improvement Experience</u> (X_{15})

Those ranchers who had done pasture improvement work ranked range improvement higher, in terms of profitability, than did those ranchers who had not done pasture improvement work. The correlation coefficient of -.183 was significant at a 5 per cent level of probability.

V. RANGE IMPROVEMENT ON A SMALL SCALE

<u>Problem of Handling Livestock</u> (X_6)

The opinion of ranchers regarding the feasibility of small scale range improvement work was significantly associated with the degree to which they observed the handling of livestock as a problem. The correlation coefficient was significant at the 1 per cent level among all ranchers in the survey and significant at the 5 per cent level among ranchers who had done pasture improvement work. The inverse association of these variables, as quantified, means that those ranchers who felt that the handling of livestock was a problem also felt that range improvement work could not be done on a small scale basis.

Experience in Pasture Improvement (X_{15})

Experience in pasture improvement work was associated with the opinion that range improvement could be done on a small scale basis. Table 40, page 130, shows that the correlation coefficient of .187 was significant at a 5 per cent level.[2]

VI. PROBLEM OF HANDLING LIVESTOCK

Pasture Acres Per Animal Unit (X_7)

Pasture acres per animal unit was inversely associated with the problem of handling livestock. A correlation coefficient of -.285 was significant at a 5 per cent level when only those ranchers who had done pasture improvement work were included in the analysis. Among all ranchers included in the survey the association was not significant.

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[2]It should be noted that the two variables involved (X_5 and X_{15}) are both dummy variables. Therefore, probability distributions cannot be assumed and there is no validity to a statistical test of significance for the correlation coefficient. Other statistical tests, such as Chi square, may be employed if further research is desired. However, the correlation analysis may be regarded as evidence in support of an association between the variables.

The inverse association indicated that ranchers who had a low stocking rate (high in acres per A.U.) tended to regard the handling of livestock as an unimportant problem.

Understanding of Pasture Improvement Technology (X_9)

The association between an understanding of pasture improvement technology and the problem of handling livestock, as shown in Table 40, page 130, was significant at a 5 per cent level of probability. The correlation coefficient was -.172. Those ranchers who scored high in an understanding of pasture improvement technology ranked the problem of handling livestock as relatively unimportant.

Innovativeness of the Rancher (X_{10})

Innovativeness was inversely associated with the problem of handling livestock among all ranchers included in the survey. However, this association was not true among ranchers who had done pasture improvement work. This is reasonable to expect, since those individuals who had done improvement work were more innovative in nature. Within a group of innovative individuals there was no association between the degree of innovativeness and the problem of handling livestock. Among all ranchers in the survey there was a significant association between the variables as measured by a correlation coefficient of -.187. Innovative individuals ranked the problem of handling livestock as relatively unimportant.

Total Ranch Acres (X_{13})

Among all ranchers in the survey there was a significant association between ranch size and the problem of handling livestock. As ranch size increased the problem of handling livestock became less important.

Total Acres of Pasture Improvement Work Done (X_{14})

Table 40, page 130, shows a correlation coefficient of -.169 between the amount of pasture improvement work done and the problem of handling livestock. This is significant at a 5 per cent level of probability. The negative association means that those ranchers who rated the handling of livestock as not important have also done more pasture improvement work.

VII. PASTURE ACRES PER ANIMAL UNIT

Age of the Operator in Years (X_{11})

Among all ranchers included in the survey there was a direct association between age and pasture acres per animal unit. This association was not true among those ranchers who had done pasture improvement work. Older operators had more acres per animal unit.

Total Ranch Acres (X_{13})

In both Table 40, page 130, and Table 41, page 131, there was a correlation coefficient between total ranch acres and acres per animal unit that was significant at the .01 level of probability. The large ranches had more acres per animal unit. This, of course, could mean that the large ranches had land with lower grass productivity per acre and not that the operators of large ranches made different management decisions regarding the stocking rate. However, both of these elements may be involved in the association.

Total Acres of Pasture Improvement Work (X_{14})

Among ranchers who had done pasture improvement work there was an association between the amount of pasture improvement work done and the acres per animal unit. A correlation coefficient of .286 was significant at a 5 per cent level. When all ranchers in the survey were included in the analysis, the correlation coefficient was far below a significant level. Ranchers, who had done pasture improvement work and had a low pasture stocking rate (high acres per A.U.), had also done the most pasture improvement work.

VIII. PER CENT OF LAND OPERATED THAT IS OWNED

Age of the Operator in Years (X_{11})

Among all ranchers in the survey there was an association between per cent of land operated that is owned and the age of the operator. Table 40, page 130, shows a correlation coefficient that is significant at the .01 level of probability. This is a logical association. Older operators own more of the land they are operating than do the younger operators.

IX. UNDERSTANDING OF PASTURE IMPROVEMENT TECHNOLOGY

Innovativeness of the Rancher (X_{10})

Innovativeness was directly associated with an understanding of pasture improvement technology. Table 40, page 130, shows a correlation coefficient of .192 between the two variables which is significant at a 5 per cent level of probability. The more innovative individuals had a higher score in understanding of pasture improvement technology.

Age of the Operator in Years (X_{11})

There was a significant association between age of the operator and an understanding of pasture improvement technology. Younger operators scored higher in their knowledge of the technology of pasture improvement. The correlation coefficient in Table 40, page 130, was significant at a .01 level of probability.

Years of Formal Education (X_{12})

Among those ranchers who had done pasture improvement work there was an association of level of education with an understanding of pasture improvement technology. The correlation coefficient in Table 41, page 131, was significant at a .01 level of probability.

Pasture Improvement Experience (X_{15})

Those ranchers who had pasture improvement experience had higher scores in their understanding of pasture improvement technology. The association, as shown in Table 40, page 130, was significant at a .01 level of probability.

X. INNOVATIVENESS

Years of Formal Education (X_{12})

Innovativeness was associated with years of formal education. The more innovative individuals had more years of formal schooling. The association was significant at a .05 level of probability.

Total Ranch Acres (X_{13})

Innovativeness and ranch size were significantly associated among all ranchers in the survey. The association was significant at a 5 per cent level of probability.

Total Acres of Pasture Improvement Work Done (X_{14})

The amount of pasture improvement work done varied with innovativeness. Innovative individuals did more pasture improvement work. The association was significant at a .01 level of probability.

XI. AGE OF THE OPERATOR

Years of Formal Education (X_{12})

An inverse association existed between age and years of formal education. The older ranchers had fewer years of formal schooling. The association was significant at the .01 level of probability.

Experience in Pasture Improvement (X_{15})

Experience in pasture improvement was measured by a dummy variable. It was a yes or no situation. In the model a "1" indicated experience and a "0" indicated no experience. An inverse association, as indicated in Table 40, page 130, means that those with experience in pasture improvement were found more frequently among the younger ranchers.

XII. OTHER ASSOCIATIONS

There was a highly significant association between variable X_{14} and X_{15} in Table 40, page 130. Variable X_{14} measured the amount of pasture improvement work done while variable X_{15} indicated whether or not pasture improvement work had been done. Those ranchers with a zero rating for the X_{15} variable necessarily have no acres of pasture improvement work done. Therefore, this association is not pertinent to the current discussion.

CHAPTER XIV

RESULTS OF MULTIPLE CORRELATION ANALYSIS

Fifteen variables were identified and discussed in Chapter XII for inclusion in the multiple correlation model used in this study. Variable X_{14} measured the amount of pasture improvement work done (acres) and served as a dependent variable. Variable X_{15} was a dummy variable. It measured the presence or absence of experience in pasture improvement work and also was used as a dependent variable in one model.

Three multiple regression models were used. One model employed X_{14} as a dependent variable with X_1 through X_{13} as independent variables. A second model substituted X_{15} for X_{14} as a dependent variable. A third model used only the sixty-four ranchers who had done pasture improvement work as observations. Variable X_1 through X_{13} were independent variables and X_{14} was the dependent variable. These models are subsequently referred to as Model A, Model B, and Model C, respectively.

This chapter discusses the results of the multiple correlation analysis using Models A, B, and C.

I. MODEL A

A stepwise multiple regression program for the I.B.M. 1620 electronic computer was used for this analysis. Results of the program are presented in Table 42. The table presents the values for R^2 and

Table 42. F Level for Testing the Significance of R^2 and for Testing the Significance of an Increase in Explained Sum of Squares Due to the Introduction of an Additional Variable, 156 Observations, Acres of Pasture Improvement Work as Dependent Variable.

(N = Number of Observations k = Number of Independent Variables)

k	N-k-1	R^2	R^2F Level	Xn	Variable F Level
13	142	.13136	1.652	5	0.010
12	143	.13130	1.801	1	0.017
11	144	.13119	1.977**	13	0.044
10	145	.13092	2.184**	11	0.114
9	146	.13024	2.429**	8	0.110
8	147	.12959	2.736*	9	0.262
7	148	.12803	3.104*	12	0.413
6	149	.12560	3.555*	7	0.730
5	150	.12132	4.142*	3	1.581
4	151	.11205	4.764*	6	2.385
3	152	.09803	5.501*	4	2.904****
2	153	.08079	6.724*	2	3.820***
1	154	.05785	9.456*	10	9.456*

*Significant at the 1 per cent level

**Significant at the 5 per cent level

***Significant at the 6 per cent level

****Significant at the 10 per cent level the computed F level[1] for testing the significance of R^2. It also shows the F level for testing the additional explained sum of squares due to introducing a specific variable into the problem.[2]

When all thirteen variables were included in the regression problem, R^2 was not significant at the 5 per cent level. When variable X_5 (range improvement done on a small scale) was dropped from the problem, and twelve independent variables were used, the value of R^2 still was not significant. However, when eleven independent variables, or less, were employed in the model the value of R^2 became significant at the 5 per cent level. It became significant at the .01 level of probability when eight or less independent variables were used in the regression model.

The X_n column in Table 42 identifies the variable to be deleted in the stepwise regression analysis. For example, with thirteen independent variables, an R^2 of .13136 is obtained. The variable which reduced the explained sum of squares least (reduce the value of R^2) when removed from the regression problem was variable X_5. The next variable to be removed from the model was X_1. This is the net worth variable. It will be recalled from Part One of this study that a reduction in available capital generally resulted in less pasture improvement

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[1] $F = \dfrac{R^2\,(N-k-1)}{(1-R^2)\,(k)}$ with $n_1 = k$ and $n_2 = N-k-1$

[2] $F = \dfrac{(\text{Explained SS with k var.}) - (\text{Explained SS with k-1 var.})}{(\text{Error SS with k variables}) \div (N-k-1)}$

With $n_1 = 1$ and $n_2 = N-k-1$

work and a smaller cow herd. However, in the current regression analysis the capital position, as measured by net worth, was not significantly related to the amount of pasture improvement work.

This can logically be interpreted to mean that capital (as measured by net worth) was not a limiting factor in pasture improvement work among the ranchers surveyed. But, in terms of optimum organization, if capital is, in fact, a limiting factor it will reduce the amount of pasture improvement work done.

In Table 42, page 145, when only one independent variable remained in the model, we obtained an R^2 of .05785. This is the same as the zero order correlation coefficient of determination as presented in Chapter XIII between X_{14} and X_{10}. Variable X_{10} measures innovativeness. It was the variable most significantly associated with the amount of pasture improvement work done. When variable X_2 (expectation of satisfactory stand from a new seeding) was added to the model, there was a significant increase in the explained sum of squares, as shown in Table 42, page 145.

It is also observed in Table 42 that variables X_{10}, X_2, and X_4 explain 9.8 per cent of the variation in X_{14}. The explained variation, when thirteen independent variables were used in the model, was 13.1 per cent. It can now be seen that the data presented in Table 42, page 145, may be summarized in two main statements.

1. The independent variables do not explain a very large portion of the variation in X_{14}. However, the multiple coefficient of determination is significantly large when all but X_{13}

and X_{12} are included in the model.

2. Most of the variation in X_{14} was explained by a relatively few independent variables. Innovativeness (X_{10}) and expectation of a satisfactory stand from a new seeding (X_2) were the only two variables which added significantly to the explained sum of squares at a .06 level of probability.

II. MODEL B

Table 43 presents the values of R^2 and the F level for tests of significance when variable X_{15} was used as the dependent variable. Variable fifteen measured whether or not the rancher had done pasture improvement work. When all thirteen of the independent variables were included, an R^2 value of .21579 was obtained. This was significant at a .01 level of probability. Table 43 shows that all of the R^2 values obtained by reducing the number of independent variables one at a time were significant at a .01 level of probability.

Table 43 also shows that X_2, X_9, X_{10}, and X_{11} were the only variables that added significantly to the explained sum of squares. These were the variables with significant partial correlation coefficients. Variables X_9 and X_{11} became significant in Model B, whereas, they were not significant in Model A. Variable X_9 measured understanding of the technology of pasture improvement and X_{11} was the age of the operator. This would indicate that pasture improvement work was carried out by those who were innovative in nature, understood the technology, were younger in age, and had good expectations for a satis-

Table 43. F Level for Testing the Significance of R^2 and for Testing the Significance of an Increase in Explained Sum of Squares Due to the Introduction of an Additional Variable, 156 Observations, Did or Did Not Do Pasture Improvement Work as Dependent Variable.

(N = Number of Observations k = Number of Independent Variables)

k	N-k-1	R^2	R^2F Level	Xn	Variable F Level
13	142	.21579	3.006*	1	1.326
12	143	.20847	3.138*	13	0.252
11	144	.20708	3.419*	8	0.368
10	145	.20505	3.740*	6	0.703
9	146	.20119	4.086*	12	0.643
8	147	.19767	4.940*	7	1.248
7	148	.19086	5.026*	5	1.177
6	149	.18443	5.616*	3	2.226
5	150	.17220	6.241*	4	2.238
4	151	.15989	7.184*	2	4.561**
3	152	.13452	7.875*	11	6.145**
2	153	.09953	8.456*	10	6.308**
1	154	.0625	10.267*	9	10.250*

*Significant at the 1 per cent level

**Significant at the 5 per cent level

factory stand from a new seeding.

III. MODEL C

Table 44 presents the results of the correlation analysis when X_{14} (amount of pasture improvement work done) was used as a dependent variable and only the sixty-four ranchers who did pasture improvement work were included in the analysis. The table shows that a significant value of R^2 was not obtained until five or less independent variables were included in the model. The five variables measured years of formal education, profitability of range improvement, innovativeness, age of the operator, and pasture acres per animal unit.

An F test showed that X_7 (pasture acres per animal unit) was the only independent variable that added significantly to the explained sum of squares. The F value of 5.503 was significant at a .05 level of probability.

This would indicate that, among those ranchers who have done pasture improvement work, the factor most closely associated with the amount of pasture improvement work done is the pasture acres per animal unit. This is the same as the simple correlation analysis presented in Chapter XIII. Those ranchers with the greater pasture acres per animal unit were the ranchers who had done the most pasture improvement work.

Table 44. F Level for Testing the Significance of R^2 and for Testing the Significance of an Increase in Explained Sum of Squares Due to the Introduction of an Additional Variable, 64 Observations, Acres of Pasture Improvement Work as Dependent Variable.

(N = Number of Observations k = Number of Independent Variables)

k	N-k-1	R^2	R^2F Level	Xn	Variable F Level
13	50	.22222	1.0988	9	0.006
12	51	.22211	1.2134	2	0.287
11	52	.21773	1.3157	13	0.666
10	53	.20771	1.3894	1	0.212
9	54	.20454	1.5428	3	0.214
8	55	.20139	1.7337	5	0.384
7	56	.19582	1.9480	6	0.282
6	57	.19177	2.2540	8	0.424
5	58	.18576	2.6464**	12	0.497
4	59	.17879	3.2113**	4	0.544
3	60	.17122	4.1318*	10	2.631
2	61	.13487	4.7548**	11	3.762
1	62	.08152	5.5028**	7	5.503**

*Significant at .01 level

**Significant at .05 level

PART THREE

SUMMARY AND CONCLUSIONS

CHAPTER XV

SUMMARY AND CONCLUSIONS

This study was concerned with the optimum organization of a typical ranch on a Williams-Tetonka-Cavour soil association in central South Dakota. The major objectives of this study were:

1. To present alternative ranch plans for maximizing net returns under varied capital levels and efficiency levels.
2. To determine a profit maximizing land use program from among the many pasture improvement programs and pasture management systems for beef production on a typical ranch.
3. To estimate optimum adjustment in ranch organization while undertaking a pasture renovation program.
4. To identify factors associated with the amount of pasture improvement work done.

A profit maximizing linear programming model was used in arriving at optimum plans. Low, medium, and high levels of efficiency were assumed in grain crop and livestock production. Forage production was obtained from different management systems on tame grasses and native grasses. Tame grass included brome-alfalfa, crested wheatgrass, Russian wild rye, and sudan grass. Native grass pastures were either renovated, fertilized, continuous grazed, or rotation grazed. Optimum plans, under five different levels of capital restriction, were developed for each of the efficiency levels in crop and livestock production. The typical ranch in this analysis had five hundred acres of cropland and 1,056 acres of native grass.

I. OPTIMUM RANCH PLANS

Results

At a low level of efficiency cropland was shifted out of pasture production and into production of corn, sorghum, and barley as capital became more limited. Land with a 3 to 6 per cent slope was maintained in a corn-wheat rotation in all situations. With unlimited capital 173 acres of cropland were used in pasture production and an eighty-five cow herd, under a $5\frac{1}{2}$ month grazing program, was maintained. As capital became more limited the size of the cow herd was reduced and fattening activities were curtailed. Pasture land in poor condition was utilized through a deferred grazing system. A summary of net ranch incomes, under various capital and efficiency level situations, is presented in Table 45. Net ranch income varied from $6,008, under a five thousand dollar capital restriction, to $11,296 with unlimited capital. A summary of the returns to management is given in Table 46.

At a medium level of efficiency, cropland with less than 3 per cent slope was used to produce flax and sorghum, except under unlimited and extremely limited capital situations. With unlimited capital 125 acres of cropland were used for pasture and all the level cropland was in sorghum and barley. When capital was restricted to five thousand dollars, this cropland was used to produce sorghum and wheat. Some' crested wheatgrass was brought into the plans at ten and fifteen thousand dollar capital restrictions to provide early spring grazing for

Table 45. Net Ranch Income Under Various Capital Limiting Situations and Efficiency Levels in Production

Production Efficiency Level	Capital Limits (Dollars)				
	5,000	10,000	15,000	20,000	Unlimited
	-Dollars-				
Low in crop & livestock	6,008	7,549	8,900	9,936	11,296
Medium in crop & livestock	6,296	7,949	9,516	10,742	12,749
High in crop & livestock	6,709	11,152	12,598	14,110	16,974
Variable in crop & livestock	8,868	11,217	12,799	14,275	16,974
Low in crop & high in livestock	---	---	---	---	14,390
High in crop & low in livestock	---	---	---	---	15,478

Table 46. Return to Management Under Various Capital Limiting Situations and Efficiency Levels in Production

Production Efficiency Level	Capital Limits (Dollars)				
	5,000	10,000	15,000	20,000	Unlimited
	-Dollars-				
Low in crop & livestock	-144	590	1,184	1,527	1,209
Medium in crop & livestock	693	1,656	2,500	3,123	3,039
High in crop & livestock	1,472	4,990	5,843	6,760	8,242
Variable in crop & livestock	3,126	4,965	5,752	6,583	8,246
Low in crop & high in livestock	---	---	---	---	3,578
High in crop & low in livestock	---	---	---	---	6,595

yearling cattle. With unlimited capital an 88 cow herd, under a $5\frac{1}{2}$ month grazing program, was maintained. As capital became limited the size of the cow herd was reduced and fattening programs were curtailed. At a five thousand dollar capital restriction, no livestock was produced and net ranch income was $6,296. With unlimited capital, net ranch income was $12,749.

At a high level of efficiency in crop and livestock production it became profitable to renovate pasture land in 25 per cent condition, if capital was not limited. When capital was limited, deferred grazing was used on pasture in 25 per cent condition and all level cropland was used to produce corn and flax. With unlimited capital twenty acres of cropland were used to produce pasture. All level cropland was in a wheat-wheat-fallow rotation when capital was limited to five thousand dollars. A cow herd of fifty-three cows was maintained with unlimited capital. The size of the herd was reduced as capital became limited. Calves were wintered, summer grazed, and then placed in a fattening program at all levels of capital restriction. Net ranch income was $16,974 with unlimited capital and $6,709 when capital was limited to five thousand dollars.

With high efficiency in livestock and low efficiency in crop production, 236 acres of cropland were used to produce brome-alfalfa, sudan grass, and Russian wild rye pasture. A herd of 105 cows was maintained and the calves were wintered, summer grazed, and then fattened.

With high efficiency in crop production and low efficiency in livestock there was only 31.7 acres of cropland used for pasture and the cow herd was reduced to 52 cows. Corn and flax were produced on level cropland. All but 12.5 acres of the level cropland were used for corn production when the crop production efficiency was low relative to that in livestock. Land with 3 to 6 per cent slope was kept in a corn-wheat rotation in both plans under mixed efficiency levels.

The "low crop-high livestock" situation employed $24,007 more capital and 485 hours more labor than the "high crop-low livestock" situation. But the return to management was $3,017 greater when the efficiency in crop production was high.

When the efficiency levels were variable and the choice of efficiency levels was given over to the linear programming procedure, the optimum plan, under an unlimited capital situation, was the same as under a high efficiency situation in both crop and livestock production. With unlimited capital the optimum plan selected the high efficiency enterprises in all cases. As capital becomes limiting the crop production program was not altered from the program carried out under high efficiency in both crop and livestock production until the five thousand dollar capital level was reached. Corn and flax were the only crops produced. At the five thousand dollar capital level 298 acres of corn were produced at a medium level efficiency and the remaining cropland had 120 acres of a wheat-wheat-fallow rotation and 12.1 acres of flax. Capital was removed first from the livestock program as capital became more limiting. This was done by shifting to low efficiency cows and reducing the size of the herd. Such a procedure permitted more cows to be maintained, than if high efficiency cows were kept, and more grassland was utilized.

To maintain a fifty cow herd during a period of time in which 160 acres of native grassland were being renovated, the optimum plan converted cropland to tame pasture production. Brome-alfalfa pasture that was rotated and fertilized was the major pasture crop that was added. A cow-calf program under a $5\frac{1}{2}$ month grazing program was maintained before and after renovation. All calves in both time periods were wintered, summer grazed, and then fattened.

The supply of May and/or October labor was a limiting resource in many of the plans. Table 47 presents a summary of unused labor in the optimum plans for different efficiency situations and capital levels. A zero in the table indicates that the supply of labor was exhausted.

Conclusions

Cropland had priority on the use of capital at all levels of efficiency employed in this study. When capital is very limited, profits will be maximized by limiting the size of the beef cow herd and permitting pasture land to go idle. As capital becomes available it is profitable to place it first into crop production through the use of fertilizer, weed and pest control, and improved crop varieties. A corn-wheat rotation was consistently the most profitable plan on land with a 3 to 6 per cent slope in all efficiency situations employed in this study.

The most profitable crop program on level land is highly

Table 47. Hours of Unused Labor in Optimum Plans for Various Capital Limitations and Efficiency Levels

Labor Period	Capital Limits (Dollars)				
	5,000	10,000	15,000	20,000	Unlimited
Low Level Production Efficiency					
April	281	232	199	184	209
May	0	0	0	0	0
June	314	306	305	305	304
July	399	378	364	361	390
August	482	393	321	254	0
September	502	505	488	464	426
October	0	0	0	0	14
Annual total	3093	2755	2449	2172	1453
Medium Level Production Efficiency					
April	373	269	221	179	161
May	40	0	0	0	0
June	485	496	488	483	406
July	427	425	409	396	383
August	506	459	385	323	0
September	191	176	188	167	248
October	269	259	249	248	212
Annual total	3491	3175	2906	2661	1851
High Level Production Efficiency					
April	220	339	312	284	230
May	456	31	22	14	0
June	468	316	314	313	312
July	320	505	500	495	482
August	477	444	380	314	157
September	477	520	511	500	475
October	287	0	0	0	4
Annual total	3903	3317	3114	2908	2429
Variable Level Production Efficiency					
April	393	335	299	265	231
May	21	26	7	0	0
June	304	313	305	304	312
July	452	502	491	485	482
August	505	432	341	269	157
September	511	519	508	499	476
October	0	0	0	2	4
Annual total	3387	3252	2903	2666	2430

dependent upon the relative crop production efficiencies and the assumed price relationships. Individual operators must evaluate their own production efficiency in the various crops and determine the most profitable crops to produce through the budgeting procedure. At a low level of efficiency in all crops, as assumed in this study, corn and barley were produced on level cropland in the optimum plan. Under a medium level of efficiency flax and sorghum become the primary crops. At a high level of efficiency corn and flax were produced in all cases except where capital was extremely limited--in which case all cropland was used by a wheat-wheat-fallow rotation.

The optimum plans, obtained when efficiency levels were permitted to vary, indicate that capital is added beyond the cropping program by first investing in low efficiency livestock. This permits more acres of native grassland to be used. As capital becomes more available, livestock numbers are expanded and livestock efficiency is increased by investing in better breeding stock and improved management programs. Livestock fattening activities are also added as more capital becomes available.

In this study, it was only under a high efficiency level in both crop and livestock that it became profitable to interseed the 25 per cent condition rangeland. In all other situations this rangeland was utilized through a deferred grazing program. Crop production is competitive with livestock for the use of cropland. The results of this study would indicate that the renovation of native pastures is not profitable unless there is a high efficiency in both crop and livestock production and capital is not a limiting factor. As the efficiency in crop production increases it becomes more profitable to use cropland to produce cash crops. Forage production for livestock must then come from native grassland. It is not profitable to invest in range improvement unless the efficiency in livestock production is relatively high.

The profitability of tame grass pastures is dependent upon the efficiency level in crop production and the amount of capital available. Optimum plans in this study used more cropland for tame grass pastures as the crop efficiency level decreased and as the capital level increased. The most cropland used for tame pasture production was under a situation of low efficiency in crops and high efficiency in livestock, with capital unlimited.

Using cropland for the production of tame grass pastures to provide one month of early spring grazing was not profitable, in most instances. Only under a medium level efficiency, where the summer grazing of yearling cattle for $6\frac{1}{2}$ months was included in the livestock program, was it profitable to produce crested wheatgrass.

Cow herds, in all instances, used a $5\frac{1}{2}$ month grazing program and were wintered on pasture and hay from November 1 to May 15. A fall pasture of Russian wild rye, produced on cropland, was profitable in most instances. The Russian wild rye, along with aftermath grazing in the corn stubble, provided the required three months of winter grazing for the calf crop.

The results of this study indicate the complexity of the management decisions that must be made on a typical ranch in central South Dakota. The optimum plan for any individual ranch is dependent upon a variety of factors. It varies with the labor supply, land resources, capital available, efficiency levels, and price relationships. All of the assumptions set forth in developing the optimum plans in this study may not fit all ranch situations. However, the plans may serve as guidelines to ranchers as they develop their own plans to fit their particular situations.

Suggestions for Further Research

No investigation was made into the possibility of converting some native grassland to tame grass production as a means of increasing productivity. Further investigation may also be made into the effect of changing price relationships upon the optimum ranch organization.

Enterprises, other than beef, need to be studied as possible activities in an optimum ranch plan. Likewise, the purchase of beef feeder cattle was not permitted in this model and further analysis may be made regarding this activity.

Investigation may also be made into the optimum plan for different soil resource situations. Models that permit the hiring of labor may also be employed in further studies.

The feasibility of additional efficiency levels may need to be investigated. The low efficiency in crop production in this study was approximately at current normal yield levels. Perhaps a lower efficiency level in crop production should be considered. Also, the feasibility of higher and/or lower levels of efficiency in livestock production may be studied.

A minimum resource model to attain a specified level of income may also be studied.

As part of Research Project 423, the South Dakota Experiment Station has established a pasture research farm at Norbeck, South Dakota. Further analysis needs to be made in the light of new information regarding pasture productivity and management programs as a result of research currently being conducted.

Additional studies may also be conducted into the effect of different machine complements on resource use and optimum ranch organization. The effect of government acreage control programs and land tenure systems on optimum ranch plans also needs to be investigated.

II. FACTORS ASSOCIATED WITH THE AMOUNT OF PASTURE IMPROVEMENT WORK DONE

Thirteen variables were quantified by means of data obtained in a random sample survey of 160 farmers and ranchers in Faulk, Hyde, Aurora, and Gregory Counties. A linear multiple correlation analysis was used to identify variables associated with the amount of pasture improvement work done. The correlation analysis was made using all ranchers included in the survey and also using only those ranchers who had done pasture improvement work.

Results

Much intercorrelation existed between the variables used in this study. Among all ranchers included in the survey, the following relationships were found to be significant at a .01 level of probability.

Age of the operator in years and --

Profitability of range improvement (rancher's opinion)
Per cent of total land operated that is owned
Understanding of the technology of pasture improvement
Years of formal education

Innovativeness of the rancher and --

Net worth
Total ranch acres
Total acres of pasture improvement work done

Total ranch acres and --

Net worth
Total pasture acres per animal unit

Feasibility of range improvement on a small scale and --

The problem of handling livestock when renovating a pasture

Per cent of land operated that is owned and --

Net worth

Relationships that were significant at a 5 per cent level of probability were found between the following variables:

The degree to which handling of livestock, while seeding is established, is observed as a problem and --

Total acres of pasture improvement work done
Total ranch acres
Innovativeness of the rancher
Understanding of the technology of pasture improvement

Innovativeness of the rancher and --

Years of formal education
Understanding of pasture improvement technology

Age of the operator in years and --

Net worth
Total pasture acres per animal unit

Understanding of pasture improvement technology and --

Expectation of a satisfactory stand from a new seeding

Profitability of range improvement (rancher's opinion) and --

Feasibility of doing range improvement on a small scale

A dummy variable, which measured whether or not pasture improvement work was done, was included in the model.

There was a significant simple correlation coefficient between the doing of pasture improvement work and --

Expectation of satisfactory stand from a new seeding
Profitability of range improvement (rancher's opinion)
Feasibility of range improvement on a small scale
Understanding of pasture improvement technology
Innovativeness of the rancher
Age of the operator in years

A multiple correlation analysis was made using 156 observations (all ranchers in the survey) and thirteen independent variables, with pasture improvement work done as a dependent variable. The independent variables which added significantly to the explained sum of squares were:

1. Innovativeness of the rancher (.01)[1]

2. Expectation of a satisfactory stand from a new seeding (.06)

3. Profitability of range improvement (rancher's opinion) (.10)

An R^2 value of .098 was obtained when the above three variables were the only independent variables in the model. The R^2 value was significantly large at a .01 level of probability.

A second multiple correlation analysis was made using 156 observations and thirteen independent variables with the dependent variable being a dummy variable which measured whether or not pasture improvement work was done. The independent variables which added significantly to the explained sum of squares were:[2]

1. Understanding of pasture improvement technology (.01)

2. Innovativeness of the rancher (.05)

3. Age of the operator in years (.05)

4. Expectation of a satisfactory stand from a new seeding (.05)

A third multiple correlation analysis was made using 64 observations (those who have done pasture improvement work) and thirteen independent variables, with the amount of pasture improvement work done as a dependent variable. Pasture acres per animal unit was the only variable which added significantly to the explained sum of squares in this instance.

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[1]Numbers in parentheses indicate the probability level for significance as determined by an F test.

[2]An R^2 value of .15989 was significant at a .01 level of probability.

Conclusions

Approximately 13 per cent of the variation in the amount of pasture improvement work done can be explained by the variables employed in this study. This is a relatively small amount, but the association of the independent variables with the dependent variable is statistically significant. Those factors that contributed most significantly to the variation in the amount of pasture improvement work done were innovativeness of the rancher, his expectations regarding a satisfactory stand from a new seeding, and his opinion regarding the profitability of range improvement. The first of these three variables was found to be significantly associated with the years of formal education. It should be further noted that the results of the simple correlation analysis has shown a statistically significant association between understanding of the technology of pasture improvement and the expectation of a satisfactory stand from a new seeding. This has implications for Extension workers in developing educational programs. Farm and ranch tours to observe successful applications of pasture improvement technology, information on improved varieties and methods of seeding, demonstration plots, and other educational activities of this nature can influence the amount of pasture improvement work done.

Research work to develop improved techniques for pasture renovation and reduce the risk factor in establishing new seedings would also aid in getting more pasture improvement work done.

The rancher also needs to decide whether or not pasture improvement is the most profitable activity for him to undertake. Results of the linear programming study has indicated that pasture improvement can be profitable, but this is only after capital has been utilized to its fullest extent in the cropping program. It therefore does not seem likely that pasture improvement will be undertaken seriously until efficiencies in crop production have been fully exploited and adequate capital is available for investment in livestock programs. It should be recognized, however, that this study has not evaluated the risk and uncertainty involved in crop production. Ranchers in the survey rated cash crop production as the most risky enterprise.

A distinction needs to be made between the amount of pasture improvement done and the decision to do pasture improvement work in either a small or a large amount. This is the difference between Model A and Model B in the multiple correlation analysis of this study. The Model B analysis indicated that those who had done pasture improvement work were frequently more innovative in nature, had higher scores in the understanding of pasture improvement technology, were younger, and had higher expectations of success from a new seeding. These were the four independent variables most significantly associated with the undertaking of pasture improvement work, not considering the amount of pasture improvement work done.

Suggestions for Further Research

Investigation may be conducted into new techniques for measuring the variables employed in this study. Likewise, additional variables may be considered that would add to the per cent of explained variation in pasture improvement work.

Additional studies of this nature may be undertaken in the West River area of South Dakota. This is the area where native range is of primary importance and the role of range improvement in maximizing profits may be different from that in central South Dakota. Information needs to be obtained from the West River area on rancher experience and attitude toward pasture improvement work.

Additional statistical techniques, including nonparametric statistics, may be employed in making further analysis of the variables identified in this study.

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APPENDIX

Table 48. Fixed Costs and Unallocated Expenses Assumed in Programming

Item	Amount
Machinery	
Depreciation	$ 1390
Taxes	173
Interest on investment	518
Insurance	73
Housing	86
Total	$ 2240
Fencing (annual costs: 28 miles @ 25¢/rod)	224
Telephone and electricity	300
Professional services	50
Land tax (55¢ per acre)	880
Building depreciation	354
Liability insurance	50
Total	$ 4098
Interest on land ($95,408 @ 4%)[a]	3816
TOTAL COSTS	7914

[a]Average value of land operated, Hyde County survey = $59.63 per acre.

Table 49. Inventory of Permanent Structures Assumed on Typical 1600 Acre Ranch, Hyde County

Item	Number	Size or Capacity	Value
Trench silo	1	240 ton	$ 420
Barn	1	2112 sq. ft.	4224
Sheds	2	2600 sq. ft.	2600
Grain storage	3	4850 bushels	1698
Corrals	2	1600 lineal ft.	800
Wells	1	----	200
Dugouts[a]	5	1200 cu. yards	700
TOTAL VALUE			$10642

[a]Valued at farmer's share of cost

Table 50. Return Over Variable Costs Per Acre for Different Rotations at Three Levels of Efficiency

Rotation	Efficiency Level Low	Medium	High
	-Dollars-		
Corn	21.58	26.79	30.03
Barley	14.34	18.66	22.63
Oats	10.68	14.95	15.74
Flax	9.00	19.27	27.01
Sorghum	17.26	21.98	26.12
Wheat-wheat-fallow	12.60	17.77	22.62
Corn-oats	16.13	20.87	22.89
Corn-wheat	20.71	26.79	31.72
Sorghum-wheat	18.55	24.38	29.76
Corn-barley	17.96	22.73	26.33
Corn-flax	15.29	23.03	28.52

Table 51. Summary of Beef Cattle Labor Requirements*

Number of Farms	52	55	19	13	5
Number of Cows	10-49	50-99	100-149	150-199	200-350
Item					
			-Man Hours Per Cow-		
Grinding feed	0.538	0.292	0.352	0.193	0.726
Hauling feed	4.049	1.599	1.135	1.216	1.070
Hauling hay	6.387	4.106	2.986	2.374	1.078
Haul manure	1.233	1.002	0.597	0.454	0.172
Dehorn, castrate, brand, & vaccinate	0.479	0.570	0.421	0.350	0.400
Care at calving	2.385	1.602	1.568	1.741	2.620
Veterinary	0.056	0.071	0.053	0.037	0.012
General management	3.079	2.114	1.940	1.640	0.731
TOTAL	18.206	11.356	9.052	8.005	6.809

*Summary of data obtained in survey.

Figure IV. Relationship of Man Hours Per Cow to Size of Herd

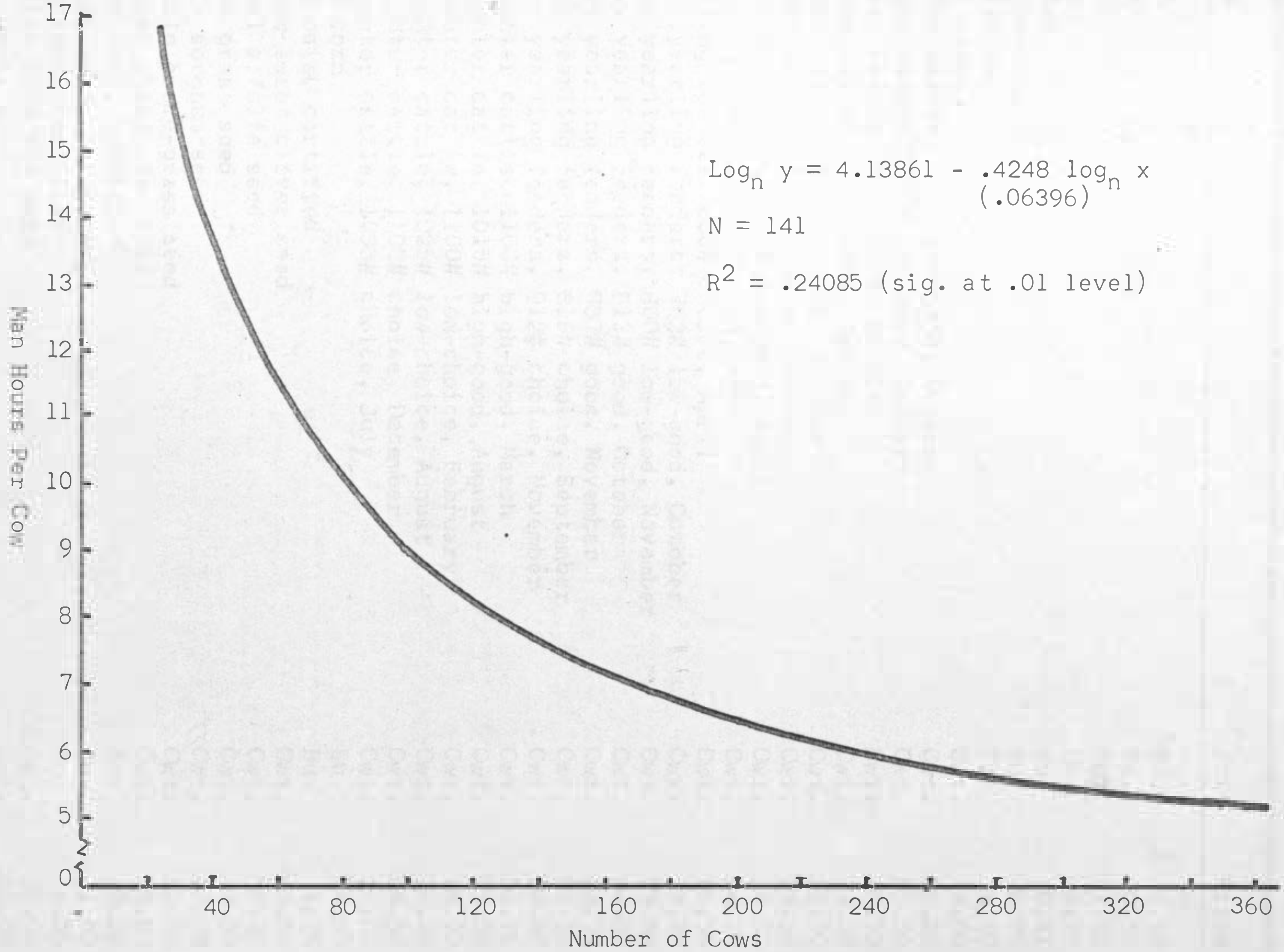

Table 52. Price Assumptions Used in Programming

Item	Unit	Price
Corn	Bu.	$ 1.10
Oats	Bu.	0.55
Wheat	Bu.	1.82
Flax	Bu.	2.75
Barley	Bu.	0.81
Sorghum grain	Bu.	0.95
Native hay	Ton	15.00
Cull cows	Cwt.	14.00
Feeder calves, 415# low-good, October	Cwt.	26.00
Feeder calves, 480# low-good, January	Cwt.	25.50
Feeder calves, 425# good, October	Cwt.	27.50
Feeder calves, 500# good, January	Cwt.	27.00
Feeder calves, 435# choice, October	Cwt.	29.00
Feeder calves, 520# choice, January	Cwt.	28.50
Yearling feeders, 547# low-good, April	Cwt.	24.00
Yearling feeders, 574# good, April	Cwt.	24.75
Yearling feeders, 600# choice, April	Cwt.	25.50
Heavy yearling feeders, 762# low-good, October	Cwt.	23.75
Heavy yearling feeders, 800# low-good, November	Cwt.	23.50
Heavy yearling feeders, 813# good, October	Cwt.	24.00
Heavy yearling feeders, 857# good, November	Cwt.	23.75
Heavy yearling feeders, 816# choice, September	Cwt.	24.25
Heavy yearling feeders, 912# choice, November	Cwt.	24.00
Slaughter cattle, 1100# high-good, March	Cwt.	23.75
Slaughter cattle, 1015# high-good, August	Cwt.	23.00
Slaughter cattle, 1100# low-choice, February	Cwt.	24.00
Slaughter cattle, 1025# low-choice, August	Cwt.	24.00
Slaughter cattle, 1100# choice, December	Cwt.	24.50
Slaughter cattle, 1035# choice, July	Cwt.	25.00
Seed corn	Bu.	14.50
Seed oats, certified	Bu.	1.75
Yellow sweet clover seed	Cwt.	13.50
Vernal alfalfa seed	Cwt.	59.00
Sudan grass seed	Cwt.	14.00
Grain sorghum seed	Cwt.	20.00
Lincoln brome-grass seed	Cwt.	33.00
Crested wheatgrass seed	Cwt.	59.00
Wheat seed, certified	Bu.	3.20
Barley seed, certified	Bu.	1.30
Flax seed, certified	Bu.	4.25
Russian wild rye seed	Cwt.	26.00
Blue grama seed	Cwt.	100.00
Western wheatgrass seed	Cwt.	75.00

Table 52. (continued)

Item	Unit	Price
Buffalo grass seed	Cwt.	$150.00
Big bluestem seed	Cwt.	100.00
Green needlegrass seed	Cwt.	100.00
Nitrogen fertilizer	Lb.	0.13
Phosphate fertilizer	Lb. of P_2O_5	0.10
Potash fertilizer	Lb.	0.06
Diesel fuel (less tax refund)	Gal.	0.17
Gasoline (less tax refund)	Gal.	0.195
Labor (operator and/or hired)	Hour	1.50
2,4-D herbicide, amine	Lb. of actual	0.80
Aldrin insecticide	Lb. of actual	5.75

Table 53. Estimated Fuel Consumption and Cost Per Tractor Hour[a]

Fuel Type	Tractor Size	75% Load		50% Load	
		Gallon	Cost	Gallon	Cost
Diesel	4 plow	2.6	0.442	2.1	0.357
Gasoline	3 plow	2.9	0.565	2.4	0.468

[a]Fuel consumption estimates based on 1965 Agricultural Engineers Yearbook. Cost estimates are based on current fuel prices less tax refund.

Table 54. Estimated Time Requirements and Repair and Service Cost for Various Machine Operations[a]

Machine Operation	Size	Man Hours Per Acre	Machine Hours Per Acre	Tractor & Implement Repairs and Service	
				Per Hour	Per Acre
Plow	4-14"	.77	.70	$ .47	$ .33
Disk (single)	20 ft.	.37	.34	.37	.13
Harrow	30 ft.	.11	.10	.27	.03
Plant	4 row	.24	.22	.49	.11
Drill	12 ft.	.25	.23	.75	.17
Spread fertilizer	12 ft.	.25	.23	.75	.17
Cultivate	4 row	.59	.54	.43	.23
Spray	8 row	.04	.03	.36	.01
Windrow (pull type)	12 ft.	.22	.20	.39	.08
Pick corn	2 row	.58	.53	.50	.27
Haul & store corn	wagons	.33	.30	.39	.12
Haul & store small grain	wagons	.33	.30	.22	.07
Mow	7 ft.	.41	.37	.35	.13
Rake	8 ft.	.39	.35	.37	.13
Bale	---	.44	.40	2.08	.83
Chop silage	1 row	.23/ton	.21/ton	.75	.16/ton
Haul & store silage	wagons	.45/ton	.13/ton	.68	.09/ton
Stack hay	---	.62/ton	.56/ton	.39	.22/ton
Combine	6' PTO	.55	.50	.37	.19

[a]Estimates are based on North Central Regional Project Number 54 data as prepared by Professor John Sanderson and upon data obtained in survey.

Table 55. Number of Once-Over Machine Operations Assumed in Crop Production

Machine Operation	Corn Grain	Corn Silage	Sor-ghum Grain	Small Grain After Row Crop	Small Grain After Alfalfa	Spring Wheat After Fallow	Spring Wheat After Small Grain	Flax	Hay Harvest	Fallow
Plow	1	1	1		1		1	1		
Disk	1	1	1	2	1	1	1	1		4
Harrow	1	1	2	1	1	1	1	1		
Plant	1	1	1							
Drill				1	1	1	1	1		
Cultivate	1	1	1							
Spray	1	1	1					1		
Windrow				1	1	1	1	1		
Combine[a]			1	1	1	1	1	1		
Pick corn	1									
Haul & store corn	1									
Haul & store small grain			1	1	1	1	1	1		
Mow									1	
Rake									1	
Stack hay									1	
Chop silage		1								
Haul & store silage		1								

[a]Combining was custom hired.

Table 56. Estimated Time Requirement and Machine Repair and Service Cost Per Acre for Various Crops[a]

Crop	Repairs and Service[b] Pre-Harvest	Harvest	Total Cost	Man Hours Pre-Harvest	Harvest	Machine Hours Pre-Harvest	Harvest
Corn grain	$ .85	$ .38	$1.23	2.15	.91	1.95	.83
Corn silage	.85	.17[c]	---	2.15	.68[c]	1.95	.34[c]
Sorghum grain	.87	.07	.94	2.26	.36	2.06	.33
Sorghum silage	.87	.18[c]	---	2.26	.68[c]	2.06	.34[c]
Spring wheat after row crop	.46	.15	.61	1.11	.58	1.01	.53
Spring wheat after fallow	.33	.14	.47	.73	.58	.67	.53
Spring wheat after small grain	.66	.14	.80	1.50	.58	1.37	.53
Oats after corn	.46	.15	.61	1.11	.58	1.01	.53
Oats after alfalfa	.67	.15	.82	1.50	.58	1.37	.53
Oats and alfalfa seeding	.46	.15	.61	1.34	.58	1.24	.53
Barley after corn	.46	.15	.61	1.11	.58	1.01	.53
Barley after alfalfa	.67	.15	.82	1.50	.58	1.37	.53
Flax	.68	.15	.83	1.54	.58	1.40	.53
Hay making							
One cutting (.9 tons)	---	.44	.44	---	1.36	---	1.22
Two cuttings (1.6 tons)	---	.86	.86	---	2.60	---	2.34

[a]Machine plus tractor

[b]Combining was custom hired and not included

[c]Amount per ton

Table 57. Fixed Costs Per Hour and Per Year for a Typical Machine Complement, 1600 Acre Hyde County Ranch

Implement	Size	Purchase Cost[a]	Hours Life[b]	Years Life	Depreciation Per Hour	Annual Depreciation	Taxes Interest[c] Insurance	Housing[d]
Truck	1½ ton	$ 1,820	75,000[e]	15	$ .024[e]	$ 121	$ 80	$ 9.10
Tractor, 42 hp.	4 plow	2,760	12,000	13	.23	212	122	13.80
Tractor, 40 hp.	3 plow	1,942	12,000	13	.16	149	86	9.71
Windrower, self prop.	14 foot	1,750	2,500	10	.70	175	77	8.75
Plow	4-14"	465	2,500	14	.19	33	20	2.33
Disc, single	20 foot	931	2,500	13	.37	72	41	4.65
Hay baler	PTO, twine	950	2,500	10	.38	95	42	4.75
Spike tooth harrow	5 section	125	2,500	15	.05	8	6	0.63
Corn planter	4 row	585	1,200	15	.49	39	26	2.92
Cultivator	4 row	450	2,500	15	.18	30	20	2.25
Mower	7 foot	545	2,000	13	.27	42	24	2.72
Loader	----	338	2,500	15	.14	23	15	1.69
Side rake	8 foot	308	2,500	12	.12	26	14	1.54
Field chopper, PTO	1 row	925	2,000	10	.46	93	41	4.63
Corn picker	1 row	1,250	2,000	11	.63	113	55	6.25
3 wagons	Flare box	788	5,000	15	.16	53	35	3.94
Fertilizer spreader	12 foot	178	1,500	10	.12	18	8	0.89
Grain drill	14 foot	625	1,200	18	.52	35	28	3.13
Elevator	48 foot	533	2,500	10	.21	53	24	2.66
TOTAL		$ 17,268				$ 1,390	$ 764	$ 86.34

Table 57. (continued)

[a]One-half of new cost as reported in *Midwest Farm Planning Manual*, Iowa State University Press, Ames, Iowa

[b]1965 Agricultural Engineers Yearbook

[c]Interest = 3% of purchase cost, tax = 1%, insurance = .42%

[d]Housing = .5% of purchase cost

[e]Miles

Table 58. Activities and Restrictions for Three Levels of Efficiency for a 1600 Acre Ranch on Williams-Tetonka-Cavour Soil Association, Central South Dakota

Description	Unit	Efficiency Level Low	Medium	High
		-Activity Number-		
Activities				
Corn	Acre	1	12	23
Wheat-wheat-fallow	Acre	2	13	24
Barley	Acre	3	14	25
Oats	Acre	4	15	26
Flax	Acre	5	16	27
Sorghum	Acre	6	17	28
Corn-oats	Acre	7	18	29
Corn-wheat	Acre	8	19	30
Sorghum-wheat	Acre	9	20	31
Corn-barley	Acre	10	21	32
Corn-flax	Acre	11	22	33
Beef cows, calf raising, 10 months grazing, sell in October	Head	34	38	42
Beef cows, calf raising, $5\frac{1}{2}$ months grazing, sell in October	Head	35	39	43
Beef cows, calf raising, 10 months grazing, sell in January	Head	36	40	44
Beef cows, calf raising, $5\frac{1}{2}$ months grazing, sell in January	Head	37	41	45
Winter October calf on silage	Head	46	50	54
Winter October calf, pasture and hay	Head	47	51	55
Summer graze yearlings, $6\frac{1}{2}$ months	Head	48	52	56
Summer graze yearlings, $4\frac{1}{2}$ months	Head	49	53	57
Fatten yearlings grazed $4\frac{1}{2}$ months	Head	58	60	62
Fatten October calf	Head	59	61	63
Cull cow sale	Cwt.	64	64	64
Sell October calf	Head	65	66	67
Sell wintered calves	Head	68	69	70
Sell yearlings grazed $4\frac{1}{2}$ months	Head	71	72	73
System pasture production	Acre	74	74	74
Crested wheat, not fertilized	Acre	75	75	75
Crested wheat, fertilized	Acre	76	76	76
Crested wheat and alfalfa	Acre	77	77	77
Brome-alfalfa pasture, rotated and fertilized	Acre	78	78	78
Brome-alfalfa pasture, not rotated or fertilized	Acre	79	79	79
Sudan grass	Acre	80	80	80
Russian wild rye	Acre	81	81	81

Table 58. (continued)

Description	Unit	Efficiency Level Low	Medium	High
		-Activity Number-		
Oats-alfalfa-brome for hay on level land, not fertilized	Acre	82	82	82
Oats-alfalfa-brome for hay on level land, fertilized	Acre	83	83	83
Oats-alfalfa-brome for hay, sloping land, not fertilized	Acre	84	84	84
Oats-alfalfa-brome for hay, sloping land, fertilized	Acre	85	85	85
Harvest corn for grain	Acre	86	88	90
Harvest corn for silage	Acre	87	89	91
Native grass, 75% condition, not fertilized	Acre	92	92	92
Native grass, 75% condition, fertilized	Acre	93	93	93
Native grass, 25% condition	Acre	94	94	94
Deferred grazing system	Acre	95	95	95
Native grass for winter grazing	Acre	96	96	96
Native haymaking	Acre	97	97	97
Pasture renovation	Acre	98	98	98
Borrow capital	$100	99	99	99
Sell corn	10 Bu.	100	100	100
Restrictions			Row Number	
Cropland, 0 to 3 per cent slope	Acre		801	
Cropland, 3 to 6 per cent slope	Acre		802	
Native pasture 25% condition	Acre		803	
Native pasture 75% condition	Acre		804	
Total labor	Hour		805	
April labor	Hour		806	
May labor	Hour		807	
June labor	Hour		808	
July labor	Hour		809	
August labor	Hour		810	
September labor	Hour		811	
October labor	Hour		812	
Capital	Dol.		813	
Livestock investment capital	Dol.		814	
Corn to harvest	Bu.		815	
Corn equivalent bushels	Bu.		816	
Corn silage	Ton		817	

Table 58. (continued)

Description	Unit	Row Number
Grazing		
April 16 to May 15	AUM	818
May 16 to July 15	AUM	819
July 16 to August 31	AUM	820
September 1 to October 31	AUM	821
November 1 to April 15	AUM	822
Grass hay equivalent	Ton	823
Calf transfer (low)	Head	824
Light yearling transfer (low)	Head	825
Heavy yearling transfer (low)	Head	826
Calf transfer (medium)	Head	827
Light yearling transfer (medium)	Head	828
Heavy yearling transfer (medium)	Head	829
Calf transfer (high)	Head	830
Light yearling transfer (high)	Head	831
Heavy yearling transfer (high)	Head	832
Beef for sale	Cwt.	833

Table 59. Linear Programming Matrix for a 1600 Acre Ranch on Williams-Tetonka-Cavour Soil Association, Central South Dakota

Item	Unit	Row	B_i	Crop Activities Efficiency Level Low P_1	P_2
Cropland, 0-3% slope	Acre	R01	431	1.0	1.0
Cropland, 3-6% slope	Acre	R02	69		
Native pasture land, 25% condition	Acre	R03	160		
Native pasture land, 75% condition	Acre	R04	896		
Total labor	Hour	R05	4650	2.33	1.928
April labor	Hour	R06	525		.817
May labor	Hour	R07	525	1.64	.137
June labor	Hour	R08	525	.69	.137
July labor	Hour	R09	525		.563
August labor	Hour	R10	525		.137
September labor	Hour	R11	525		.137
October labor	Hour	R12	300		
Capital	Dol.	R13		3.17	5.603
Livestock investment capital	Dol.	R14			
Corn to harvest	Bu.	R15		-23.0	
Corn equivalent	Bu.	R16			
Corn silage	Ton	R17			
AUM's grazing transfer:					
April 16-May 15	AUM	R18			
May 16-July 15	AUM	R19			
July 16-August 31	AUM	R20			-0.067
September 1-October 31	AUM	R21			
November 1-April 15	AUM	R22			
Grass hay equivalent	Ton	R23			
Calf transfer (low)	Head	R24			
Light yearling transfer (low)	Head	R25			
Heavy yearling transfer (low)	Head	R26			
Calf transfer (medium)	Head	R27			
Light yearling transfer (medium)	Head	R28			
Heavy yearling transfer (medium)	Head	R29			
Calf transfer (high)	Head	R30			
Light yearling transfer (high)	Head	R31			
Heavy yearling transfer (high)	Head	R32			
Beef for sale	Cwt.	R33			
Return over variable cost (C_j)	Dol.			-3.17	12.597

Table 59. (continued)

Row	Crop Activities					
	Efficiency Level					
	Low					
	P_3	P_4	P_5	P_6	P_7	P_8
R01	1.0	1.0	1.0	1.0		
R02					1.0	1.0
R03						
R04						
R05	1.86	1.86	2.33	2.88	2.095	2.095
R06	1.22	1.22	1.69		.61	.61
R07				1.64	.82	.82
R08					.345	.345
R09	.64	.64	.64		.32	.32
R10						
R11				1.24		
R12						
R13	6.72	8.57	7.50	6.49	5.87	5.32
R14						
R15					-11.5	-11.5
R16	-19.24	-17.5		-21.5	-8.75	
R17						
R18						
R19						
R20	-0.1	-0.1			-0.05	-0.05
R21						
R22						
R23						
R24						
R25						
R26						
R27						
R28						
R29						
R30						
R31						
R32						
R33						
C_j	-6.72	-8.57	9.00	-6.49	-5.87	8.33

Table 59. (continued)

	Crop Activities					
	Efficiency Level					
	Low			Medium		
Row	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}
R01				1.0	1.0	1.0
R02	1.0	1.0	1.0			
R03						
R04						
R05	2.37	2.095	2.33	2.12	1.745	1.69
R06	.61	.61	.845		.743	1.11
R07	.82	.82	.82	1.49	.123	
R08		.345	.345	.63	.123	
R09	.32	.32			.51	.58
R10			.32		.123	
R11	.62				.123	
R12						
R13	6.98	4.67	5.06	7.70	7.713	10.50
R14						
R15		-11.5	-11.5	-32.0		
R16	-10.75	-9.62				-26.64
R17						
R18						
R19						
R20	-0.05	-0.05			-0.067	-0.10
R21						
R22						
R23						
R24						
R25						
R26						
R27						
R28						
R29						
R30						
R31						
R32						
R33						
C_j	6.67	-4.945	2.915	-7.70	17.767	-10.50

Table 59. (continued)

	Crop Activities					
	Efficiency Level					
	Medium					
Row	P_{15}	P_{16}	P_{17}	P_{18}	P_{19}	P_{20}
R01	1.0	1.0	1.0			
R02				1.0	1.0	1.0
R03						
R04						
R05	1.69	2.12	2.62	1.905	1.905	2.155
R06	1.11	1.54		.555	.555	.555
R07			1.49	.745	.745	.745
R08				.315	.315	
R09	.58	.58		.29	.29	.29
R10						
R11			1.13			.565
R12						
R13	10.90	10.98	11.27	9.30	9.57	11.355
R14						
R15				-16.0	-16.0	
R16	-23.5		-30.1	-11.75		-15.05
R17						
R18						
R19						
R20	-0.1			-0.05	-0.05	-0.05
R21						
R22						
R23						
R24						
R25						
R26						
R27						
R28						
R29						
R30						
R31						
R32						
R33						
C_j	-10.90	19.27	-11.27	-9.30	9.54	7.755

Table 59. (continued)

	Crop Activities					
	Efficiency Level					
	Medium		High			
Row	P_{21}	P_{22}	P_{23}	P_{24}	P_{25}	P_{26}
R01			1.0	1.0	1.0	1.0
R02	1.0	1.0				
R03						
R04						
R05	1.905	2.12	1.91	1.567	1.52	1.52
R06	.555	.77		.67	1.0	1.0
R07	.745	.745	1.34	.11		
R08	.315	.315	.57	.11		
R09	.29			.457	.52	.52
R10		.29		.11		
R11				.11		
R12						
R13	9.1	9.34	14.26	10.143	14.63	16.71
R14						
R15	-16.0	-16.0	-41.0			
R16	-13.32				-34.04	-29.5
R17						
R18						
R19						
R20	-0.05			-0.067	-0.1	-0.1
R21						
R22						
R23						
R24						
R25						
R26						
R27						
R28						
R29						
R30						
R31						
R32						
R33						
C_j	-9.10	5.785	-14.26	22.617	-14.63	-16.71

Table 59. (continued)

	Crop Activities					
	Efficiency Level					
	High					
Row	P_{27}	P_{28}	P_{29}	P_{30}	P_{31}	P_{32}
R01	1.0	1.0				
R02			1.0	1.0	1.0	1.0
R03						
R04						
R05	1.91	2.36	1.715	1.715	1.94	1.715
R06	1.39		.5	.5	.5	.5
R07		1.34	.67	.67	.67	.67
R08			.285	.285		.285
R09			.26	.26	.26	.26
R10	.52					
R11		1.02			.51	
R12						
R13	16.99	16.63	15.485	15.00	16.185	14.445
R14						
R15			-20.5	-20.5		-20.5
R16		-38.7	-14.75		-19.35	-17.02
R17						
R18						
R19						
R20			-0.05	-0.05	-0.05	-0.05
R21						
R22						
R23						
R24						
R25						
R26						
R27						
R28						
R29						
R30						
R31						
R32						
R33						
C_j	27.01	-16.63	-15.485	9.57	8.385	-14.445

Table 59. (continued)

	Beef Cows					
	Efficiency Level					
	High	Low				Medium
Row	P_{33}	P_{34}	P_{35}	P_{36}	P_{37}	P_{38}
R01						
R02	1.0					
R03						
R04						
R05	1.91	10.0	12.0	11.0	13.0	8.0
R06	.695	1.054	1.304	1.054	1.304	1.29
R07	.67	1.054	1.304	1.054	1.304	1.29
R08	.285	.270	.270	.270	.270	.22
R09		.270	.270	.270	.270	.22
R10	.26	.270	.270	.270	.270	.22
R11		.291	.291	.270	.291	.23
R12		.291	.291	.270	.291	.23
R13	15.625	231.0	231.0	233.0	233.0	264.0
R14		-220.0	-220.0	-220.0	-220.0	-253.0
R15	-20.5					
R16		4.35	4.35	7.0	7.0	4.35
R17						
R18		1.015		1.015		1.015
R19		2.03	2.31	2.03	2.31	2.03
R20		1.523	1.73	1.523	1.73	1.523
R21		2.03	2.31	2.03	2.31	2.03
R22		3.552		3.902		3.552
R23		1.28	2.7	1.60	3.1	1.28
R24		-0.72	-0.72			
R25						
R26						
R27						-0.74
R28						
R29						
R30						
R31						
R32						
R33		-1.664	-1.664			-1.664
C_j	6.375	-22.88	-22.88	84.93	84.93	-24.88

Table 59. (continued)

Row	Beef Cows					
	Efficiency Level					
	Medium			High		
	P_{39}	P_{40}	P_{41}	P_{42}	P_{43}	P_{44}
R01						
R02						
R03						
R04						
R05	10.0	9.0	11.0	6.0	8.0	7.0
R06	1.54	1.29	1.54	.98	1.23	.98
R07	1.54	1.29	1.54	.98	1.23	.98
R08	.22	.22	.22	.17	.17	.17
R09	.22	.22	.22	.17	.17	.17
R10	.22	.22	.22	.17	.17	.17
R11	.23	.23	.23	.19	.19	.19
R12	.23	.23	.23	.19	.19	.19
R13	264.0	266.0	266.0	299.0	299.0	301.0
R14	-253.0	-253.0	-253.0	-288.0	-288.0	-288.0
R15						
R16	4.35	7.0	7.0	4.35	4.35	7.0
R17						
R18		1.015		1.015		1.015
R19	2.31	2.03	2.31	2.03	2.31	2.03
R20	1.73	1.523	1.73	1.523	1.73	1.523
R21	2.31	2.03	2.31	2.03	2.31	2.03
R22		3.552		3.552		3.552
R23	2.7	1.6	3.1	1.28	2.7	1.6
R24						
R25						
R26						
R27	-0.74					
R28						
R29						
R30				-0.76	-0.76	
R31						
R32						
R33	-1.664			-1.664	-1.664	
C_j	-24.88	94.7	94.7	-26.88	-26.88	105.44

Table 59. (continued)

	Wintering and Grazing Activities					
	Efficiency Level					
	High	Low				Medium
Row	P_{45}	P_{46}	P_{47}	P_{48}	P_{49}	P_{50}
R01						
R02						
R03						
R04						
R05	9.0	5.5	4.4	4.0	3.5	5.0
R06	1.23	.5	.4	.3	.4	.5
R07	1.23			.6	.6	
R08	.17			.6	.6	
R09	.17			.6	.6	
R10	.17			.6	.6	
R11	.19			.6	.6	
R12	.19			.7		
R13	301.0	54.68	49.49	84.32	73.18	59.37
R14	-288.0	-77.67	-77.67	-131.28	-131.28	-86.49
R15						
R16	7.0					
R17		2.89				2.97
R18				.572		
R19	2.31			1.25	1.25	
R20	1.73			1.035	1.035	
R21	2.31			1.523	.742	
R22			1.68			
R23	3.1		.35		.2	
R24		1.0	1.0			
R25		-1.0	-1.0	1.0	1.0	
R26					-1.0	
R27						1.0
R28						-1.0
R29						
R30						
R31						
R32						
R33						
C_j	105.44	-12.35	-11.44	179.81	-4.21	-12.35

Table 59. (continued)

Row	Wintering and Grazing Activities					
	Efficiency Level					
	Medium			High		
	P_{51}	P_{52}	P_{53}	P_{54}	P_{55}	P_{56}
R01						
R02						
R03						
R04						
R05	4.0	3.5	3.0	4.5	3.6	3.0
R06	.3	.3	.4	.4	.3	.3
R07		.5	.6			.4
R08		.5	.5			.4
R09		.5	.5			.4
R10		.5	.5			.4
R11		.5	.5			.5
R12		.7				.6
R13	54.02	79.81	79.21	64.34	58.73	97.97
R14	-86.49	-142.07	-142.07	-95.87	-95.87	-153.00
R15						
R16						
R17				3.05		
R18		.601				.63
R19		1.321	1.32			1.392
R20		1.1	1.1			1.164
R21		1.628	.8			1.728
R22	1.75				1.81	
R23	.36		.22		.37	
R24						
R25						
R26						
R27	1.0					
R28	-1.0	1.0	1.0			
R29			-1.0			
R30				1.0	1.0	
R31				-1.0	-1.0	1.0
R32						
R33						
C_j	-11.44	199.25	-4.47	-12.35	-11.44	209.91

Table 59. (continued)

	Cattle Fattening Activities					
	Efficiency Level					
	High	Low		Medium		High
Row	P_{57}	P_{58}	P_{59}	P_{60}	P_{61}	P_{62}
R01						
R02						
R03						
R04						
R05	2.0	3.5	7.7	2.4	6.3	2.0
R06	.4		.7		.6	
R07	.5		.7		.6	
R08	.4		.7		.6	
R09	.4		.7		.6	
R10	.4		.7		.3	
R11						.5
R12		.7	.7	.6	.6	.5
R13	85.12	89.71	145.23	75.98	153.55	70.77
R14	-153.0	-180.98	-107.90	-195.12	-116.88	-206.04
R15						
R16		35.75	53.0	28.0	53.0	26.0
R17		1.16		.92		.86
R18						
R19	1.392					
R20	1.164					
R21						
R22						
R23	.23	.231	1.4	.18	1.4	.17
R24			1.0			
R25						
R26		1.0				
R27					1.0	
R28						
R29				1.0		
R30						
R31	1.0					
R32	-1.0					1.0
R33						
C_j	-4.72	242.37	208.29	245.95	220.61	255.29

Table 59. (continued)

		Cull	October Calf Selling			
		Cow		Efficiency Level		
	High	Sale	Low	Medium	High	Low
Row	P_{63}	P_{64}	P_{65}	P_{66}	P_{67}	P_{68}
R01						
R02						
R03						
R04						
R05	5.0					
R06	.5					
R07	.5					
R08	.5					
R09	.5					
R10						
R11						
R12	.5					
R13	145.69					
R14	-126.15					
R15						
R16	53.0					
R17						
R18						
R19						
R20						
R21						
R22						
R23	1.4					
R24			1.0			
R25						1.0
R26						
R27				1.0		
R28						
R29						
R30	1.0				1.0	
R31						
R32						
R33		1.0				
C_j	232.99	14.0	105.58	114.555	123.83	128.55

Table 59. (continued)

	Sell Light Yearling		Sell Heavy Yearling			
	Efficiency Level					
	Medium	High	Low	Medium	High	
Row	P_{69}	P_{70}	P_{71}	P_{72}	P_{73}	P_{74}
R01						.75
R02						
R03						
R04						.25
R05						.291
R06						.132
R07						
R08						.091
R09						.023
R10						.007
R11						
R12						.001
R13						3.316
R14						
R15						
R16						-0.813
R17						
R18						-0.275
R19						-0.418
R20						-0.195
R21						-0.604
R22						
R23						-0.083
R24						
R25						
R26			1.0			
R27						
R28	1.0					
R29				1.0		
R30						
R31		1.0				
R32					1.0	
R33						
C_j	139.34	150.27	177.17	191.05	193.56	-3.316

Table 59. (continued)

	Pasture Production Activities					
	Cropland 0-3% Slope					
Row	P_{75}	P_{76}	P_{77}	P_{78}	P_{79}	P_{80}
R01	1.0	1.0	1.0	1.0	1.0	1.0
R02						
R03						
R04						
R05	.219	.444	.219	1.07	.32	1.35
R06	.178	.178	.178	.431	.223	
R07						
R08				.542		1.35
R09	.041	.041	.044	.097	.097	
R10						
R11						
R12						
R13	1.47	6.37	1.44	6.483	2.13	10.92
R14						
R15						
R16				-3.25	-1.83	
R17						
R18	-1.0	-1.52	-1.11			
R19				-1.667	-1.0	
R20				-0.308	-0.75	-5.0
R21				-0.417	-0.5	
R22						
R23				-0.37		
R24						
R25						
R26						
R27						
R28						
R29						
R30						
R31						
R32						
R33						
C_j	-1.47	-6.37	-1.44	-6.483	-2.13	-10.92

Table 59. (continued)

Row	Hay Production Activities					
		0-3% Land		3-6% Land		Low
	P_{81}	P_{82}	P_{83}	P_{84}	P_{85}	P_{86}
R01	1.0	1.0	1.0			
R02				1.0	1.0	
R03						
R04						
R05	.444	2.178	2.387	2.178	2.387	1.0
R06	.178	.223	.432	.223	.432	
R07						
R08		1.083	1.083	1.083	1.083	
R09		.097	.097	.097	.097	
R10	.041	.775	.775	.775	.775	
R11						
R12						1.0
R13	5.27	3.713	7.463	3.713	7.463	.55
R14						
R15						1.0
R16		-1.83	-1.83	-1.83	-1.83	-23.0
R17						
R18						
R19						
R20						
R21	-2.0	-0.2	-0.5	-0.2	-0.5	
R22						-0.3
R23		-1.12	-1.68	-1.12	-1.68	
R24						
R25						
R26						
R27						
R28						
R29						
R30						
R31						
R32						
R33						
C_j	-5.27	-3.713	-7.463	-3.713	-7.463	-0.55

Table 59. (continued)

	Corn Harvesting Activities					
	Efficiency Level					
	Low	Medium		High		
Row	P_{87}	P_{88}	P_{89}	P_{90}	P_{91}	P_{92}
R01						
R02						
R03						
R04						1.0
R05	3.83	.91	4.55	.82	5.06	.014
R06						
R07						
R08						
R09						
R10						
R11	3.83		4.55		5.06	
R12		.91		.82		
R13	2.05	.71	2.39	.81	2.60	.07
R14						
R15	1.0	1.0	1.0	1.0	1.0	
R16		-32.0		-41.0		
R17	-5.111		-7.111		-9.111	
R18						
R19						-0.21
R20						-0.16
R21						-0.1
R22		-0.35		-0.4		
R23						
R24						
R25						
R26						
R27						
R28						
R29						
R30						
R31						
R32						
R33						
C_j	-2.05	-0.71	-2.39	-0.81	-2.6	-0.07

Table 59. (continued)

	Pasture Production Activities					
	Native Grassland					
Row	P_{93}	P_{94}	P_{95}	P_{96}	P_{97}	P_{98}
R01						
R02						
R03		1.0	1.0			1.0
R04	1.0			1.0	1.0	-1.0
R05	.234	.014	.264	.014	1.3	
R06	.112					
R07						
R08						
R09						
R10			.260		1.3	
R11						
R12	.112					
R13	5.44	.131	.255	.07	1.06	1.14
R14						
R15						
R16						
R17						
R18						
R19	-0.41	-0.07	-0.1			
R20	-0.31	-0.05	-0.06			
R21	-0.21	-0.03	-0.08			
R22			-0.12	-0.57		
R23			-0.16		-0.8	
R24						
R25						
R26						
R27						
R28						
R29						
R30						
R31						
R32						
R33						
C_j	-5.44	-0.131	-0.255	-0.07	-1.06	-1.14

Table 59. (continued)

Row	Borrow Capital P_{99}	Sell Corn P_{100}
R01		
R02		
R03		
R04		
R05		
R06		
R07		
R08		
R09		
R10		
R11		
R12		
R13	-100.0	
R14		
R15		
R16		10.0
R17		
R18		
R19		
R20		
R21		
R22		
R23		
R24		
R25		
R26		
R27		
R28		
R29		
R30		
R31		
R32		
R33		
C_j	-6.0	11.0

Table 60. Crop Activity Budgets for Low, Medium, and High Efficiency Levels on Williams-Tetonka-Cavour Soil Association, Central South Dakota

Item	Corn								
	For Grain						For Silage		
	Following Row Crop			Following Legume			Corn After Row Crop		
	Low	Medium	High	Low	Medium	High	Low	Medium	High
Hours of labor									
April									
May	1.64	1.49	1.34	.79	.72	.65	1.64	1.49	1.34
June	.69	.63	.57	.69	.63	.57	.69	.63	.57
July									
August									
September				.85	.77	.69	3.83	4.55	5.06
October	1.0	.91	.82	1.0	.91	.82			
Total hours of labor	3.33	3.03	2.73	3.33	3.03	2.73	6.16	6.67	6.97
Variable costs (Dollars)									
Preharvest									
Fuel	.88	.80	.72	.98	.90	.82	.88	.80	.72
Oil and Grease	.11	.10	.09	.11	.10	.09	.11	.10	.09
Repairs	.94	.85	.76	.94	.85	.76	.94	.85	.76
Seed	1.24	1.45	1.64	1.24	1.45	1.64	1.24	1.45	1.64
Chemicals	.00	.60	3.47	.00	2.87	3.47	.00	.60	3.47
Fertilizer	.00	3.90	7.58	.00	.00	3.30	.00	3.90	7.58
Harvest									
Fuel	.22	.29	.34	.22	.29	.34	.92	1.07	1.16
Oil and grease	.04	.04	.04	.04	.04	.04	.11	.11	.11
Repairs	.29	.38	.43	.29	.38	.43	1.02	1.21	1.33
Custom hired									
Total variable costs	3.72	8.41	15.07	3.82	6.88	10.89	5.22	10.09	16.86
Yield (Bushels or tons)	23	32	41	28	34	41	5.111	7.111	9.111
Price	$ 1.10	$ 1.10	$ 1.10	$ 1.10	$ 1.10	$ 1.10			
Gross Returns	25.30	35.20	45.10	30.80	37.40	45.10			
RETURNS OVER VARIABLE COST	21.58	26.79	30.03	26.98	30.52	34.21			

Table 60. (continued)

Item	Barley						Oats		
	After Row Crop			After Row Crop With Alfalfa Seeding			After Row Crop		
	Low	Medium	High	Low	Medium	High	Low	Medium	High
Hours of labor									
April	1.22	1.11	1.00	1.47	1.34	1.21	1.22	1.11	1.00
May									
June									
July	.64	.58	.52	.64	.58	.52	.64	.58	.52
August									
September									
October									
Total hours of labor	1.86	1.69	1.52	2.11	1.92	1.73	1.86	1.69	1.52
Variable costs (Dollars)									
Preharvest									
Fuel	.39	.35	.31	.50	.45	.40	.39	.35	.31
Oil and grease	.06	.05	.04	.07	.06	.05	.06	.05	.04
Repairs	.51	.46	.41	.51	.46	.41	.51	.46	.41
Seed	1.94	2.10	2.27	5.51	5.88	6.40	1.80	2.50	3.50
Chemicals	.00	.00	1.50	.00	.00	.00	.00	.00	1.50
Fertilizer	.00	3.60	6.04	.00	3.60	6.04	1.95	3.60	6.95
Harvest									
Fuel	.18	.26	.34	.18	.26	.34	.18	.26	.34
Oil and grease	.03	.03	.03	.03	.03	.03	.03	.03	.03
Repairs	.11	.15	.19	.11	.15	.19	.11	.15	.19
Custom hired	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Total variable costs	6.72	10.50	14.63	10.41	14.39	17.36	8.57	10.90	16.71
Yield (Bushels or tons)	26	36	46	26	36	46	35	47	59
Price	$ .81	$ .81	$ .81	$ .81	$ .81	$ .81	$ .55	$ .55	$ .55
Gross Returns	21.06	29.16	37.26	21.06	29.16	37.26	19.25	25.85	32.45
RETURNS OVER VARIABLE COST	14.34	18.66	22.63	10.65	14.77	19.90	10.68	14.95	15.74

Table 60. (continued)

	Oats						Spring Wheat		
				After Row Crop					
	After Alfalfa			With Alfalfa Seeding			After Row Crop		
Item	Low	Medium	High	Low	Medium	High	Low	Medium	High
Hours of labor									
April	.74	.67	.60	1.47	1.34	1.21	1.22	1.11	1.00
May									
June									
July	.64	.58	.52	.64	.58	.52	.64	.58	.52
August									
September	.77	.70	.63						
October									
Total hours of labor	2.15	1.95	1.75	2.11	1.92	1.73	1.86	1.69	1.52
Variable costs (Dollars)									
Preharvest									
Fuel	.70	.64	.58	.50	.45	.40	.44	.40	.36
Oil and grease	.08	.07	.06	.07	.06	.05	.06	.05	.04
Repairs	.74	.67	.60	.51	.46	.41	.51	.46	.41
Seed	1.80	2.50	3.50	4.69	5.34	7.63	2.65	3.20	3.20
Chemicals	.00	.00	1.50	.00	.00	.00	.00	1.50	1.50
Fertilizer	.00	2.95	5.90	1.95	3.60	6.95	.00	1.95	6.30
Harvest									
Fuel	.18	.26	.34	.18	.26	.34	.16	.20	.23
Oil and grease	.03	.03	.03	.03	.03	.03	.03	.03	.03
Repairs	.11	.15	.19	.11	.15	.19	.12	.15	.17
Custom hired	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Total variable costs	7.18	10.77	16.14	11.58	13.85	19.44	7.47	11.44	15.74
Yield (Bushels or tons)	35	47	59	27	39	51	15	21	27
Price	$ .55	$ .55	$ .55	$ .55	$ .55	$ .55	$ 1.82	$ 1.82	$ 1.82
Gross Returns	19.25	25.85	32.45	14.85	21.45	28.05	27.30	38.22	49.14
RETURNS OVER VARIABLE COST	12.07	15.08	16.31	3.27	7.60	8.61	19.83	26.78	33.40

Table 60. (continued)

	Spring Wheat								
	After Small Grain			After Fallow			After Alfalfa		
Item	Low	Medium	High	Low	Medium	High	Low	Medium	High
Hours of labor									
April	1.65	1.50	1.35	.80	.73	.66	1.65	1.50	1.35
May									
June									
July	.64	.58	.52	.64	.58	.52	.64	.58	.52
August									
September									
October									
Total hours of labor	2.29	2.08	1.87	1.44	1.31	1.18	2.29	2.08	1.87
Variable costs (Dollars)									
Preharvest									
Fuel	.80	.73	.66	.26	.24	.22	.90	.83	.76
Oil and grease	.08	.07	.06	.04	.03	.02	.08	.07	.06
Repairs	.73	.66	.59	.36	.33	.30	.73	.66	.59
Seed	2.65	3.20	3.20	2.65	3.20	3.20	2.65	3.20	3.20
Chemicals	.00	1.50	1.50	.00	.00	1.50	.00	.00	1.50
Fertilizer	.00	1.95	6.30	.00	2.00	3.70	.00	2.00	3.70
Harvest									
Fuel	.16	.20	.23	.16	.20	.23	.16	.20	.23
Oil and grease	.03	.03	.03	.03	.03	.03	.03	.03	.03
Repairs	.12	.15	.17	.12	.15	.17	.12	.15	.17
Custom hired	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Total variable costs	8.07	11.99	16.24	7.12	9.68	12.87	8.17	10.64	13.74
Yield (Bushels or tons)	12	18	24	18	24	30	18	24	30
Price	$ 1.82	$ 1.82	$ 1.82	$ 1.82	$ 1.82	$ 1.82	$ 1.82	$ 1.82	$ 1.82
Gross Returns	21.84	32.76	43.68	32.76	43.68	54.60	32.76	43.68	54.60
RETURNS OVER VARIABLE COST	13.77	20.77	27.44	25.64	34.00	41.73	24.59	33.04	40.86

Table 60. (continued)

Item	Sorghum								
	Fall Plow						For Silage-Spring Plow		
	Following Legume			Following Row Crop			Following Row Crop		
	Low	Medium	High	Low	Medium	High	Low	Medium	High
Hours of labor									
April									
May	1.64	1.49	1.34	1.64	1.49	1.34	2.49	2.26	2.03
June									
July									
August									
September	1.24	1.13	1.02	1.24	1.13	1.02	4.20	4.96	5.49
October									
Total hours of labor	2.88	2.62	2.36	2.88	2.62	2.36	6.69	7.22	7.52
Variable costs (Dollars)									
Preharvest									
Fuel	.98	.90	.82	.88	.80	.72	.88	.80	.72
Oil and grease	.11	.10	.09	.11	.10	.09	.11	.10	.09
Repairs	.96	.87	.74	.96	.87	.74	.96	.87	.74
Seed	.80	1.00	1.20	.80	1.00	1.20	.80	1.00	1.20
Chemicals	.00	.80	2.45	.00	.80	2.45	.00	.80	2.45
Fertilizer	.00	.00	3.30	.00	3.90	7.58	.00	3.90	7.58
Harvest									
Fuel	.16	.20	.23	.16	.20	.23	1.01	1.17	1.26
Oil and grease	.03	.03	.03	.03	.03	.03	.11	.11	.11
Repairs	.05	.07	.09	.05	.07	.09	1.12	1.31	1.44
Custom hired	3.50	3.50	3.50	3.50	3.50	3.50	.00	.00	.00
Total variable costs	6.59	7.47	12.45	6.49	11.27	16.63	4.99	10.06	15.59
Yield (Bushels or tons)	25	35	45	25	35	45	5.6	7.3	9.0
Price	$ .95	$ .95	$ .95	$ .95	$ .95	$ .95			
Gross Returns	23.75	33.25	42.75	23.75	33.25	42.75			
RETURNS OVER VARIABLE COST	17.16	25.78	30.30	17.26	21.98	26.12			

Table 60. (continued)

Item	Flax After Row Crop			Fallow		
	Low	Medium	High	Low	Medium	High
Hours of labor						
April	1.69	1.54	1.39			
May				.41	.37	.33
June				.41	.37	.33
July				.41	.37	.33
August	.64	.58	.52	.41	.37	.33
September				.41	.37	.33
October						
Total hours of labor	2.33	2.12	1.91	2.05	1.85	1.65
Variable costs (Dollars)						
Preharvest						
Fuel	.55	.50	.45	.83	.75	.67
Oil and grease	.08	.07	.06	.10	.09	.08
Repairs	.74	.67	.60	.69	.63	.57
Seed	2.43	2.96	3.50			
Chemicals	.00	.00	1.50			
Fertilizer	.00	2.95	6.95			
Harvest						
Fuel	.10	.16	.22			
Oil and grease	.03	.03	.03			
Repairs	.07	.14	.18			
Custom hired	3.50	3.50	3.50			
Total variable costs	7.50	10.98	16.99	1.62	1.47	1.32
Yield (Bushels or tons)	6	11	16			
Price	$ 2.75	$ 2.75	$ 2.75			
Gross Returns	16.50	30.25	44.00			
RETURNS OVER VARIABLE COST	9.00	19.27	27.01			