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An Economic Analysis of the Impacts of Weather Modification on Crop and Livestock Production in Southeastern South Dakota

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AN ECONOMIC ANALYSIS OF THE IMPACTS OF WEATHER MODIFICATION ON CROP AND LIVESTOCK PRODUCTION IN SOUTHEASTERN SOUTH DAKOTA

BY

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Advisor Date

Head, Economics Department Date

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CHAPTER I

INTRODUCTION

Statement of the Problem

Agriculture is an important part of South Dakota's economy. Therefore, most factors which benefit the profitability of agriculture help the economy of the entire state. Donald Kettering in a study of Brookings County found that an additional dollar in the agricultural sector resulted in a three dollar total impact upon the economy of the county.[1] A similar effect could be expected for the state as a whole. The profitability of agriculture is directly related to its productivity. If the productivity could be improved it would be expected to aid the economy of the state as a whole.

Moisture is generally considered to be one of the limiting factors in the level of agricultural productivity in South Dakota. The addition of extra water normally results in higher yields, except under special conditions and times such as disease infestations. As a result of this relationship, efforts have been made in the state to better utilize available water, through conservation practices, and to supply additional moisture, through irrigation programs and, recently, through a weather modification program. Weather modification

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[1] Donald L. Kettering, An Economic Analysis of the Brookings Study Area (unpublished Master's Thesis, South Dakota State University, Brookings, 1970), p. 41.

is particularly attractive because it is quite inexpensive, approximately 3.2 cents per acre in 1973.[2]

The question of interest to those financing this program is, what are the economic benefits which would result from a program of weather modification. The answer to this question is made more complex, because a yield increase from added precipitation causes the supply of the crop in question to increase. While the addition to supply resulting from increased production of an individual farmer would be negligible, the addition to supply when a region or a state increases production is significant. If demand did not change, this increased supply would result in a lower price, which might possibly result in lower total revenues or profits. The magnitude of the effect would be related to the price elasticity of demand in the area of the curve in question and the percentage of national production of the good which is produced in the area.

Objectives of the Study

1. The first objective is to estimate the effect of weather modification upon the profitability of agriculture in the ninth Crop Reporting District of South Dakota. This objective will be met by means of two sub-objectives:

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[2]Effects of Additional Precipitation on Agricultural Production, the Environment, the Economy and Human Society in South Dakota. A Report to the Division of Atmospheric Water Resources Management of the Bureau of Reclamation, United States Department of Interior, Vol. I (Prepared by a special Study Team of the Agricultural Experiment Station, South Dakota State University, Brookings, 1973), p. 117.

A. A series of estimates of the profitability of agriculture in the region will be determined considering various sets of possible yield increases.

B. Estimates will also be determined when a lower price results from the increased supply.

2. The second objective will be to examine the findings from the first objective for possible policy implications and for implications that will aid decision makers.

Study Procedure

The procedure used for the study was the application of linear programming to an aggregate farm. The characteristics of this aggregate farm were determined from data compiled by the South Dakota Crop and Livestock Reporting Service, with assistance from Dr. Wallace Aanderud and Dr. Richard Rudel, both with the Economics Department at South Dakota State University.

The method of an aggregate farm approach was used because the desired estimates are of an aggregate nature. The activities were limited to their actual historical limits, in order to obtain results as representative of the actual effects of weather modification as possible. This means that the optimizing allowed was unusually restrictive.

Linear programming is a method for determining that combination of activities which will optimize a particular objective, e.g. obtain maximum profits within the restrictive framework of certain constraints.

By adjusting the resource use and profitability of the various activities, comparable results can be obtained which will yield the desired estimates of profits.

The use of linear programming involves four basic assumptions:[3]

1. Additivity and Linearity--separate activities must be additive, i.e. no change in resource requirements per unit or productivity per unit is possible to reflect differences resulting from two activities occuring together or separately.

2. Divisibility--it is assumed that all inputs and outputs can be used and produced in fractional parts.

3. Finiteness--there are not an infinite number of alternatives or restrictions.

4. Single Value Expectations--the values of all parameters are known with certainty, e.g. prices, budgets, available resources.

Developing a linear programming model involves four basic steps.[4] These are: (1) state the problem in terms of an objective; (2) determine what information is necessary for solution of the problem; (3) gather the necessary information; (4) put this information in the form of a system of related linear equations and inequalities.

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[3]Earl O. Heady and Wilfred Chandler, Linear Programming Methods (Ames, Iowa: Iowa State University Press, 1966), pp. 17-18.

[4]Robert O. Ferguson and Lauren F. Sargent, Linear Programming (New York: McGraw Hill Book Company, Inc., 1958), pp. 9-10.

In the explanation of the development of my model, found in this and the following chapter, this progression may be seen.

The use of the aggregate farm method introduces two implicit assumptions. The first assumption is that each producer has the same technical requirements for each activity, e.g. each farmer in the area uses the same amount of fertilizer per acre of corn. The second assumption states each producer has proportional resource restrictions. Obviously, these assumptions do not mirror reality. Variability does exist between producers, both in budgets and in resource restrictions. The goal is that the budgets and resource restrictions used are representative enough to minimize the effect of these variations, therefore yielding reasonable results.

Description of the Study Area

The study area is the ninth Crop Reporting District of South Dakota. The counties in the area are Bon Homme, Charles Mix, Clay, Douglas, Hutchinson, Lincoln, Turner, Union and Yankton counties. A map of the study area is shown in Figure 1.

The major crops of the region are corn, oats, pasture, both native and cropland, alfalfa, soybeans, sorghum and wild hay. Lesser amounts of spring wheat, barley, winter wheat, rye and durum wheat are also grown.[5]

The area engages in various livestock activities, including

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[5]South Dakota Crop and Livestock Reporting Service, South Dakota Agriculture, 1967-1971, various pages.

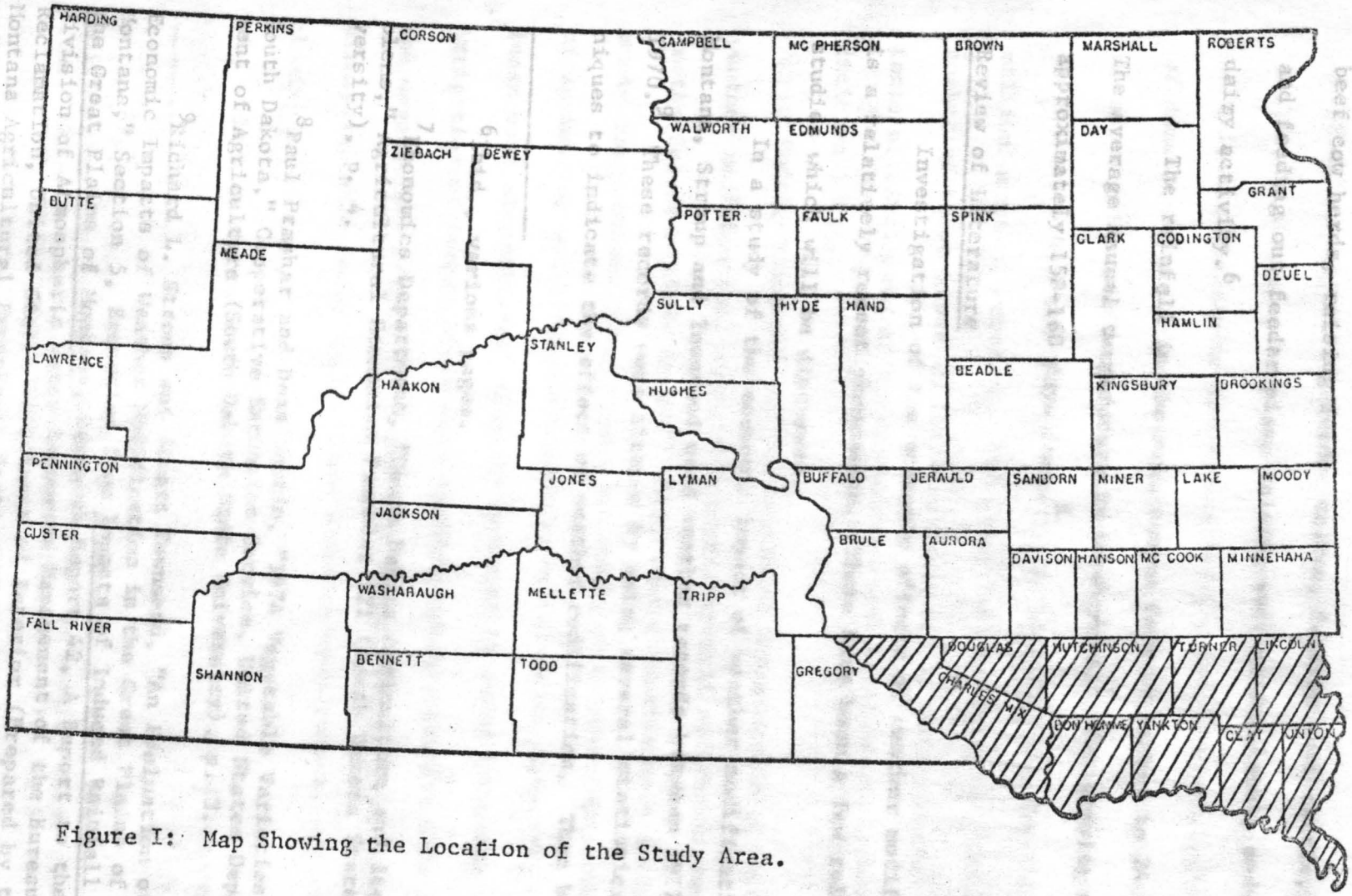

Figure I: Map Showing the Location of the Study Area.

beef cow herds, raising feeder calves, feeding beef cattle, raising and feeding out feeder pigs, raising and feeding lambs, and some dairy activity.[6]

The rainfall in the area ranges from 19 inches to 24 inches. The average annual temperature is 48 degrees.[7] The growing season is approximately 150-160 days long.[8]

Review of Literature

Investigation of the economic effects of weather modification is a relatively recent phenomenon. There have been a few relevant studies which will be discussed.

In a study of the economic impact of weather modification in Montana, Stroup and Townsend used weather records between 1917 and 1970.[9] These records were altered by using several statistical techniques to indicate the effect of weather modification. Then both the

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[6]Ibid., various pages.

[7]Economics Department, "South Dakota Agriculture and its Problems," Agricultural Economics Pamphlet 121 (South Dakota State University), p. 4.

[8]Paul Prashar and Dean Martin, "1974 Vegetable Varieties for South Dakota," Cooperative Extension Service, United States Department of Agriculture (South Dakota State University), p. 3.

[9]Richard L. Stroup and Stuart Townsend, "An Evaluation of the Economic Impacts of Weather Modification in the Great Plains of Montana," Section 5, Economics from Impacts of Induced Rainfall on the Great Plains of Montana, Research Report 42, A Report to the Division of Atmospheric Water Resources Management of the Bureau of Reclamation, United States Department of Interior (Prepared by the Montana Agricultural Experiment Station, Montana State University, Bozeman, 1973).

original and adjusted weather data were used to generate expected yields, producing a base and an increased yield. These were used in a linear program to derive net farm income. Price elasticities of demand for the crops were estimated and introduced in a series of steps. The study found that increased rainfall would lead to at least a $10 million increase in net revenues from about twenty million acres of cropland. The study took advantage of the limited number of crops grown in the area examined, by incorporating effects of timeliness of the additional precipitation and price elasticities.

Rudel, Stockwell and Walsh studied the economic effects of weather modification, used to increase snowfall and therefore runoff, in the Colorado River Basin.[10] They used a benefit cost analysis to study the problem. They found that compared to other proposed methods of augmenting water supplies, weather modification appeared to be a least cost alternative. Benefits occurred in power production and irrigation of forage crops with possible future benefits from fruit and vegetable production. Costs were largely direct costs, these mainly variable, with indirect costs due to snow removal and mine closing expenses.

In a study in Illinois, Changnon and Huff studied potential

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[10] R. K. Rudel, H. J. Stockwell and R. G. Walsh, "Weather Modification: An Economic Alternative for Augmenting Water Supplies," Water Resources Bulletin, 9:1 (February 1973), 116-128.

benefits of weather modification on agriculture.[11] Their approach was a probabilistic one, where with corn and soybeans, probabilities of different magnitudes were assigned to various weather modification plans, and from this, tables of minimum expected profit or loss for each probability were estimated. They found that for any given year weather modification would be beneficial more frequently than detrimental in each of 13 regions but one. For a five year period a substantially higher probability of beneficial results occurred in each area.

There has also been research which, while not directly concerned with weather modification, is of interest to the study. This research was concerned with finding the marginal value of water in order to determine the feasibility of water transfers.

Brown and McGuire studied the problem of allocating surface water and optimizing pumping of ground water among the constituents of the Kern County Water Agency.[12] The problem was how to price the water to insure that it would be fully utilized and that allocation between districts would be economical. Two sets of data were optimized yielding two optimum prices. Cost of delivery was added to the

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[11] S. A. Changnon, Jr. and F. A. Huff, "Evaluation of Potential Benefits of Weather Modification on Agriculture," A report to the Division of Atmospheric Water Resources Research of the Bureau of Reclamation, United States Department of Interior (Prepared by Illinois State Water Survey, 1971).

[12] Gardener M. Brown, Jr. and C. B. McGuire, "A Socially Optimum Pricing Policy for a Public Water Agency," Water Resources Research, 3:1 (1967), 33-43.

optimim prices to get a delivered price which equals the prospective marginal value of water. These prospective marginal values of water ranged from $14.50 to $28.75 per acre-foot for one set of data and $10.85 to $25.10 per acre-foot for the other.

Young and Martin studied the value of water in Arizona agriculture through budget studies for a typical farm.[13] The characteristics of the farm were synthesized through surveys of farms in the area. From this they found the marginal value of water to be $34 per acre-foot for cotton, $13 per acre-foot for alfalfa hay, $20 per acre-foot for sorghum and $21 per acre-foot for barley. These marginal values were short run and in the longer term an additional $8 per acre-foot in expenses would have to be covered.

Howe and Easter evaluated the direct and indirect costs and benefits of interbasin water transfers.[14] They attempted to determine what the marginal value of water was in the areas which received the transferred water. They considered the value to agriculture, since it has the lowest values and is the greatest user. They made use of existing studies, including the two mentioned just previously, and added work of their own. They found the marginal value of water

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[13]Robert A. Young and William E. Martin, "The Economics of Arizona's Water Pollution," Arizona Review, 16:3 (1967), 9-18.

[14]Charles W. Howe and K. William Easter, Interbasin Transfers of Water, Economic Issues and Impacts, (Baltimore: John Hopkins Press, 1971).

to range from $10 to $20 per acre-foot and the costs of interbasin transfers were found to be $50 to $60 per acre-foot. As a result of this they suggested other means of obtaining additional water, especially the reduction of conveyance losses.

CHAPTER II

ASSUMPTIONS

Introduction

The method of linear programming maximizes (or minimizes) a linear objective function subject to a number of constraints. The solution provides the combination of activities which produces the maximum value of the objective function (in this case, profit), and satisfies the constraints. Linear programming was used because the agriculture of the area can be described quite accurately as a system of distinct, yet interrelated activities. The data necessary for construction of a linear programming model suitable for the problem was readily available, with minor exceptions, however, this data was better suited to an aggregate approach; rather than an individual enterprise approach. The major reason for use of linear programming was that it provided the clearest view possible of the problem, considering the data available.

In order to use linear programming to solve problems, certain assumptions must be made about the real world situation which the model attempts to depict. This chapter presents the assumptions made, and develops the resulting model. These assumptions are of two types, those concerning resource restrictions and those concerning enterprise alternatives.

RESOURCE RESTRICTIONS

The initial values of the resource restrictions are listed in

Table I of Appendix A.

Land

The size of the farm enterprise was fixed at the total acreage of the study area. This was broken down into tillable cropland and native pasture, with 2,517,000 acres of tillable cropland and 434,000 acres of native pasture.[15] The acreage allowed for each crop was initially limited to the average acreage of that crop grown for the five year period 1967-71. Later this restriction was relaxed, and the acreage of each crop was allowed to range within the historic limits for the five year period. The exception to this restriction was corn. Pasture was not sold, with only as much grown as was required by the livestock activities. As yields increased fewer acres of pasture were required to supply these needs. These acres were converted to corn. Corn was chosen since it is the most common crop of the area and the impact upon its total acreage would be proportionately smallest. Therefore the acreage of corn was somewhat greater than the historical acreage. The five-year period was used to dampen the effects of any one-time fluctuations and still remain a short enough time period for technology to remain relatively constant. Since the study is an aggregation, a large amount of freedom in the constraints would detract from the reliability of the estimates obtained. If a

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[15]U. S. Bureau of the Census, Census of Agriculture, 1969, Vol. I, Area Reports, Part 19, South Dakota, Section 2, County Data (Washington: Government Printing Office, 1972), various pages.

large amount of freedom was allowed in the crop constraints, the resulting solution would contain no oats, yet this would hardly be an accurate representation of the study area, since oats is a major crop in the region.

Livestock Restrictions

Participation in the various livestock activities was handled similarly to the crops. Initially, the numbers of each type of livestock were fixed at the average amounts actually raised during the the five year period. The data used to compile these averages, as well as the crop acreages, the yields and the prices, was obtained from the annual reports of the South Dakota Crop and Livestock Reporting Service. Since the data regarding cattle was rather general, the model was allowed to satisfy the cattle constraints through a variety of alternatives. These alternatives will be discussed later in this chapter in the section titled Beef Cattle Activities.

Labor Restrictions

The amount of labor available to the enterprise was not restricted and therefore assumed to be sufficient. Because the data required to differentiate between operator labor and hired labor was not available, no such differentiation was imposed. Rather all labor was assumed to be identical, with no distinction between operator and hired labor and the enterprises were charged $2.00 per hour for all labor used.

Capital Restrictions

A similar situation exists regarding the availability of, and need for, capital. Once again data was not available stating the amount of farm expenses financed internally and the amount financed by borrowing. In the model, capital is not restricted nor is any charge imposed for capital. In other words, it is assumed that sufficient internal capital is available for any required financing.

Other Restrictions

Taxes were omitted from the model and no land charge was levied. These two assumptions were also necessitated by data limitations.

ENTERPRISE ALTERNATIVES

The alternative activities available in the model were representative of those enterprises commonly found on farms in the study area. A listing of these activities is presented in Table II of Appendix A.

Crops

Crop activities considered were the major crops grown in the area. The criterion used to determine whether a crop was included was the average number of acres grown in the area. If the five year average acreage of a crop was greater than 1,000 acres, then the crop was included. The base yields were the five year average yields obtained from the South Dakota Crop and Livestock Reporting Service. The yield changes attributable to an added inch of rainfall were obtained from the Agricultural Engineering and Plant Science Departments

of South Dakota State University.[16] A range of possible yield increases was used, indicating a minimum, average and maximum expected yield increase. Yield increases are dependent upon the timeliness of the added precipitation and the ability of the farmer to take maximum advantage of the additional moisture. Base yields are listed in Table II-1, while the yield increases are listed in Table II-2.

Representative budgets for these crops were prepared from various sources with the assistance of Dr. Wallace Aanderud, Extension Economist in Farm Management at South Dakota State University, and these are presented in Tables I through XVI in Appendix C.

Harvest Activities

Corn, oats and sorghum were harvested either as grain or silage. Since the silage activity most predominant is corn silage, a minimum acreage restriction was placed on this. Because the available data did not indicate acreage harvested for silage, the choice of silage type was left open after the minimum corn silage requirement was satisfied. For all other crops only the form of harvest generally associated with that crop was allowed.

Livestock Activities

Livestock activities included beef cattle, hogs and sheep activities. Dairy was not included in the model because its relatively small size was not felt to outweigh the difficulties associated with its inclusion.

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[16] Effects of Additional Precipitation, op. cit., pp. 4-36.

Table II-1: Five Year Average Yields for the Study Area

Crop	Unit	Yield/Acre
Corn Grain	Bushels	43.81
Oats Grain	Bushels	42.44
Sorghum Grain	Bushels	39.83
Soybeans	Bushels	20.25
Spring Wheat	Bushels	20.72
Winter Wheat	Bushels	29.14
Durum Wheat	Bushels	22.29
Rye	Bushels	25.70
Barley	Bushels	33.50
Corn Silage	Tons	7.37
Sorghum Silage	Tons	6.49
Oat Silage	Tons	6.67
Wild Hay	Tons	1.00
Alfalfa Hay	Tons	2.20
Cropland Pasture	AUM	3.75
Native Pasture	AUM	2.25

Source: South Dakota Crop and Livestock Reporting Service, South Dakota Agriculture, 1967-71, various pages.

Table II-2: Expected Yield Increase from an Added Inch of Precipitation.

Crop	Unit	Expected Increase Per Acre Minimum	Average	Maximum
Corn Grain	Bushels	2	8	12
Oats Grain	Bushels	1	3	5
Sorghum Grain	Bushels	2	8	12
Soybeans	Bushels	1	3	5
Spring Wheat	Bushels	1	3	5
Winter Wheat	Bushels	1	4	5
Durum Wheat	Bushels	1	3	5
Rye	Bushels	1	3	5
Barley	Bushels	1	3	5
Corn Silage	Tons	0.34	1.35	2.02
Sorghum Silage	Tons	0.33	1.30	1.96
Oat Silage	Tons	0.16	0.47	0.79
Wild Hay	Tons	0.05	0.15	0.25
Alfalfa Hay	Tons	0.05	0.25	0.50
Cropland Pasture	AUM	0.08	0.17	0.34
Native Pasture	AUM	0.08	0.17	0.33

Source: Effects of Additional Precipitation on Agricultural Production, the Environment, the Economy and Human Society in South Dakota, A Report to the Division of Atmospheric Water Resources Management of the Bureau of Reclamation, United States Department of Interior, Vol. I (Prepared by a special Study Team of the Agricultural Experiment Station, South Dakota State University, Brookings, 1973), p. 4-36.

Beef Cattle Activities

Beef cattle operations were divided into several activities, and certain assumptions were made about the characteristics of these activities. Beef cattle statistics were general and a rather free choice between activities was allowed with the only limitations being on the number of cows, calves, heifers heavier than 500 pounds and steers heavier than 500 pounds. Descriptions of the beef cattle activities and the resource requirements were obtained from a recent study by Darwin Johnson on beef enterprises engaged in by farmers in part of the area included in this study.[17]

Two beef cow alternatives were offered, one which raises replacement heifers and one which purchases replacement heifers. Both of these alternatives assumes a 16 per cent replacement rate. In the activity raising replacements, 20 per cent of the heifer calves were held back for replacement purposes with 20 per cent of these, or four per cent of the heifer calves, later culled and transferred to a feeding or selling activity. The remaining 80 per cent satisfied the 16 per cent replacement requirement. The activity purchasing replacement heifers was a separate enterprise. One bull was required per 25 cows. Raised replacement heifers were assumed to calve at two years of age. All costs associated with the bull and with maintaining the raised replacements were included in the beef cow activity budgets.

[17] Darwin K. Johnson, An Economic Analysis of Selected Beef Enterprise Systems for Southeast South Dakota (unpublished Master's thesis, South Dakota State University, 1973), pp. 26-28.

A 92 per cent calf crop was assumed, with 50 per cent of each sex. In the activity purchasing replacements, all of the calves were transferred to other activities. For the activity raising replacements, all of the steer calves and 56.5 per cent of the heifer calves were transferred. Weaning weights were assumed to be 450 pounds for a steer calf and 410 pounds for a heifer calf, with weaning on October 15.

There were three other types of beef cattle activities available. These were raised yearlings, feeding calves in drylot and feeding yearlings in drylot.

The activities for raising yearling feeder cattle were divided into steers and heifers. The calves used for this could be purchased or could be obtained from the beef cow herd activities. Steer calves were assumed to weigh 450 pounds at the beginning of the period and 650 pounds at the end. Both were wintered from October 15 to April 10 on a ration of corn, or corn equivalents, hay and pasture. At the end of the period the animals were sold, or transferred to yearling feeder activities.[18]

The activities for feeding calves in drylot were also divided into separate steer and heifer activities. Calves were bought, or obtained from the beef cow activity. Steer calves weighed 450 pounds at the start of the period and were sold at 1,100 pounds, Heifer calves initially weighed 410 pounds and were sold at 950 pounds.[19]

[18] Ibid., p. 29.

[19] Ibid.

The yearling feeder activities were divided into steers and heifers as were the other cattle activities. Similarly, an option to raise or purchase yearlings was allowed. Steers were initially 650 pounds while heifers were 600 pounds. Steers sold at 1,200 pounds and heifers at 1,050 pounds. An annual turnover rate of 1.8 was assumed.[20] Budgets for the cattle activities are listed in Tables I through VIII of Appendix D.

Hog Activities

Two types of hog activities were allowed, a sow herd enterprise and a feeder pig enterprise. The sow herd activity used the concept of a sow unit. It assumed one boar per 25 sows. Two litters per year, with March and September farrowing, were assumed, with the five-year average of 14.5 pigs weaned per year per unit, yielding 40 pound feeder pigs to be transferred to the feeder pig activity. One pig is saved from the March litter as a replacement sow. The costs of maintaining the boar and the replacement sow are included in the activity.[21]

The feeder pig activity begins with 40 pound feeder pigs, either from the sow herd or purchased. The finished butcher hogs

[20] Ibid., pp. 29-30.

[21] Wallace G. Aanderud, Myron T. Barber and Merlyn M. Dahl, Guidebook for Planning a Farm or Ranch Business, Extension Circular 633 (rev.), Cooperative Extension Service, United States Department of Agriculture (South Dakota State University), pp. 94-95.

weigh 225 pounds. Half of the pigs were finished for August or September marketing, with the other half finished for February or March marketing. The spring pigs were pastured and the fall pigs were fed in drylot.[22] Budgets for these activities are listed in Tables IX and X of Appendix D.

Sheep Activities

Sheep activities were also divided into two basic types, a ewe herd enterprise and a feeder lamb enterprise. A choice of two ewe herd activities was available with no restrictions limiting the degree of participation in either. In the first of these, replacement ewes were raised, and in the other, replacement ewes were purchased. A 20 per cent replacement rate was assumed. In the activity raising replacement ewes, 20.4 per cent of the lambs were retained each year for replacement purposes, with a two per cent death loss. A 120 per cent lamb crop was assumed for both with half of these being August feeders and half May-June feeders. The feeder lambs, weighing 70 pounds, may be either sold or transferred to the feeder lamb enterprise. One ram was assumed per 35 ewes with the cost of maintaining it included in the enterprise. The cost of maintaining the replacement ewe was also included in the case of the raising replacement ewes alternative.[23]

The feeder lamb enterprise begins with 70 pound feeder lambs,

[22] Ibid., pp. 96-99.

[23] Ibid., pp. 78-79, 82-83, 86-87.

feeds them in drylot for two months, and sells 100 pound fat lambs. The feeder lambs may either be purchased or obtained from the ewe herd activity.[24] Budgets for the sheep activities are listed in Tables XI through XIII of Appendix D.

Purchase of Feed and Livestock

Purchase was allowed of eight types of livestock. These were replacement heifers, steer calves, heifer calves, yearling steers, yearling heifers, feeder pigs, replacement ewes and feeder lambs. In addition the purchase of alfalfa hay and corn was also permitted.

Sale of Crops and Livestock

All crops were allowed to be sold except silage and pasture. Units used were the standard units associated with each crop.

Cattle sale activities occurred at each stage of the production process, i.e. cull cows, calves, yearling feeders, fed calves and fed yearlings. Hog sales were allowed for butcher hogs and cull sows, and sheep sales were allowed for cull ewes, feeder lambs and fat lambs. For all livestock sales the units used were hundred weights.

Prices

Prices used were the five year historical average prices for the period 1967-71. A price decrease was used for cash grain crops to reflect the depressed market price due to increased supply. Where prices required were not available, they were interpolated using

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[24] Ibid., pp. 88-89.

traditional price relationships, via comparison to known prices. Prices used are listed in Table I of Appendix B. In addition, the prices of related products which appear in the budgets are also typical of this period.

CHAPTER III

ANALYSIS OF THE RESULTS

Introduction

In this chapter, the results obtained from the linear programming model are presented. The results obtained from various combinations of yield increases and price changes are compared and analyzed. These findings are divided into two parts, those obtained when the bounds of the activities were fixed at historical averages, and those obtained when these bounds are relaxed, allowing the activities to range to the maximum limits.

Nine basic statistics were generated for each situation. These statistics were gross value of crops, crop costs, crop profits, livestock revenue, livestock costs, livestock profits, total revenue, total costs and total profits. Since these statistics were used as a basis for the entire chapter's discussion, rather exact definition of them is worthwhile.

Gross value of crops is the market value of all of the crops produced in the area. This statistic includes the market value of some crops not generally sold. For example, silage was given a value of $8.00 per ton and pasture was given a value of $4.50 per AUM. Therefore, gross value of crops does not present the actual cash receipts realized from sale of crops. Crop costs are the total expenditures for crops including labor charges. Crop profits is the difference between these two figures. Crop profits is therefore the

estimated profit from crops.

Livestock revenue is the sum of the livestock related receipts for the region. This does not include intra-regional sales between producers. Livestock costs is the sum of the costs of operating and maintaining the livestock enterprises. This includes implicit as well as explicit costs. Once again $4.50 per AUM was charged for the pasture fed and $8.00 per ton for the silage fed.

Total revenue is the total sales of the area to other regions or to sections of this region not represented in the model. Total costs is the sum of the costs of agricultural inputs used in the region, including the $2.00 labor charge. Total profits is the difference between these two statistics. This profit may therefore be broken down into individual sector profits, helping to identify the recipients of the benefits of weather modification.

FIXED CROP ACREAGE RESTRICTIONS

In order to obtain a benchmark against which comparisons could be made, a historic situation was inserted in the model. This base run used the five year average yields and the five year average prices for the area. Acreages for each crop for this entire set of runs were fixed at the five year average number of acres for each crop grown. The numbers of each type of livestock were subject to a similar constraint. Various combinations of assumptions concerning weather modification and its effects were then inserted into the model and these findings were compared to the results from the base run.

For the base run, total revenue was $150.239 million and total

costs were $93.471 million. Total profits were $56.768 million. Livestock revenue was $100.807 million and gross value of crops was $97.836 million. This indicated that approximately one half of the crops produced in the region were fed to the region's livestock. Livestock costs were $81.468 million and crop costs were $60.408 million. Livestock profits were $19.339 million and crop profits were $37.428 million.

In the base run, oat silage was the first preference for feed, followed by corn silage. No sorghum silage was fed and corn silage acreage was at its lower bound. In the choice between feed grains, sorghum and barley were the first two choices, with corn following. No oats were fed. Wild hay was fed before alfalfa hay. Each of these feed preference decisions were caused by minor differences in the feed value per dollar of the crops in question.

Replacement heifers were raised rather than purchased and both steer and heifer calves were fed out. Replacement ewes were purchased rather than raised.

Each of the preferences concerning feed or livestock choices held except where noted. The most important change was that steer calves were not fed as the price of feed grains decreased. The feeding requirement regarding the number of steers being fattened was fulfilled by feeding yearling steers.

The first case involving weather modification assumes that weather modification causes a minimum yield increase. It is further assumed that no price change accompanies the minimum yield increase. The

values obtained from this run, the base run, and a third run assuming the minimum yield increase accompanied by a five cent per bushel price decrease for cash grains, are listed in Table III-1.

The results of the first case showed that total profits increased 6.96 per cent over the base run. The gross value of crops increased 4.31 per cent. This increase, which offset a slight increase in crop costs occurring because fewer acres of pasture were required and corn was grown on these available acres, meant an increase of 10.5 per cent in crop profits. Livestock revenue was unchanged, but livestock costs decreased slightly because more sorghum, barley and wild hay were available, meaning an increase in the feed value per dollar, since these feeds had slight advantages in this respect. Cost decreases were reflected in a slight increase in livestock profits. The application of weather modification in the area resulted in an increase in agricultural profits of $3.950 million under this set of assumptions.

The next set of assumptions inserted into the model were a minimum yield increase, accompanied by a five cent per bushel price decrease. Decreased prices created a lower opportunity cost for feed grains. The feed requirements used in the model for feeding yearling steers were more feed grain intensive than the requirements used for feeding steer calves, which were silage intensive. The yearling feeder steer enterprise was preferable to the steer feeder calf enterprise and entered instead of it under these assumptions. This substitution required more feed and considerably more capital. These increased

Table III-1: Computer Analyses of Costs and Benefits of Weather Modification with Minimum Yield Increase and Fixed Crop Acreage.

Statistic Name	Price Planning Situation 1	2	3
	Dollars (000 omitted)		
Gross Value of Crops	$ 97,836	$102,049	$ 97,883
Crop Costs	60,408	60,718	60,592
Profits from Crops	$ 37,408	$ 41,331	$ 37,291
Livestock Revenue	$100,807	$100,807	$143,955
Livestock Costs	81,468	81,421	122,896
Profits from Livestock	$ 19,339	$ 19,386	$ 21,059
Total Revenue	$150,239	$154,499	$189,967
Total Costs	93,471	93,781	131,617
Total Profits	$ 56,768	$ 60,718	$ 58,350

1. Historical yields, historical prices.
2. Minimum yield increase, historical prices.
3. Minimum yield increase, historical prices minus $0.05.

requirements were reflected in higher revenues and costs. Livestock revenue increased 42.8 per cent and livestock costs increased 50.9 per cent over the base run. Livestock profits increased 8.89 per cent on lower profit margins. The gross value of crops increased slightly as did crop costs, leaving the crop profits slightly lower. Total revenue and total costs both increased with livestock revenue and costs, leaving total profits 2.79 per cent higher. Under this set of assumptions, agricultural profits were increased $1.582 million by weather modification. This profit increase went entirely to the livestock sector, which benefited from cheaper feed prices.

The next set of assumptions considered assumed that weather modification resulted in an average yield increase with no accompanying price decrease. The gross value of crops increased 15.8 per cent, while crop costs increased 1.01 per cent as the increased pasture yield freed additional acres which were switched to corn. These changes meant an increase in crop profits of 39.6 per cent. Livestock costs decreased slightly from the base run while livestock revenues were unchanged. Livestock profits were slightly higher. Total revenue increased 10.3 per cent, and total costs increased slightly, leaving total profits 26.2 per cent higher than the base run. All livestock activity choices were the same as those chosen in the base run. This set of assumptions concerning the effects of weather modification resulted in an estimated increase of $14.897 million in agricultural profits for the area, with most of this increase received

by the crop producing sector. The results of this run, and the next two to be discussed, are presented in Table III-2.

The assumption of an average yield increase was coupled with an assumption of a five cent per bushel price decrease for the next case investigated. Total profits increased 21.2 per cent, while total costs increased 41.1 per cent and total revenue increased 33.6 per cent. These large increases in total costs and revenue were due to the same switch which occurred in the previous case where grain prices fell, with the feeding of steer calves discontinued and the feeding of yearling steers substituted in its place. Livestock revenue rose 42.8 per cent and livestock costs rose 50.8 per cent for this same reason. Livestock profits increased 9.16 per cent over the base run. The gross value of crops increased 11.0 per cent and crop costs increased slightly. Crop profits increased 27.6 per cent. The effect of weather modification on the area, under this set of assumptions, was an $12.058 million increase in agricultural profits. Most of the benefits were received by the crop sector.

For the next run, the price per bushel of cash grains was assumed to decrease ten cents below the five year average price. The average expected yield increase was again used. Total costs, crop costs and livestock revenue were the same as in the previous run, since all activities operated at the same level. Total revenue was 31.7 per cent higher than in the base run and livestock costs were 48.9 per cent higher, increasing livestock profits 17.1 per cent. Gross value of crops increased 6.56 per cent and crop profits were

Table III-2: Computer Analyses of Costs and Benefits of Weather Modification with Average Yield Increase and Fixed Crop Acreage.

Statistic Name	Price Planning Situation 1	2	3
	Dollars (000 omitted)		
Gross Value of Crops	$113,249	$108,613	$104,257
Crop Costs	61,018	60,897	60,897
Profits from Crops	$ 52,231	$ 47,716	$ 43,360
Livestock Revenue	$100,807	$143,955	$143,955
Livestock Costs	81,374	122,845	121,311
Profits from Livestock	$ 19,433	$ 21,110	$ 22,644
Total Revenue	$165,746	$200,748	$197,927
Total Costs	94,080	131,922	131,922
Total Profits	$ 71,665	$ 68,826	$ 66,005

1. Average yield increase, historical prices.

2. Average yield increase, historical prices minus $0.05.

3. Average yield increase, historical prices minus $0.10.

15.9 per cent higher than the base. Total profits were 16.3 percent higher, meaning agricultural profits in the area increased $9.237 million due to weather modification. This increase was shared proportionally by the livestock and crop sectors, with a slightly greater advantage to the livestock portion of the economy.

The next group of runs with the fixed acreage restrictions assumed that maximum yield increases would accompany the weather modification program. The four runs of this group assumed five-year average prices, and a five, ten and fifteen cent per bushel price decrease, respectively. These results are presented in Table III-3.

The first run of this group assumed the maximum yield increase would be accompanied by the five-year average prices with no price decrease. Total profits increased 42.2 per cent over the base run, from $56.768 million to $80.720 million. Crop costs increased 1.96 per cent as increased pasture yields freed additional acres for corn. This increase also resulted in a 1.27 per cent increase in total costs. Livestock costs decreased slightly. Gross value of crops increased 25.6 per cent and crop profits increased 63.7 per cent. Livestock profits were slightly higher, because of greater availability of low cost feed. Results based on this set of assumptions were that agricultural profits increased $23.952 million, with the increase received almost entirely by the crop enterprises and only slight increases in livestock profits.

The next set of assumptions inserted into the model assumed that the maximum yield increase was accompanied by a five cent per

Table III-3: Computer Analyses of Costs and Benefits of Weather Modification with Maximum Yield Increase and Fixed Crop Acreage.

Statistic Name	Price Planning Situation 1	2	3	4
	Dollars (000 omitted)			
Gross Value of Crops	$122,831	$177,788	$113,055	$108,318
Crop Costs	61,594	61,488	61,488	61,488
Profits from Crops	$ 61,237	$ 56,300	$ 51,567	$ 46,830
Livestock Revenue	$100,807	$143,955	$143,955	$143,955
Livestock Costs	81,323	122,791	121,254	119,202
Profits from Livestock	$ 19,484	$ 21,164	$ 22,701	$ 24,753
Total Revenue	$175,376	$209,974	$206,777	$204,096
Total Costs	94,657	132,513	132,513	132,513
Total Profits	$ 80,720	$ 77,461	$ 74,264	$ 71,583

1. Maximum yield increase, historical prices.
2. Maximum yield increase, historical prices minus $0.05.
3. Maximum yield increase, historical prices minus $0.10.
4. Maximum yield increase, historical prices minus $0.15.

bushel decrease in the price of cash grains. Because the price of feed grains decreased, the feeding of yearling steers became more profitable than feeding steer calves, and entered the solution in its place. This change increased livestock revenue 42.8 per cent over the base, and livestock costs 50.7 per cent. Livestock profits increased 9.44 per cent. Gross value of crops increased 20.4 per cent. This increase, combined with a slight decrease in crop costs, resulted in a 50.5 per cent increase in crop profits. Total costs increased 41.3 per cent, but this increase was offset by a 39.5 per cent increase in total revenue, with a resulting 36.5 per cent rise in total profits. Thus, the effect of weather modification, under this set of assumptions, was a $20.693 million increase in agricultural profits in the study area, with most of the increase experienced by the crop sector, but with considerable benefits accruing to the livestock sector due to lower feed prices.

The next case considered assumed that a ten cent per bushel price decrease accompanied the maximum yield increase. Livestock revenue was unchanged from the previous run; however, due to lower feed grain prices, livestock costs decreased 1.25 per cent from the previous run. Livestock profits increased 7.26 per cent over the previous run and 17.4 per cent over the base run. Gross value of crops was 15.6 per cent higher than the base run and crop profits were 37.9 per cent higher. Total revenue increased 37.6 per cent, with total profits increasing 30.8 per cent. The increase in agricultural profits due to weather modification under these assumptions was $17.496

million. Profits increased most in the crop sector, but the livestock sector also reaped significant benefits.

The maximum price decrease considered was fifteen cents per bushel. Livestock costs were 1.69 per cent lower than when feed grain prices were ten cents below the five-year average. This caused livestock profits to increase 9.04 per cent over the last run and 28.0 per cent over the base run. Gross value of crops increased 10.7 per cent over the base and crop profits increased 25.2 per cent. Total revenue was 35.8 per cent higher than the base run and total profits were 26.1 per cent higher. When the maximum price decrease was assumed, oats were fed rather than corn because the nutrient value per dollar becomes greater due to the higher percentage price decrease. Agricultural profits increased $14.815 million over the base situation under this set of assumptions, with the livestock sector experiencing a larger percentage increase than the crop sector, but with each receiving considerable benefits from the program.

For the entire set of runs where the acreage constraints for individual crops were fixed at the five year average acreage, weather modification was found to increase profits. As the assumptions regarding the effect of increased supply on price varied, the distribution of these profits between the crop sector and livestock sector varied, with the livestock sector benefiting most when the largest price decreases occurred.

Relaxed Crop Acreage Restrictions

The second major portion of the analysis allowed the fixed

constraints upon the acreage of each crop grown to be relaxed, with the number of acres of each crop permitted to be anywhere within the range established during the five-year history period. This relaxation allowed the model to increase the participation of the most profitable activities, at the expense of less profitable activities. Estimates produced in this manner provide for partial reaction by the farmers in response to changes in their operating environment.

The first group of runs in this portion of the analysis are presented in Table III-4. This table is analogous to Table III-1 with fixed crop restrictions. Once again the first run of the series was a base run. This run, when compared to the original base run, indicates the effect of more efficient utilization of resources in the model, because the producers were allowed to respond to changes in their operating environment. Gross value of crops decreased by 1.22 per cent from the original base. Crop costs decreased by 2.79 per cent, with the net effect being a 1.37 per cent increase in the crop profits. A more substantial difference appeared in the livestock portion of the model. Livestock revenue increased 53.4 per cent and livestock costs increased 63.4 per cent. The result of these two increases was a 11.2 per cent increase in livestock profits. Total revenues increased 29.0 per cent and total costs increased 43.8 per cent, with a 4.67 per cent increase in total profits.

These differences arose for several reasons. The livestock differences are caused by the choice of feeding yearling steers rather than steer calves. In the previous portion of the analysis this

Table III-4: Computer Analyses of Costs and Benefits of Weather Modification with Minimum Yield Increase and Variable Crop Acreage.

Statistic Name	Price Planning Situation 1	2	3
	Dollars (000 omitted)		
Gross Value of Crops	$ 96,639	$101,231	$ 97,142
Crop Costs	58,720	59,365	59,073
Profits from Crops	$ 37,919	$ 41,866	$ 38,069
Livestock Revenue	$154,631	$154,631	$154,631
Livestock Costs	133,121	133,123	131,434
Profits from Livestock	$ 21,510	$ 21,508	$ 23,197
Total Revenue	$193,858	$198,287	$195,675
Total Costs	134,438	134,919	134,411
Total Profits	$ 59,420	$ 63,368	$ 61,264

1. Historical yields, historical prices.

2. Minimum yield increase, historical prices.

3. Minimum yield increase, historical prices minus $0.05.

switch did not occur until the price of feed grains was decreased by five cents per bushel. However, in these cases fewer acres of oat silage were harvested as the oat acreage decreased, and corn silage fed to steer calves was not worth more than corn grain fed to yearling steers. Basically what occurred was that the oat acreage in this run faced an alternative more profitable than either raising silage or selling oats for grain. Therefore, this choice was more profitable than feeding silage to steer calves. Other changes occurred because the added flexibility yielded increased efficiency, thereby allowing minor profit increases and cost decreases.

Some of the activity preferences displayed in this run were continued throughout every run considered. The model minimized the acreage grown of oats, spring wheat, durum wheat, barley and rye in every run. It chose to maximize the acreage grown of alfalfa, soybeans and winter wheat in every run. However, corn, sorghum and wild hay were grown at various levels, depending upon their relative yields and prices.

The choice of livestock activities was not altered as the assumptions changed. Each activity participated at its maximum level except for the ewe herd activity which remained at its minimum level.

For this base run, sorghum and wild hay were at their upper bounds, replacing some corn acreage. The model tells us that, with greater responsiveness to operating conditions, profits of agriculture in the area could be increased by $2.652 million. The possiblilty for this increase is naturally easier to locate after the fact than it

would be when planting plans were made. The remainder of the runs in this second portion of the analysis will be compared to the run just discussed. This will allow isolation of the effects of weather modification from those caused by more efficient utilization of resources.

The first set of assumptions considered assumed that the minimum yield increase resulted from the weather modification program, and that no price decrease occurred because of the increase in supply. Gross value of crops increased 4.75 per cent and crop costs increased 1.10 per cent. Crop profits increased 10.4 per cent. The increase in crop costs was due to the switching of those flexible acres of wild hay and sorghum from these crops to corn, with the accompanying increase in expenses, and the additional acreage freed for corn due to increased pasture yields. Livestock revenues did not change as the previous optimum was carried forward. Livestock costs were also unchanged, leaving livestock profits unchanged. Total revenues increased 2.29 per cent, and total costs increased slightly, and total profits increased 6.64 per cent. The estimated effect of weather modification was a $3.948 million dollar increase in agricultural profits, with the entire increase going to the crop sector, and a slight profit decrease received by the livestock sector.

When the minimum yield increase was accompanied by a five cent decrease, the gross value of crops increased slightly, as did crop costs. This resulted in a small increase in crop profits. Under this set of assumptions, wild hay and sorghum remained at their upper bounds, being slightly more profitable than corn. Livestock revenues

were unchanged, but livestock costs were 1.27 per cent lower, because of lower feed prices. Livestock profits increased accordingly by 7.84 per cent. Total revenue increased slightly and total costs decreased slightly, with the net effect being a 3.10 per cent increase in total profits. This represents a $1.844 million increase in the agricultural profits of the area with the increase received almost entirely by the livestock sector. Therefore, the recipient of the benefits of weather modification, when the minimum yield increases are assumed, is determined by whether a price decrease accompanies the yield increase.

The next group of three runs assumes that the average yield increase accompanied the weather modification program. The runs assumed the five-year average prices, a five cent per bushel price decrease, and a ten cent per bushel price decrease, respectively. The results of these runs are listed in Table III-5. This table is the counter part of Table III-2.

When the five-year average prices were assumed to accompany the average yield increase, the flexible wild hay and sorghum acres were replaced by corn. This, plus the higher costs on the acres freed by higher pasture yields, resulted in a 2.58 per cent increase in crop costs. Gross value of crops increased 17.0 per cent and crop profits increased 39.4 per cent. Livestock costs increased slightly, causing a small decline in livestock profits. Total revenue increased 8.18 per cent and total costs increased slightly. Total profits rose by 25.0 per cent. The effect of weather modification on

Table III-5: Computer Analyses of Costs and Benefits of Weather Modification with Average Yield Increase and Variable Crop Acreage.

Statistic Name	Price Planning Situation 1	2	3
	Dollars (000 omitted)		
Gross Value of Crops	$113,085	$108,137	$103,928
Crop Costs	60,237	59,694	59,694
Profits from Crops	$ 52,848	$ 48,443	$ 44,234
Livestock Revenue	$154,631	$154,631	$154,631
Livestock Costs	133,209	131,389	129,749
Profits from Livestock	$ 21,422	$ 23,242	$ 24,882
Total Revenue	$209,717	$206,589	$204,021
Total Costs	135,447	134,904	134,904
Total Profits	$ 74,270	$ 71,685	$ 69,116

1. Average yield increase, historical prices.
2. Average yield increase, historical prices minus $0.05.
3. Average yield increase, historical prices minus $0.10.

agricultural profits in the study area was, under this set of assumptions, a $14.850 million increase, entirely received by the crop producers.

The next run assumed that a five cent per bushel price decrease accompanied the average yield increase. Under these assumptions, wild hay remained at its lower bound, while sorghum moved to its upper bound. Gross value of crops increased 11.9 per cent over the base, while crop costs increased 1.66 per cent, due to the higher costs of producing an acre of corn, compared to an acre of wild hay or pasture. Crop profits increased 27.8 per cent. Livestock costs decreased 1.30 per cent with the greater amounts of inexpensive feeds available. Livestock profits increased 8.05 per cent because of the decrease in costs. Total revenue was 6.57 per cent higher and total costs were slightly higher. Total profits were higher by 20.6 per cent or an increase of $12.265 million. Most of the increase in agricultural profits was experienced in the crop sector, with lesser benefits received by the livestock sector due to lower feed grain costs.

The third run assuming an average yield increase also assumed a ten cent price decrease from the five-year average. Crop costs were identical to those of the run just discussed, because there was no change in the cropping pattern. Gross value of crops was 7.54 per cent higher than the base and crop profits increased 16.7 per cent. Livestock costs decreased 2.53 per cent and the livestock profits increased 15.7 per cent. Total revenues were 5.24 per cent higher and total profits increased 16.3 per cent. Agricultural profits increased

$9.696 million with approximately equal percentage increases shared by both sectors.

The last group of runs from this second portion of the analysis assumed the maximum expected yield increase and four different sets of prices. These were historical prices, a five cent per bushel decrease, a ten cent per bushel decrease and a fifteen cent per bushel decrease. The results of these runs are presented in Table III-6. This table is analogous to Table III-3.

When the maximum yields were assumed, sorghum silage became more attractive than corn silage and the corn silage acreage fell to its lower bound. This did not occur when the constraints on acreage were fixed because more acres of oats were grown, and all of the necessary silage was supplied as oat silage.

The first of these runs assumed the five year average price and the maximum yield increase. This set of assumptions resulted in wild hay and sorghum at their lower bounds, with corn grown on these acres instead. This, plus the higher costs on the acreage freed by higher pasture yields, increased crop costs 3.75 per cent over the base. Gross value of crops was 27.1 per cent higher and crop profits were 63.3 per cent higher. Livestock costs were slightly higher causing a slight decrease in livestock profits. Total revenue was 13.2 per cent higher, total costs increased by 1.26 per cent, and total profits were 40.3 per cent higher. The projected increase in agricultural profits for the area, under this set of assumptions, was $23.939 million.

When prices were decreased five cents per bushel below their

Table III-6: Computer Analyses of Costs and Benefits of Weather Modification with Maximum Yield Increase and Variable Crop Acreage.

Statistic Name	Price Planning Situation 1	2	3	4
	Dollars (000 omitted)			
Gross Value of Crops	$122,833	$118,240	$112,894	$108,038
Crop Costs	60,923	60,923	60,379	60,125
Profits from Crops	$ 61,910	$ 57,317	$ 52,515	$ 47,913
Livestock Revenue	$154,631	$154,631	$154,631	$154,631
Livestock Costs	133,180	131,552	129,701	127,557
Profits from Livestock	$ 21,451	$ 23,079	$ 24,930	$ 27,074
Total Revenue	$219,492	$216,527	$213,031	$210,321
Total Costs	136,133	136,133	135,590	135,335
Total Profits	$ 83,359	$ 80,394	$ 77,441	$ 74,986

1. Maximum yield increase, historical prices.
2. Maximum yield increase, historical prices minus $0.05.
3. Maximum yield increase, historical prices minus $0.10.
4. Maximum yield increase, historical prices minus $0.15.

five-year average, no change from the previous run occurred either in the wild hay or sorghum acreages. The gross value of crops was 22.4 per cent higher than the base and crop profits were 51.2 per cent higher. Livestock costs decreased by 1.20 per cent causing a 7.29 per cent increase in livestock profits. Total revenue was 11.7 per cent higher and total profits were 35.3 per cent higher. The effect of weather modification, under this set of assumptions, was found to be a $20.974 million increase in agricultural profits, received primarily by the crop sector.

Prices were set at ten cents per bushel below the five-year average prices for the third run assuming maximum yields. Sorghum was at its upper bound and wild hay was at its lower bound. Crop costs were 2.83 per cent higher than the base run, and gross value of crops was 16.8 per cent greater. Crop profits were 38.5 per cent higher. Livestock costs were 2.57 per cent lower, causing an increase in livestock profits of 15.9 per cent. Total revenue increased 9.89 per cent as total costs increased slightly. The net effect was a 30.3 per cent increase in total profits. The projected increase in agricultural profits from weather modification under this set of assumptions was $18.021 million, with both sectors receiving major increases, particularily the crop sector.

The final run of this group set prices fifteen cents per bushel below the five-year average. These conditions made it most profitable for wild hay and sorghum to be at their upper bounds. Crop costs rose by 2.39 per cent and the gross value of crops increased 11.8 per cent.

Crop profits were 26.4 per cent higher than the base. Livestock costs decreased by 4.18 per cent and livestock profits increased 25.9 per cent. Total revenue increased 8.49 per cent, and total costs increased slightly. The net effect was a 26.1 per cent increase in total profits. Because the nutrient value per dollar for oats increased proportionately more than corn, with the maximum price decrease, oats was fed rather than corn. The projected increase in profits from weather modification, under this set of assumptions, was $15.566 million, with similar percentage increases felt by each sector.

For each set of assumptions tried, weather modification increased the returns to agriculture in the area. When extra flexibility was introduced into the model, the magnitude of the returns increased. A summary of the increases and other findings, along with their implications are presented in the following chapter.

CHAPTER IV
SUMMARY AND CONCLUSIONS

The linear programming analyses of the area showed profit increases over the base run in every case. A summary of these results is given in Table IV-1. The estimated profit increases ranged from $1.582 million to $23.952 million with the fixed acreage assumption, and from $1.844 million to $23.939 million with the flexible crop acreage restrictions.

When the constraints controlling the level of participation in each activity were relaxed, the model could choose between the activities to a limited degree. The crop activities which were participated in to the maximum allowable extent were alfalfa hay, soybeans, and winter wheat. The crop activities participated in to the minimum allowable extent were oats, spring wheat, durum wheat, barley and rye. It is interesting to note that, with the exception of winter wheat, all of the upper bound activities were in fact among the most common crops of the area. Similarly, those crops which were lower bound activities, with the exception of oats, were not widely grown. The three crops which had variable participation levels were corn, sorghum and wild hay. These three crops are all widely grown in the area. Apparently, oats is grown for reasons other than those appearing in the model. According to Dr. Herbert Allen, Professor of Economics in Farm Management at South Dakota State University, two of these reasons are, first, because oats are necessary for certain types of crop

Table IV-1: Profit Increases from Weather Modification Obtained from Selected Computer Analyses

Yield Increase	Price Change	Bounds Fixed	Bounds Relaxed
		Dollars (000 omitted)	
Minimum	none	3.950	3.948
Minimum	minus $0.05	1.582	1.844
Average	none	14,897	14,850
Average	minus $0.05	12,058	12,265
Average	minus $0.10	9,237	9,696
Maximum	none	23,952	23,939
Maximum	minus $0.05	20,693	20,974
Maximum	minus $0.10	17,496	18,021
Maximum	minus $0.15	14,815	15,566
Base Profit		56,768	59,420

rotation, and second, because of tradition or habit.[25] Planting difficulties with winter wheat partly explain its absence as a major crop despite its profitability.

Cattle activities chosen were raising replacement heifers, feeding heifer calves and feeding either steer calves or yearling steers. It is reassuring to note that these activities are also representative of the area's activities. Feeding lambs was an upper bound activity and the ewe herd was a lower bound activity.

The choice of which estimate of the profit increase from weather modification, of the eighteen generated, is most appropriate depends on several factors. The first of these is the timeliness of the rainfall increase. The importance of this factor cannot be overstressed. Weather modification must not be considered similar to a faucet, which may be turned on whenever extra moisture is required. The practice requires clouds, and opportunities are not particularly prevalent during dry periods. While extra rainfall is almost always helpful, the expected yield increase which is appropriate is related to the timeliness of the rainfall.

The second factor affecting this choice is which price decrease is appropriate for the supply increase chosen. The magnitude of this price decrease would be determined by the impact on the total nation's supply. This effect would vary considerably from crop to crop. In Table IV-2 is a listing of the percentage of the total U. S. production which was grown in South Dakota for several crops. Because of the

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[25]Personal interview, March 12, 1974.

Table IV-2: South Dakota Production as a Percentage of U. S. Production, 1970.

Crop	Percentage
Corn	2.50
Oats	11.26
Barley	2.96
Rye	23.29
Sorghum	1.29
Soybeans	0.38
Potatoes	0.22
All wheat	2.87
Durum	4.16
Winter	1.27
Other spring	11.03
Flaxseed	24.66
All hay	4.55
Wild hay	2.60
Alfalfa hay	5.18

Source: South Dakota Crop and Livestock Reporting Service, South Dakota Agriculture, 1970, p. 8.

state's position on the western edge of the corn belt, and the eastern edge of the wheat belt, the state does not concentrate on any one crop as many states do. This means that the state's impact on total national supply of any one crop will be fairly limited. The price change appropriate varies from crop to crop, and from year to year. The alternative price decreases considered were believed to be sufficient to approximate the most severe price reduction which might occur.

When considering the impact of an increase in production in the state on prices, the price elasticity of demand for agricultural products is important. South Dakota's percentage of the value of national farm production of those crops grown in South Dakota was found to be 2.7 per cent for 1970.[26] The percentage increase from weather modification considered was less than twenty per cent in every instance. This would mean an increase in national production of less than 0.54 per cent. The price elasticity of demand for agricultural products has been estimated at -0.2 by Rojko.[27] Using this figure with the quantity increase of 0.54 per cent, a price decrease of 2.7 per cent is obtained. Since the prices used were all below $1.50 per bushel, except for soybeans, this would be at most a four cent price decrease. Other estimates of elasticity vary from Rojko's in both directions. Since the quantity increase used for this discussion assumed the

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[26]South Dakota Crop and Livestock Reporting Service, South Dakota Agriculture, 1970, p. 53.

[27]Anthony S. Rojko et al. World Demand Prospects for Grain in 1980, Foreign Agricultural Economic Report No. 75, United States Department of Agriculture, as reported in Stroup and Townsend, op. cit., p. 9.

maximum price decrease, the larger price changes used in the model were somewhat pessimistic, if Rojko's estimate is reasonable. The price decreases, in any case, should not be greater than those considered.

As mentioned previously, the cost of the weather modification program for South Dakota in fiscal 1973 was approximately 3.2 cents per acre. When this figure is applied to the nine county area, a projected total cost of $113,200 is obtained. It is this low cost, compared to irrigation or other water increase alternatives, which has made operational weather modification programs technological inputs that producers must consider. Needless to say this figure is considerably smaller than any of the estimates of agricultural profit increase for the area. Even the most pessimistic estimate would cover these costs more than ten times.

Certain assumptions were made which deviated from reality. It is therefore desirable to speculate on the effect of these assumptions on the estimates. The first of these assumptions is the exclusion of the dairy sector from the model. The inclusion of dairy would increase costs, revenues and profits, and would use more feed. More silage would be required, leaving less grain available for sale. The effect of these two factors would be a damping of the effect of the price decrease. Each time another sector is added which benefits from lower feed prices, part of the decrease in the crop sector's profits, because of a price decrease, is offset by a profit increase in the new sector. The effect of excluding dairy was therefore viewed as having no negative effect on the findings.

The effect of excluding taxes and interest was to increase total profits. Since the capital base was not affected greatly by weather modification, the difference between profits with and without weather modification shouldn't be significant, but total profits would be smaller. It should be noted, however, that weather modification might result in higher land values, thereby, having some potential impact on taxes and interest which could decrease the profits for land owners.

The most important assumption, with regard to effects on the results, was the assumption that no change occurs in harvesting costs when the yield increases. This is obviously not true. Some changes certainly occur, particularly with the maximum yield increases. One consolation is that the added cost is positively correlated with the yield increase, as is the size of the profit increase.

In those cases where large profit increases were estimated, relaxation of this assumption would reduce the size of the projected increase, but not appreciably. The only case where increased harvest costs were significant was the case which yielded the smallest profit increase (a minimum yield increase was assumed to accompany a five cent per bushel price decrease). In that case, the estimated profit increases were $1.582 million and $1.844 million. A pessimistic estimate of the cost increase which might accompany this case is $0.25 per acre, or $700,000 for the area, based on the budgets used as a basis for those in the model. When this amount is subtracted from the estimated profit increase, the remaining estimated profit increase is

$800,000, or approximately seven times the estimated cost of the program. This is a marked decrease, even though it does not negate the estimated profitability of the weather modification program by any means. However, this particular example combines three very pessimistic assumptions and should be considered in that light. With any more optimistic assumptions the effect of the assumption in question is lessened considerably. Therefore, it must be concluded that the assumption of no cost increase associated with harvesting higher yields, did not affect appreciably the findings of the study, particularly regarding the attractiveness of a weather modification program. While the profit increases projected would be lower without this assumption, none would be so small that it would barely cover the costs of the program.

The entire field of weather modification is young and all of the effects of it are not entirely clear. The assumptions of this study, particularly the assumption that an additional inch of rain can be supplied, represent a rather elementary approach to the problem. Further research would be useful, i.e. investigating the economic effects of hail suppression, the indirect effects of weather modification, and the economics of a national or a worldwide program. It appears that a national or worldwide program would substantially increase food producing capacity. The effect and size of these supply increases and other interesting possibilities make the topic a likely candidate for considerable additional research in the future.

BIBLIOGRAPHY

BIBLIOGRAPHY

Aanderud, Wallace G., Myron T. Barber and Merlyn M. Dahl. Guidebook for Planning a Farm or Ranch Business, Extension Circular 644 (Revised). Cooperative Extension Service, United States Department of Agriculture, South Dakota State University, 1970.

Aanderud, Wallace G., Merlyn M. Dahl and John N. Maher. "Ten Steps for Planning Your Farm or Ranch Business," Extension Circular 632 (Revised). Cooperative Extension Service, United States Department of Agriculture, South Dakota State University, 1970.

Brown, Gardener M. Jr., and C. B. McGuire. "A Socially Optimum Pricing Policy for a Public Water Agency," Water Resources Research, 3:1 (1967), 33-43.

Changnon, S. A. Jr., and F. A. Huff. "Evaluation of Potential Benefits of Weather Modification on Agriculture." A report to the Division of Atmospheric Water Resources Research of the Bureau of Reclamation, United States Department of Interior. Prepared by Illinois State Water Survey, 1971.

Economics Department. "South Dakota Agriculture and its Problems." Agricultural Economics Pamphlet 121. South Dakota State University, 1964.

Effects of Additional Precipitation on Agricultural Production, the Environment, the Economy and Human Society in South Dakota. 2 vols. A report to the Division of Atmospheric Water Resources Management of the Bureau of Reclamation, United Stated Department of Interior. Prepared by a special study team of the Agricultural Experiment Station, South Dakota State University, 1973.

Ferguson, Robert O., and Lauren F. Sargent. Linear Programming. New York: McGraw Hill Book Company, Inc., 1958.

Heady, Earl O., and Wilfred Chandler. Linear Programming Methods. Ames: Iowa State University Press, 1966.

Howe, Charles W., and K. William Easter. Interbasin Transfers of Water, Economic Issues and Impacts. Baltimore: John Hopkins Press, 1971.

Johnson, Darwin K. An Economic Analysis of Selected Beef Enterprise Systems for Southeast South Dakota. Unpublished Master's thesis, South Dakota State University, 1973.

Kettering, Donald L. An Economic Analysis of the Brookings Study Area. Unpublished Master's thesis, South Dakota State University, 1970.

Prasher, Paul, and Dean Martin. "1974 Vegetable Varieties for South Dakota." Cooperative Extension Service, United States Department of Agriculture, South Dakota State University, 1974.

Rudel, R. K., H. J. Stockwell and R. G. Walsh. "Weather Modification: An Economic Alternative for Augmenting Water Supplies," Water Resources Bulletin, 9:1 (February, 1973), 116-128.

South Dakota Crop and Livestock Reporting Service. South Dakota Agriculture, 1967-71.

Stroup, Richard L., and Stuart Townsend. "An Evaluation of the Economic Impacts of Weather Modification in the Great Plains of Montana," Section 5, Economics, from Impacts of Induced Rainfall on the Great Plains of Montana. Research Report 42. A report to the Division of Atmospheric Water Resources Management of the Bureau of Reclamation, United States Department of Interior. Prepared by the Montana Agricultural Experiment Station, Montana State University, 1973.

United States Bureau of the Census. Census of Agriculture, 1969. Vol. I, Area Reports. Part 19, South Dakota. Section 2, County Data. Washington: Government Printing Office, 1972.

United States Department of Agriculture. Selected U. S. Crop Budgets: Yields, Inputs, and Variable Costs. Vol. III, Great Plains Re-

APPENDICIES

APPENDIX A

Appendix A, Table I: Resource Restrictions Used Initially in the Linear Programming Model.

Row	Item	Unit	Initial Level
TLAB	Total Labor Transfer	Man-hour	0
CORNLIM	Corn Acreage Limit	1000 Acres	FR
OATLIM	Oat Acreage Limit	1000 Acres	454.7
SWLIM	Spring Wheat Acreage Limit	1000 Acres	24.3
DWLIM	Durum Wheat Acreage Limit	1000 Acres	1.3
WWLIM	Winter Wheat Acreage Limit	1000 Acres	12.0
BLIM	Barley Acreage Limit	1000 Acres	16.3
SORGLIM	Sorghum Acreage Limit	1000 Acres	140.6
RYELIM	Rye Acreage Limit	1000 Acres	3.1
SOYLIM	Soybeans Acreage Limit	1000 Acres	183.8
ALLIM	Alfalfa Acreage Limit	1000 Acres	202.8
WHLIM	Wild Hay Acreage Limit	1000 Acres	98.2
CRPASLIM	Cropland Pasture Acreage Limit	1000 Acres	398.6
NATPASLM	Native Pasture Acreage Limit	1000 Acres	434.0
CHARV	Corn to Harvest	Acre	0
OATHARV	Oats to Harvest	Acre	0
SORGHARV	Sorghum to Harvest	Acre	0
CORNGSUP	Corn Grain Supply	Bushel	0
OATGSUP	Oat Grain Supply	Bushel	0
SORGGSUP	Sorghum Grain Supply	Bushel	0
BARSUP	Barley Supply	Bushel	0
CHARLIM	Corn Grain Harvest Limit	1000 Acres	800.0
OHARLIM	Oats Grain Harvest Limit	1000 Acres	404.9
SORHARLM	Sorhgum Grain Harvest Limit	1000 Acres	100.0
CORNSILA	Corn Silage Acreage Limit	1000 Acres	30.0
OATSILA	Oat Silage Acreage Limit	1000 Acres	FR*
SORSIL	Sorghum Silage Acreage Limit	1000 Acres	FR
CORNEQ	Corn Equivalents	Bushel	0
PAS	Pasture	AUM	0
CSTF	Corn Silage to Feed	Ton	0
HAYEQ	Hay to Feed	Ton	0
ALSUP	Alfalfa Supply	Ton	0
WHSUP	Wild Hay Supply	Ton	0
AH	Alfalfa to Harvest	Acre	0
WHH	Wild Hay to Harvest	Acre	0
AC	Acres Cropland	1000 Acres	2317.5
AP	Acres Pasture	1000 Acres	FR
TA	Total Acres	1000 Acres	2751.5
RH	Replacement Heifers Transfer	Head	0

*FR indicates a free variable. The amount of these materials used is not restricted in the solution.

Appendix A, Table I: (continued)

Row Title	Item	Unit	Initial Level
YH	Yearling Heifers Transfer	CWT	0
YS	Yearling Steers Transfer	CWT	0
HC	Heifer Calves Transfer	CWT	0
SC	Steer Calves Transfer	CWT	0
CC	Cull Cows Transfer	CWT	0
FHCALVES	Fed Heifer Calves Transfer	CWT	0
FSCALVES	Fed Steer Calves Transfer	CWT	0
FHY	Fed Yearling Heifers Transfer	CWT	0
FSY	Fed Yearling Steers Transfer	CWT	0
BCU	Beef Cow Units	100 Units	2013.0
SLIM	Steers 500lb+ Limit	100 Head	1048.0
HLIM	Heifers 500lb+ Limit	100 Head	451.3
RE	Replacement Ewes Transfer	Head	0
LAMBS	Lamb Transfer	CWT	0
CE	Cull Ewe Transfer	Head	0
EWELIM	Ewe Limit	1000 Head	40.0
LFLIM	Lambs Fed Limit	1000 Head	24.0
FP	Feeder Pig Transfer	CWT	0
SOWS	Cull Sow Transfer	Head	0
SOWLIM	Sow Limit	1000 Head	17.0
PFLIM	Pigs Fed Limit	1000 Head	1124.8
TOTCOST	Total Cost	Dollar	FR
TOTREV	Total Revenue	Dollar	FR
CROPEX	Crop Costs	Dollar	FR
GVALCROP	Gross Value of Crops	Dollar	FR
LVSTKCST	Livestock Costs	Dollar	FR
LVSTKREV	Livestock Revenue	Dollar	FR
WATER	Water Transfer	Acre-inch	0
CHARVW	Corn with Water to Harvest	Acre	0
OATHARVW	Oats with Water to Harvest	Acre	0
SORGHARV	Sorghum with Water to Harvest	Acre	0
SWWT	Spring Wheat with Water Transfer	Bushel	0
DWWT	Durum Wheat with Water Transfer	Bushel	0
WWWT	Winter Wheat with Water Transfer	Bushel	0
BARWT	Barley with Water Transfer	Bushel	0
RYEWT	Rye with Water Transfer	Bushel	0
SOYWT	Soybeans with Water Transfer	Bushel	0
CWGSUP	Corn with Water Grain Supply	Bushel	0
OWGSUP	Oats with Water Grain Supply	Bushel	0
SWGSUP	Sorghum with Water Grain Supply	Bushel	0

*FR indicates a free bound. The amount of these materials used is not restricted in the solution.

Appendix A, Table II: Activities Included in the Linear Programming Model.

Title	Activity Description	Unit of Measure
Hired Labor		
HLAB	Hired Labor	Man-hour
Cropland		
CORN	Raise Corn	Acre
OAT	Raise Oats	Acre
SW	Raise Spring Wheat	Acre
DW	Raise Durum Wheat	Acre
WW	Raise Winter Wheat	Acre
BAR	Raise Barley	Acre
SORG	Raise Sorghum	Acre
RYE	Raise Rye	Acre
Soy	Raise Soybeans	Acre
AL	Raise Alfalfa	Acre
WH	Raise Wild Hay	Acre
CRPAS	Raise Cropland Pasture	Acre
NATPAS	Raise Native Pasture	Acre
Harvest Crops		
CORNG	Harvest Corn for Grain	Acre
CORNSIL	Harvest Corn for Silage	Acre
OATG	Harvest Oats for Grain	Acre
OATSIL	Harvest Oats for Silage	Acre
SORGG	Harvest Sorghum for Grain	Acre
SORGSIL	Harvest Sorghum for Silage	Acre
HARAL	Harvest Alfalfa	Acre
HARWH	Harvest Wild Hay	Acre
Purchase and Sale of Crops		
SELCORN	Sell Corn Grain	Bushel
BUYCORN	Buy Corn Grain	Bushel
SELOAT	Sell Oats Grain	Bushel
SELSORG	Sell Sorghum Grain	Bushel
SELBAR	Sell Barley	Bushel
SELAL	Sell Alfalfa	Ton
BUYAL	Buy Alfalfa	Ton
SELWH	Sell Wild Hay	Ton

Appendix A, Table II: (continued)

Title	Activity Description	Unit of Measure
Crop Transfer		
CORNEQU	Corn Grain Transfer	10 Bushels
OATT	Oat Grain Transfer	10 Bushels
SORGT	Sorghum Grain Transfer	10 Bushels
BART	Barley Transfer	10 Bushels
ALTOFEED	Alfalfa Transfer	Ton
HEQ	Wild Hay Transfer	Ton
Cattle		
PURRH	Beef Cow Unit-Purchased Replacement	Unit
RREPH	Beef Cow Unit-Raised Replacement	Unit
RYS	Raise Yearling Steers	Head
RYH	Raise Yearling Heifers	Head
FSC	Feed Steer Calves in Drylot	Head
FHC	Feed Heifer Calves in Drylot	Head
FYS	Feed Yearling Steers in Drylot	1.8 Head
FYH	Feed Yearling Heifers in Drylot	1.8 Head
Purchase and Sale of Cattle		
BSC	Buy Steer Calves	CWT
BHC	Buy Heifer Calves	CWT
SSC	Sell Steer Calves	CWT
SHC	Sell Heifer Calves	CWT
SFSC	Sell Fed Steer Calves	CWT
SFHC	Sell Fed Heifer Calves	CWT
BYS	Buy Yearling Steers	CWT
BYH	Buy Yearling Heifers	CWT
SFYS	Sell Fed Yearling Steers	CWT
SFYH	Sell Fed Yearling Heifers	CWT
SYS	Sell Yearling Steers	CWT
SYH	Sell Yearling Heifers	CWT
BRH	Buy Replacement Heifers	Head
SCC	Sell Cull Cows	CWT
Sheep		
PREPE	Ewe Unit-Raise Replacements	Unit
PURRE	Ewe Unit-Purchase Replacements	Unit
FL	Feed Lambs	Head

Appendix A, Table II: (continued)

Title	Activity Description	Unit of Measure
Purchase and Sale of Sheep		
SELLAM	Sell Feeder Lambs	CWT
BFL	Buy Feeder Lambs	CWT
BRE	Buy Replacement Ewes	CWT
SCE	Sell Cull Ewes	CWT
Hogs		
HH	Sow Unit	Unit
FPIGS	Feed Pigs	Head
Purchase and Sale of Hogs		
BFP	Buy Feeder Pigs	CWT
SS	Sell Cull Sows	CWT
Cropland with Water		
CORNW	Raise Corn with Water	Acre
OATW	Raise Oats with Water	Acre
SWW	Raise Spring Wheat with Water	Acre
DWW	Raise Durum Wheat with Water	Acre
WWW	Raise Winter Wheat with Water	Acre
BARW	Raise Barley with Water	Acre
SORGW	Raise Sorghum with Water	Acre
RYEW	Raise Rye with Water	Acre
SOYW	Raise Soybeans with Water	Acre
ALW	Raise Alfalfa with Water	Acre
WHW	Raise Wild Hay with Water	Acre
CRPASW	Raise Cropland Pasture with Water	Acre
NATPASW	Raise Native Pasture with Water	Acre
Harvest Crops with Water		
CORNWG	Harvest Corn with Water for Grain	Acre
CWSIL	Harvest Corn with Water for Silage	Acre
OATWG	Harvest Oats with Water for Grain	Acre
OWSIL	Harvest Oats with Water for Silage	Acre
SORGWG	Harvest Sorghum with Water for Grain	Acre
SWSIL	Harvest Sorghum with Water for Silage	Acre

Appendix A, Table II: (continued)

Title	Activity Description	Unit of Measure
Sell Crops with Water		
SELCORNW	Sell Corn Grain with Water	Bushel
SELOATW	Sell Oats Grain with Water	Bushel
SELSORW	Sell Sorghum Grain with Water	Bushel
SELBARW	Sell Barley with Water	Bushel
SELSWW	Sell Spring Wheat with Water	Bushel
SELDWW	Sell Durum Wheat with Water	Bushel
SELWWW	Sell Winter Wheat with Water	Bushel
SELRYEW	Sell Rye with Water	Bushel
SELSOYW	Sell Soybeans with Water	Bushel
Crops with Water Transfer		
CORNWT	Corn Grain with Water Transfer	10 Bushels
OATWT	Oat Grain with Water Transfer	10 Bushels
BARLWT	Barley with Water Transfer	10 Bushels
SORWT	Grain Sorghum with Water Transfer	10 Bushels
Buy Water		
BUYWAT	Buy Water	Acre-foot

Appendix B, Table [illegible]

Item	[illegible]
Crops	
Corn Grain	
Oats Grain	
Soybeans	
Sorghum Grain	
Winter Wheat	
Spring Wheat	
Durum Wheat	
Rye	
Barley	
Alfalfa Hay	
Wild Hay	
Livestock	
Steer Calves	
Heifer Calves	
Steer Yearling Feeders	
Heifer Yearling Feeders	
Fed Steer Calves	
Fed Heifer Calves	
Fed Yearling Steers	
Fed Yearling Heifers	
Replacement Heifers	
Cull Cows	
Butcher Hogs	
Feeder Pigs	
Cull Sows	
Feeder Lambs	
Fat Lambs	
Replacement Ewes	
Cull Ewes	

Source: South [illegible] Dakota Agricultural [illegible]

APPENDIX B

Appendix B, Table I: Prices Used in the Model.

Item	Unit	Price
Crops		
Corn Grain	Bushel	$ 1.08
Oats Grain	Bushel	0.59
Soybeans	Bushel	2.54
Sorghum Grain	Bushel	0.92
Winter Wheat	Bushel	1.28
Spring Wheat	Bushel	1.46
Durum Wheat	Bushel	1.42
Rye	Bushel	0.88
Barley	Bushel	0.84
Alfalfa Hay	Ton	25.00
Wild Hay	Ton	18.83
Livestock		
Steer Calves	cwt	34.44
Heifer Calves	cwt	30.44
Steer Yearling Feeder	cwt	30.44
Heifer Yearling Feeder	cwt	27.44
Fed Steer Calves	cwt	27.94
Fed Heifer Calves	cwt	25.94
Fed Yearling Steers	cwt	26.94
Fed Yearling Heifers	cwt	24.94
Replacement Heifers	Head	250.00
Cull Cows	cwt	16.94
Butcher Hogs	cwt	19.54
Feeder Pigs	cwt	39.08
Cull Sows	cwt	16.50
Feeder Lambs	cwt	23.36
Fat Lambs	cwt	25.36
Replacement Ewes	cwt	24.36
Cull Ewe	cwt	5.86

Source: South Dakota Crop and Livestock Reporting Service, South Dakota Agriculture, 1967-71, various pages.

Appendix B, Table II: Method of Determining Cattle Bounds.

Unit	Number
Total Cattle in Region	620,000
Minus Beef Cows and Heifers that have Calved	-185,200
Minus Milk Cows and Heifers that have Calved	- 32,000
Minus Calves	-206,550
Minus Bulls (0.04 x 222,600)	- 8,690
Minus Replacements - Beef (0.16 x 191,100)	- 29,630
Minus Replacements - Dairy (0.25 x 31,500)	- 8,000
Animals being Fattened	149,930
Beef Steers (0.699 x 149,930)	104,800
Beef Heifers (0.301 x 149,930)	45,130

Sources: South Dakota Crop and Livestock Reporting Service, South Dakota Agriculture, 1967-71, various pages; Wallace G. Aanderud, Farm Management Extension Economist, South Dakota State University.

Appendix C, Table I: Estimated Costs Per Acre for Corn Grain, 1972.

Item	Cost
Machine Operation	$ 5.80
Fixed Machine	7.50
Seed Cost	4.09
Herbicide	2.00
Pesticide	1.50
Fertilizer	4.12
Crop Insurance	2.50
Labor	6.50
TOTAL	$33.92
Yield (bushels)	45

Sources: Selected U. S. Crop Budgets: Yields, Inputs, and Variable Costs, Vol. III, Great Plains Region, ERS 459, United States Department of Agriculture; Wallace G. Aanderud, Merlyn M. Dahl and John M. Maher, "Ten Steps for Planning Your Farm or Ranch Business," Extension Circular 632 (rev), Cooperative Extension Service, United States Department of Agriculture (South Dakota State University) Wallace G. Aanderud, Farm Management Extension Economist, SDSU.

APPENDIX C

Appendix C, Table I: Estimated Costs Per Acre for Corn Grain, 1972.

Item	Cost
Machine Operation	$ 5.80
Fixed Machine	7.50
Seed Cost	4.00
Herbicide	2.00
Pesticide	1.50
Fertilizer	4.12
Crop Insurance	2.50
Labor	6.50
TOTAL	$33.92
Yield (bushels)	45

Sources: Selected U. S. Crop Budgets: Yields, Inputs, and Variable Costs, Vol. III, Great Plains Region, ERS 459, United States Department of Agriculture; Wallace G. Aanderud, Merlyn M. Dahl and John N. Maher, "Ten Steps for Planning Your Farm or Ranch Business," Extension Circular 632 (rev), Cooperative Extension Service, United States Department of Agriculture (South Dakota State University) Wallace G. Aanderud, Farm Management Extension Economist, SDSU.

Appendix C, Table II: Estimated Costs Per Acre for Corn Silage, 1972.

Item	Cost
Machine Operation	$ 4.00
Fixed Machine	9.50
Seed Cost	4.00
Fertilizer	4.12
Herbicide	2.00
Pesticide	1.50
Crop Insurance	2.50
Labor	11.00
TOTAL	$38.62
Yield (tons)	7.5

Sources: Selected U. S. Crop Budgets: Yields, Inputs, and Variable Costs, Vol. III, Great Plains Region, ERS 459, United States Department of Agriculture; Wallace G. Aanderud, Merlyn M. Dahl and John N. Maher, "Ten Steps for Planning Your Farm or Ranch Business," Extension Circular 632 (rev), Cooperative Extension Service, United States Department of Agriculture (South Dakota State University); Wallace G. Aanderud, Farm Management Extension Economist, SDSU.

Appendix C, Table III: Estimated Costs Per Acre for Oats Grain, 1972.

Item	Cost
Machine Operation	$ 2.92
Fixed Machine	5.40
Seed Cost	1.95
Fertilizer	1.86
Pesticide	1.05
Crop Insurance	1.30
Labor	3.82
TOTAL	$18.30
Yield (bushels)	45

Sources: Selected U. S. Crop Budgets: Yields, Inputs, and Variable Costs, Vol. III, Great Plains Region, ERS 459, United States Department of Agriculture; Wallace G. Aanderud, Merlyn M. Dahl and John N. Maher, "Ten Steps for Planning Your Farm or Ranch Business," Extension Circular 632 (rev), Cooperative Extension Service, United States Department of Agriculture (South Dakota State University); Wallace G. Aanderud, Farm Management Extension Economist, SDSU.

Appendix C, Table IV: Estimated Costs Per Acre for Oat Silage, 1972.

Item	Cost
Machine Operation	$ 3.42
Fixed Machine	8.40
Seed Cost	1.95
Fertilizer	1.86
Pesticide	1.05
Crop Insurance	1.30
Labor	9.28
TOTAL	$27.26
Yield (tons)	6

Sources: Selected U. S. Crop Budgets: Yields, Inputs, and Variable Costs, Vol. III, Great Plains Region, ERS 459, United States Department of Agriculture; Wallace G. Aanderud, Merlyn M. Dahl and John N. Maher, "Ten Steps for Planning Your Farm or Ranch Business," Extension Circular 632 (rev), Cooperative Extension Service, United States Department of Agriculture (South Dakota State University); Wallace G. Aanderud, Farm Management Extension Economist, SDSU.

Appendix C, Table V: Estimated Costs Per Acre for Grain Sorghum, 1972.

Item	Cost
Machine Operation	$ 4.50
Fixed Machine	6.00
Seed Cost	1.22
Fertilizer	3.39
Pesticide	2.50
Crop Insurance	1.50
Labor	6.00
TOTAL	$25.11
Yield (bushels)	40

Sources: Selected U. S. Crop Budgets: Yields, Inputs, and Variable Costs, Vol. III, Great Plains Region, ERS 459, United States Department of Agriculture; Wallace G. Aanderud, Merlyn M. Dahl and John N. Maher, "Ten Steps for Planning Your Farm or Ranch Business," Extension Circular 632 (rev), Cooperative Extension Service, United States Department of Agriculture (South Dakota State University); Wallace G. Aanderud, Farm Management Extension Economist, SDSU.

Appendix C, Table VI: Estimated Costs Per Acre for Sorghum Silage, 1972.

Item	Cost
Machine Operation	$ 4.29
Fixed Machine	9.00
Seed Cost	1.22
Fertilizer	3.39
Pesticide	2.50
Crop Insurance	1.50
Labor	10.00
TOTAL	$31.90
Yield (tons)	7

Sources: Selected U. S. Crop Budgets: Yields, Inputs, and Variable Costs, Vol. III, Great Plains Region, ERS 459, United States Department of Agriculture; Wallace G. Aanderud, Merlyn M. Dahl and John N. Maher, "Ten Steps for Planning Your Farm or Ranch Business," Extension Circular 632 (rev), Cooperative Extension Service, United States Department of Agriculture (South Dakota State University); Wallace G. Aanderud, Farm Management Extension Economist, SDSU.

Appendix C, Table VII: Estimated Costs Per Acre for Spring Wheat, 1972.

Item	Cost
Machine Operation	$ 2.62
Fixed Machine	5.40
Seed Cost	2.83
Fertilizer	1.82
Pesticide	1.00
Crop Insurance	1.10
Labor	3.50
TOTAL	$18.27
Yield (bushels)	20

Sources: Selected U. S. Crop Budgets: Yields, Inputs, and Variable Costs, Vol. III, Great Plains Region, ERS 459, United States Department of Agriculture; Wallace G. Aanderud, Merlyn M. Dahl and John N. Maher, "Ten Steps for Planning Your Farm or Ranch Business," Extension Circular 632 (rev), Cooperative Extension Service, United States Department of Agriculture (South Dakota State University); Wallace G. Aanderud, Farm Management Extension Economist, SDSU.

Appendix C, Table VIII: Estimated Costs Per Acre for Durum Wheat, 1972.

Item	Cost
Machine Operation	$ 3.20
Fixed Machine	5.40
Seed Cost	2.87
Fertilizer	1.88
Pesticide	1.00
Crop Insurance	1.10
Labor	3.50
TOTAL	$18.95
Yield (bushels)	20

Sources: Selected U. S. Crop Budgets: Yields, Inputs, and Variable Costs, Vol. III, Great Plains Region, ERS 459, United States Department of Agriculture; Wallace G. Aanderud, Merlyn M. Dahl and John N. Maher, "Ten Steps for Planning Your Farm or Ranch Business," Extension Circular 632 (rev), Cooperative Extension Service, United States Department of Agriculture (South Dakota State University); Wallace G. Aanderud, Farm Management Extension Economist, SDSU.

Appendix C, Table IX: Estimated Costs Per Acre for Winter Wheat, 1972.

Item	Cost
Machine Operation	$ 3.05
Fixed Machine	5.40
Seed Cost	2.30
Fertilizer	1.27
Pesticide	1.00
Crop Insurance	1.10
Labor	3.50
TOTAL	$17.62
Yield (bushels)	30

Sources: Selected U. S. Crop Budgets: Yields, Inputs, and Variable Costs, Vol. III, Great Plains Region, ERS 459, United States Department of Agriculture; Wallace G. Aanderud, Merlyn M. Dahl and John N. Maher, "Ten Steps for Planning Your Farm or Ranch Business," Extension Circular 632 (rev), Cooperative Extension Service, United States Department of Agriculture (South Dakota State University); Wallace G. Aanderud, Farm Management Extension Economist, SDSU.

Appendix C, Table X: Estimated Costs Per Acre for Rye, 1972.

Item	Cost
Machine Operation	$ 3.11
Fixed Machine	5.40
Seed Cost	1.86
Fertilizer	0.88
Pesticide	1.10
Crop Insurance	1.00
Labor	3.42
TOTAL	$16.77
Yield (bushels)	25

Sources: Selected U. S. Crop Budgets: Yields, Inputs, and Variable Costs, Vol. III, Great Plains Region, ERS 459, United States Department of Agriculture; Wallace G. Aanderud, Merlyn M. Dahl and John N. Maher, "Ten Steps for Planning Your Farm or Ranch Business," Extension Circular 632 (rev), Cooperative Extension Service, United States Department of Agriculture (South Dakota State University); Wallace G. Aanderud, Farm Management Extension Economist, SDSU.

Appendix C, Table XI: Estimated Costs Per Acre for Barley, 1972.

Item	Cost
Machine Operation	$ 3.09
Fixed Machine	5.40
Seed Cost	1.50
Fertilizer	1.76
Pesticide	1.20
Crop Insurance	1.45
Labor	3.50
TOTAL	$17.90
Yield (bushels)	30

Sources: Selected U. S. Crop Budgets: Yields, Inputs, and Variable Costs, Vol. III, Great Plains Region, ERS 459, United States Department of Agriculture; Wallace G. Aanderud, Merlyn M. Dahl and John N. Maher, "Ten Steps for Planning Your Farm or Ranch Business," Extension Circular 632 (rev), Cooperative Extension Service, United States Department of Agriculture (South Dakota State University); Wallace G. Aanderud, Farm Management Extension Economist, SDSU.

Appendix C, Table XII: Estimated Costs Per Acre for Soybeans, 1972.

Item	Cost
Machine Operation	$ 4.20
Fixed Machine	6.00
Seed	3.93
Fertilizer	2.30
Pesticide	2.25
Crop Insurance	2.20
Labor	6.00
TOTAL	$26.88
Yield (bushels)	20

Sources: Selected U. S. Crop Budgets: Yields, Inputs, and Variable Costs, Vol. III, Great Plains Region, ERS 459, United States Department of Agriculture; Wallace G. Aanderud, Merlyn M. Dahl and John N. Maher, "Ten Steps for Planning Your Farm or Ranch Business," Extension Circular 632 (rev), Cooperative Extension Service, United States Department of Agriculture (South Dakota State University); Wallace G. Aanderud, Farm Management Extension Economist, SDSU.

Appendix C, Table XIII: Estimated Costs Per Acre for Alfalfa Hay, 1972.

Item	Cost
Machine Operation	$ 4.89
Fixed Machine	4.00
Seed Cost	1.19
Fertilizer	0.83
Herbicide	0.25
Pesticide	0.20
Labor	8.00
TOTAL	$19.36
Yield (tons)	2.2

Sources: Selected U. S. Crop Budgets: Yields, Inputs, and Variable Costs, Vol. III, Great Plains Region, ERS 459, United States Department of Agriculture; Wallace G. Aanderud, Merlyn M. Dahl and John N. Maher, "Ten Steps for Planning Your Farm or Ranch Business," Extension Circular 632 (rev), Cooperative Extension Service, United States Department of Agriculture (South Dakota State University); Wallace G. Aanderud, Farm Management Extension Economist, SDSU.

Appendix C, Table XIV: Estimated Costs Per Acre for Wild Hay, 1972.

Item	Cost
Machine Operations	$1.50
Fixed Machine	3.50
Fertilizer	0.00
Herbicide	0.00
Insecticide	0.00
Labor	3.00
TOTAL	$8.00
Yield (ton)	1.0

Sources: Selected U. S. Crop Budgets: Yields, Inputs, and Variable Costs, Vol. III, Great Plains Region, ERS 459, United States Department of Agriculture; Wallace G. Aanderud, Merlyn M. Dahl and John N. Maher, "Ten Steps for Planning Your Farm or Ranch Business," Extension Circular 632 (rev), Cooperative Extension Service, United States Department of Agriculture (South Dakota State University); Wallace G. Aanderud, Farm Management Extension Economist, SDSU.

Appendix C, Table XV: Estimated Costs Per Acre for Cropland Pasture, 1972.

Item	Cost
Machine Operations	$0.25
Fixed Machine	0.40
Annual Seed Charge	0.40
Annual Fence Charge	0.30
Annual Water Charge	0.10
Fertilizer	1.50
Herbicide	0.00
Insecticide	0.00
Labor	0.20
TOTAL	$3.15
Yield (AUM)	3.75

Sources: Selected U. S. Crop Budgets: Yields, Inputs, and Variable Costs, Vol. III, Great Plains Region, ERS 459, United States Department of Agriculture; Wallace G. Aanderud, Merlyn M. Dahl and John N. Maher, "Ten Steps for Planning Your Farm or Ranch Business," Extension Circular 632 (rev), Cooperative Extension Service, United States Department of Agriculture (South Dakota State University); Wallace G. Aanderud, Farm Management Extension Economist, SDSU.

Appendix C, Table XVI: Estimated Costs Per Acre for Native Pasture, 1972.

Item	Cost
Machine Operations	$0.10
Fixed Machine	0.10
Annual Fence Charge	0.30
Annual Water Charge	0.05
Herbicide	0.00
Insecticide	0.00
Labor	0.20
TOTAL	$0.75
Yield (AUM)	2.25

Sources: Selected U. S. Crop Budgets: Yields, Inputs, and Variable Costs, Vol. III, Great Plains Region, ERS 459, United States Department of Agriculture; Wallace G. Aanderud, Merlyn M. Dahl and John N. Maher, "Ten Steps for Planning Your Farm or Ranch Business," Extension Circular 632 (rev), Cooperative Extension Service, United States Department of Agriculture (South Dakota State University); Wallace G. Aanderud, Farm Management Extension Economist, SDSU.

APPENDIX D

Appendix D, Table I: Beef Cow Unit, 16% Replacements Raised, 92% Calf Crop, Feeder Calf Sold in October, Replacements First Calve at 2 Years, One Bull Per 25 Cows.

I.	Receipts	
	Steer Calf (0.46 x 4.5 cwt x $34.44)	$ 71.29
	Heifer Calf (0.26 x 4.1 cwt x $30.44)	32.45
	Cull Cow (0.15 x 11.0 cwt x $16.94)	27.95
	Cull Heifer (0.04 x 6.0 cwt x $26.44)	6.35
		$138.04
II.	Operating Expenses	
	Hay Equivalent (2.469 tons x $18.83)	$46.50
	Pasture (5.554 AUM x $4.50)	24.99
	Supplement (0.01 cwt x $4.60)	0.05
	Mineral and Salt (35 pounds x $0.03)	1.05
	Breeding Charge	5.00
	Veterinary and Drugs	3.00
	Equipment Repairs (4% x $5.60)	0.22
	Building Repairs (3.5% x $9.20)	0.32
	Transportation and Cost of Marketing	2.75
		$83.88
III.	Income Over Direct Costs (I minus II)	$54.16
IV.	Depreciation	
	Equipment (10% x $11.20)	$1.12
	Buildings (3% x $18.40)	0.55
		$1.67
V.	Return to Labor and Management (III minus IV)	$52.49
IV.	Labor Cost (7.5 hours x $2.00)	$15.00
VII.	Return to Management disregarding Capital Costs and Taxes (V minus VI)	$37.49

Sources: Darwin K. Johnson, An Economic Analysis of Selected Beef Enterprise Systems for Southeast South Dakota (unpublished Master's thesis, South Dakota State University, 1973), p. 167; Wallace G. Aanderud, Myron T. Barber and Merlyn M. Dahl, Guidebook for Planning a Farm or Ranch Business, Extension Circular 633 (rev), Cooperative Extension Service, United States Department of Agriculture (South Dakota State University), pp. 18-19, 24-27.

Appendix D, Table II: Beef Cow Unit, 16% Replacements Purchased, 92% Calf Crop, Feeder Calf Sold in October, One Bull Per 25 Cows.

I.	Receipts	
	Steer Calf (0.46 x 4.5 cwt x $34.44)	$ 71.29
	Heifer Calf (0.46 x 4.1 cwt x $30.44)	57.41
	Cull Cow (0.15 x 11.0 cwt x $16.94)	27.95
		$156.65
II.	Operating Expenses	
	Hay Equivalent (2.354 tons x $18.83)	$ 44.33
	Pasture (5.199 AUM x $4.50)	23.40
	Replacement (0.16 x $250.00)	40.00
	Mineral and Salt (25 pounds x $0.03)	0.75
	Breeding Charge	5.00
	Veterinary and Drugs	3.00
	Equipment Repairs (4% x $5.00)	0.20
	Building Repairs (3.5% x $8.00)	0.28
	Transportation and Cost of Marketing	3.00
		$119.96
III.	Income Over Direct Costs (I minus II)	$36.69
IV.	Depreciation	
	Equipment (10% x $10.00)	$1.00
	Buildings (3% x $16.00)	0.48
		$1.48
V.	Return to Labor and Management (III minus IV)	$35.21
IV.	Labor Cost (6.5 hours x $2.00)	$13.00
VII.	Return to Management disregarding Capital Costs and Taxes (V minus VI)	$22.21

Sources: Darwin K. Johnson, An Economic Analysis of Selected Beef Enterprise Systems for Southeast South Dakota (unpublished Master's thesis, South Dakota State University, 1973), p. 167; Wallace G. Aanderud, Myron T. Barber and Merlyn M. Dahl, Guidebook for Planning a Farm or Ranch Business, Extension Circular 633 (rev), Cooperative Extension Service, United States Department of Agriculture (South Dakota State University), pp. 18-19, 24-27.

Appendix D, Table III: Raise Yearling Steer Feeders, October to April, 200 Pound Weight Gain.

I.	Receipts	
	Yearling Steer Feeder (6.5 cwt x $30.44)	$197.86
	Minus Death Loss (1.5% x $197.86)	-2.99
		$194.87
II.	Operating Expenses	
	Steer Calf (4.5 cwt x $34.44)	$154.98
	Corn Equivalent (8.435 bushels x $1.08)	9.11
	Hay Equivalent (0.7812 tons x $18.83)	14.71
	Pasture (1.2 AUM x $4.50)	5.40
	Mineral and Salt (10 pounds x $0.03)	0.30
	Veterinary and Drugs	1.00
	Equipment Repairs (4% x $4.00)	0.16
	Building Repairs (3.5% x $7.00)	0.25
	Transportation and Cost of Marketing	4.36
		$190.27
III.	Income Over Direct Costs (I minus II)	$4.60
IV.	Depreciation	
	Equipment (10% x $8.00)	$0.80
	Buildings (3% x $14.00)	0.42
		$1.22
V.	Return to Labor and Management (III minus IV)	$3.38
IV.	Labor Cost (4 hours x $2.00)	$8.00
VII.	Return to Management disregarding Capital Costs and Taxes (V minus VI)	-$4.62

Source: Darwin K. Johnson, An Economic Analysis of Selected Beef Enterprise Systems for Southeast South Dakota (unpublished Master's thesis, South Dakota State University, 1973), p. 172.

Appendix D, Table IV: Raise Yearling Heifer Feeders, October to April, 190 Pound Weight Gain.

I. Receipts	
Yearling Heifer Feeder (6.0 cwt x $27.44)	$164.64
Minus Death Loss (1.5% x $158.64)	-2.47
	$162.17
II. Operating Expenses	
Heifer Calf (4.1 cwt x $30.44)	$124.80
Corn Equivalent (8.435 bushels x $1.08)	9.11
Hay Equivalent (0.7812 tons x $18.83)	14.71
Pasture (1.2 AUM x $4.50)	5.40
Mineral and Salt (10 pounds x $0.03)	0.30
Veterinary and Drugs	1.00
Equipment Repairs (4% x $4.00)	0.16
Building Repairs (3.5% x $7.00)	0.25
Transportation and Cost of Marketing	4.00
	$159.73
III. Income Over Direct Costs (I minus II)	$2.44
IV. Depreciation	
Equipment (10% x $8.00)	$0.80
Buildings (3% x $14.00)	0.42
	$1.12
V. Return to Labor and Management (III minus IV)	$1.32
IV. Labor Cost (4 hours x $2.00)	$8.00
VII. Return to Management disregarding Capital Costs and Taxes (V minus VI)	-$6.68

Source: Darwin K. Johnson, An Economic Analysis of Selected Beef Enterprise Systems for Southeast South Dakota (unpublished Master's thesis, South Dakota State University, 1973), p. 171.

Appendix D, Table V: Feed Steer Calves, 650 Pound Weight Gain in 10 Months.

I. Receipts	
Fed Steer (11.0 cwt x $27.94)	$307.34
Minus Death Loss (2% x $307.34)	-6.15
	$301.19
II. Operating Expenses	
Steer Calf (4.5 cwt x $34.44)	$154.98
Corn Equivalent (57.06 bushels x $1.08)	61.62
Corn Silage (2.925 tons x $8.00)	23.40
Hay Equivalent (0.504 tons x $18.83)	9.49
Supplement (0.3 cwt x $4.60)	1.38
Mineral and Salt (30 pounds x $0.03)	0.90
Veterinary and Drugs	2.00
Equipment Repairs (4% x $20.00)	0.80
Building Repairs (3.5% x $35.00)	1.23
Transportation and Cost of Marketing	6.11
	$261.91
III. Income Over Direct Costs (I minus II)	$39.28
IV. Depreciation	
Equipment (10% x $40.00)	$4.00
Buildings (3% x $70.00)	2.10
	$6.10
V. Return to Labor and Management (III minus IV)	$33.18
VI. Labor Cost (5 hours x $2.00)	$10.00
VII. Return to Management disregarding Capital Costs and Taxes (V minus VI)	$23.18

Source: Darwin K. Johnson, An Economic Analysis of Selected Beef Enterprise Systems for Southeast South Dakota (unpublished Master's thesis, South Dakota State University, 1973), p. 174.

Appendix D, Table VI: Feed Heifer Calves, 540 Pound Weight Gain in 10 Months.

I.	Receipts	
	Fed Heifer (9.50 cwt x $25.94)	$246.43
	Minus Death Loss (2% x $246.43	-4.93
		$241.50
II.	Operating Expenses	
	Heifer Calf (4.1 cwt x $30.44)	$124.80
	Corn Equivalent (45.6 bushels x $1.08)	49.25
	Corn Silage (2.925 tons x $8.00)	23.40
	Hay Equivalent (0.504 tons x $18.83)	9.49
	Supplement (0.30 cwt x $4.60)	1.38
	Mineral and Salt (25 pounds x $3.00)	0.75
	Veterinary and Drugs	2.00
	Equipment Repairs ($% x $20.00)	0.80
	Building Repairs (3.5% x $35.00)	1.23
	Transportation and Cost of Marketing	5.36
		$218.46
III.	Income Over Direct Costs (I minus II)	$23.04
IV.	Depreciation	
	Equipment (10% x $40.00)	$4.00
	Buildings (3% x $70.00)	2.10
		$6.10
V.	Return to Labor and Management (III minus IV)	$16.94
IV.	Labor Cost (5 hours x $2.00	$10.00
VII.	Return to Management disregarding Capital Costs and Taxes (V minus VI)	$6.94

Source: Darwin K. Johnson, An Economic Analysis of Selected Beef Enterprise Systems for Southeast South Dakota (unpublished Master's thesis, South Dakota State University, 1973), p. 173.

Appendix D, Table VII: Feed Yearling Steers, 550 Pound Weight Gain in 7 Months.

I.	Receipts	
	Fed Yearling Steers (12.00 cwt x $26.94)	$323.28
	Minus Death Loss (1.0% x $323.28)	-3.23
		$320.05
II.	Operating Expenses	
	Yearling Steer (6.5 cwt x $30.44)	$197.86
	Corn Equivalent (59.71 bushels x $1.08)	64.49
	Corn Silage (1.2 tons x $8.00)	9.60
	Hay Equivalent (0.2745 tons x $18.83)	5.17
	Supplement (1.4 cwt x $4.60)	6.44
	Mineral and Salt (22 pounds x $0.03)	0.66
	Veterinary and Drugs	1.00
	Equipment Repairs (3.0% x $20.00)	0.60
	Building Repairs (2.5% x $35.00)	0.88
	Transportation and Cost of Marketing	7.35
		$294.05
III.	Income Over Direct Costs (I minus II)	$26.00
IV.	Depreciation	
	Equipment (5.6% x $40.00)	$2.24
	Buildings (1.7% x $70.00)	1.19
		$3.43
V.	Return to Labor and Management (III minus IV)	$22.57
VI.	Labor Cost 4.5 hours x $2.00)	$9.00
VII.	Return to Management disregarding Capital Costs and Taxes (V minus VI)	$13.57

Source: Darwin K. Johnson, An Economic Analysis of Selected Beef Enterprise Systems for Southeast South Dakota (unpublished Master's thesis, South Dakota State University, 1973), p. 178.

Appendix D, Table VIII: Feed Yearling Heifers, 450 Pound Weight Gain in 7 Months.

I.	Receipts	
	Fed Yearling Heifer (10.5 cwt x $24.94)	$261.87
	Minus Death Loss (1% x $261.87)	-2.62
		$259.25
II.	Operating Expenses	
	Yearling Heifer (6.00 cwt x $27.44)	$164.64
	Corn Equivalent (47.53 bushels x $1.08)	51.33
	Corn Silage (1.65 tons x $8.00)	13.20
	Hay Equivalent (0.305 tons x $18.83)	5.74
	Supplement (0.5 cwt x $4.60)	2.30
	Mineral and Salt (17 pounds x $0.03)	0.51
	Veterinary and Drugs	1.00
	Equipment Repairs (3% x $20.00)	0.60
	Building Repairs (2.5% x $35.00)	0.88
	Transportation and Cost of Marketing	6.56
		$246.76
III.	Income Over Direct Costs (I minus II)	$12.49
IV.	Depreciation	
	Equipment (5.6% x $40.00)	$2.24
	Buildings (1.7% x $70.00)	1.19
		$3.43
V.	Return to Labor and Management (III minus IV)	$9.06
VI.	Labor Cost (4.5 hours x $2.00)	$9.00
VII.	Return to Management disregarding Capital Costs and Taxes (V minus VI)	$0.06

Source: Darwin K. Johnson, An Economic Analysis of Selected Beef Enterprise Systems for Southeast South Dakota (unpublished Master's thesis, South Dakota State University, 1973), p. 177.

Appendix D, Table IX: Sow Unit Producing Feeder Pigs, 14.5 Pigs Weaned Per Year, March and September Farrowing, One Saved for Replacement from March Litter, Sell 40 Pound Feeder Pigs, One Boar Per 25 Sows.

I.	Receipts	
	Feeder Pigs (13.5 head x $39.08 x 0.4 cwt)	$211.03
	Sow (4.5 cwt x $16.50)	74.25
	Minus Sow Death Loss (2% x $74.25)	-1.49
		$283.79
II.	Operating Expenses	
	Corn Equivalent (70 bushels x $1.08)	$75.60
	Creep Ration (425 pounds x $0.04)	17.00
	Hay Equivalent (0.336 tons x $18.83)	6.33
	Pasture (0.5 AUM x $4.50)	2.25
	Supplement (4.0 cwt x $4.75)	19.00
	Mineral and Salt (50 pounds x $0.03)	1.50
	Breeding Charge	4.00
	Veterinary and Drugs	18.00
	Equipment Repairs (4% x $32.00)	1.28
	Building Repairs (3.5% x $75.00)	2.62
	Transportation and Cost of Marketing	4.00
		$151.58
III.	Income Over Direct Costs (I minus II)	$132.21
IV.	Depreciation	
	Equipment (10% x $64.00)	$ 6.40
	Buildings (3% x $150.00)	4.50
		$10.90
V.	Return to Labor and Management (III minus IV)	$121.31
V.	Labor Cost (16 hours x $2.00)	$32.00
VII.	Return to Management disregarding Capital Costs and Taxes (V minus VI)	$89.31

Source: Wallace G. Aanderud, Myron T. Barber and Merlyn M. Dahl, Guidebook for Planning a Farm or Ranch Business, Extension Circular 633 (rev), Cooperative Extension Service, United States Department of Agriculture (South Dakota State University), pp. 94-95.

Appendix D, Table X: Feeder Pigs, Half Finished for August-September Market, Half for February-March Market, Spring Pigs on Pasture, Fall in Drylot, 40 Pounds to 225 Pounds.

I.	Receipts	
	Butcher Hogs (2.25 cwt x $19.54)	$43.96
	Minus Death Loss (1.5% x $43.96)	-0.66
		$43.30
II.	Operating Expenses	
	Feeder Pigs (0.4 cwt x $39.08)	$15.63
	Corn Equivalent (10.25 bushels x $1.08)	11.07
	Pasture (0.1 AUM x $4.50)	0.45
	Hay Equivalent (0.0112 tons x $18.83)	0.21
	Supplement (0.875 cwt x $4.75)	4.16
	Mineral and Salt (7.5 pounds x $0.03)	0.23
	Veterinary and Drugs	1.00
	Equipment Repairs (4% x $3.00)	0.12
	Building Repairs (3.5% x $6.00)	0.21
	Transportation and Cost of Marketing	1.40
		$34.48
III.	Income Over Direct Costs (I minus II)	$8.82
IV.	Depreciation	
	Equipment (10% x $0.00)	$0.60
	Buildings (3% x $12.00)	0.36
		$0.96
V.	Return to Labor and Management (III minus IV)	$7.86
VI.	Labor Cost (0.4 hours x $2.00)	$0.80
VII.	Return to Management disregarding Capital Costs and Taxes (V minus VI)	$7.06

Source: Wallace G. Aanderud, Myron T. Barber and Merlyn M. Dahl, Guidebook for Planning a Farm or Ranch Business, Extension Circular 633 (rev), Cooperative Extension Service, United States Department of Agriculture (South Dakota State University), pp. 96-99.

Appendix D, Table XI: Ewe Unit, Sell 120% Lamb Crop, Half August Feeders, Half May-June Feeders, 20% Replacement Ewes Raised, 2% Ewe Death Loss, One Ram Per 35 Ewes.

I.	Receipts	
	Feeder Lambs (0.7 cwt x 0.996 x $23.36)	$16.29
	Wool Incentive (0.7 cwt x 0.996 x $0.50)	0.35
	Cull Ewe (1.3 cwt x 0.18 x $5.86)	1.37
	Wool (11.8 pounds x $0.62)	7.32
		$25.33
II.	Operating Expenses	
	Corn Equivalent (1.08 bushels x $1.08)	$ 1.17
	Hay Equivalent (0.4414 tons x $18.83)	8.31
	Pasture (1.24 AUM x $4.50)	5.58
	Supplement (0.325 cwt x $4.60)	1.50
	Mineral and Salt (16.2 pounds x $0.03)	0.49
	Breeding Charge	0.60
	Veterinary and Drugs	0.68
	Shearing	0.60
	Equipment Repairs (4% x $2.90)	0.12
	Building Repairs (3.5% x $2.90)	0.10
	Transportation and Cost of Marketing	0.85
		$20.00
III.	Income Over Direct Costs (I minus II)	$5.33
IV.	Depreciation	
	Equipment (10% x $5.80)	$0.58
	Buildings (3% x $5.80)	0.17
		$0.75
V.	Return to Labor and Management (III minus IV)	$4.58
VI.	Labor Cost (2.9 hours x $2.00)	$5.80
VII.	Return to Management disregarding Capital Costs and Taxes (V minus VI)	-$1.22

Source: Wallace G. Aanderud, Myron T. Barber and Merlyn M. Dahl, Guidebook for Planning a Farm or Ranch Business, Extension Circular 633 (rev), Cooperative Extension Service, United States Department of Agriculture (South Dakota State University), pp. 78-79, 82-83, 86-87.

Appendix D, Table XII: Ewe Unit, Sell 120% Lamb Crop, Half August Feeders, Half May-June Feeders, 20% Replacement Ewes Purchased, 2% Ewe Death Loss, One Ram Per 35 Ewes.

I.	Receipts	
	Feeder Lambs (0.7 cwt x 1.w x $23.36)	$19.62
	Wool Incentive (0.7 cwt x 1.2 x $0.50)	0.42
	Cull Ewe (1.3 cwt x 0.18 x $5.86)	1.37
	Wool (10 pounds x $0.62)	6.20
		$27.61
II.	Operating Expenses	
	Corn Equivalent (1 bushel x $1.08)	$ 1.08
	Hay Equivalent (0.3624 x $18.83)	6.82
	Pasture (1.1 AUM x $4.50)	4.95
	Supplement (0.325 cwt x $4.60)	1.50
	Mineral and Salt (15 pounds x $0.03)	0.45
	Replacement Ewe Cost (0.2 x $24.36)	4.87
	Breeding Charge	0.60
	Veterinary and Drugs	0.60
	Shearing	0.50
	Equipment Repairs (4% x $2.50)	0.10
	Building Repairs (3.5% x $4.50)	0.09
	Transportation and Cost of Marketing	0.85
		$22.41
III.	Income Over Direct Costs (I minus II)	$5.20
IV.	Depreciation	
	Equipment (10% x $5.00)	$0.50
	Buildings (3% x $5.00)	0.15
		$0.65
V.	Return to Labor and Management (III minus IV)	$4.55
VI.	Labor Cost (2.4 hours x $2.00)	$4.80
VII.	Return to Management disregarding Capital Costs and Taxes (V minus VI)	-$0.25

Source: Wallace G. Aanderud, Myron T. Barber and Merlyn M. Dahl, Guidebook for Planning a Farm or Ranch Business, Extension Circular 633 (rev), Cooperative Extension Service, United States Department of Agriculture (South Dakota State University), pp. 78-79, 82-83.

Appendix D, Table XIII: Feeder Lambs, Drylot, 2 Month Feeding Period, 30 Pound Weight Gain Per Lamb.

I.	Receipts	
	Fat Lamb (1 cwt x $25.36)	$25.36
	Wool Incentive (.3 cwt gain x 0.50)	0.15
	Minus Death Loss (2.0% x $25.36)	-0.51
		$25.00
II.	Operating Expenses	
	Purchase Feeder (0.70 x $23.36)	$16.35
	Corn Equivalent (2.4 bushels x $1.08)	2.59
	Hay Equivalent (0.0722 tons x $18.83)	1.36
	Mineral and Salt (5 pounds x $0.03)	0.15
	Veterinary and Drugs	0.30
	Equipment Repairs (4% x $2.00)	0.08
	Building Repairs (3.5% x $4.00)	0.14
	Transportation and Costs of Marketing	0.94
		$21.91
III.	Income Over Direct Costs (I minus II)	$3.09
IV.	Depreciation	
	Equipment (10% x $4.00)	$0.40
	Buildings (3% x $8.00)	0.24
		$0.64
V.	Return to Labor and Management (III minus IV)	$2.45
VI.	Labor Cost (0.2 hours x $2.00)	$0.40
VII.	Return to Management disregarding Capital Costs and Taxes (V minus VI)	$2.05

Source: Wallace G. Aanderud, Myron T. Barber and Merlyn M. Dahl, Guidebook for Planning a Farm or Ranch Business, Extension Circular 633 (rev), Cooperative Extension Service, United States Department of Agriculture (South Dakota State University), pp. 88-89.