AN ECONOMIC ANALYSIS OF CHANGES IN IRRIGATION PRACTICES IN JEFFERSON COUNTY, IDAHO

A Thesis

Presented in Partial Fulfillment of the Requirement for the

DEGREE OF MASTER OF SCIENCE

Major in Agricultural Economics

in the

UNIVERSITY OF IDAHO GRADUATE SCHOOL

by

JOHN E. MILLINER

August 1974

AUTHORIZATION TO PROCEED WITH THE FINAL DRAFT

This thesis of John E. Milliner for the Master of Science degree with major in Agricultural Economics and titled "An Economic Analysis of Changes in Irrigation Practices in Jefferson County, Idaho" was reviewed in rough draft form by each Committee member as indicated by the signatures and dates given below and permission was granted to prepare the final copy incorporating suggestions of the Committee; permission was also given to schedule the final examination upon submission of two final copies to the Graduate School Office:

Major Professor ____________ Date Aug. 8 - 1974

Committee Members ____________ Date Aug 19 - 1974

____________ Date 9 Aug. 1974

REVIEW OF FINAL DRAFT

Department Head ____________ Date ____________

College Dean ____________ Date Aug 26, 1974

FINAL EXAMINATION: By majority vote of the candidate's Committee at the final examination held on date of ____________ Committee approval and acceptance was granted.

Major Professor ____________ Date ____________

GRADUATE COUNCIL FINAL APPROVAL AND ACCEPTANCE:

Graduate School Dean ____________ Date ____________

ACKNOWLEDGEMENTS

In preparing this study I wish to thank my committee members, Dr. Richard W. Schermerhorn and Dr. Russell V. Withers for their valuable assistance. In addition I wish to thank the graduate students in the Department of Agricultural Economics who, through an exchange of ideas, helped me to understand some difficult areas.

I wish to thank especially, Dr. Karl H. Lindeborg, my major professor, not only for his learned advice but also for his uncommon touch of class.

I dedicate this study and the future it brings to my wife, Katherine, to whom I owe everything.

TABLE OF CONTENTS

LIST OF FIGURES vi

LIST OF TABLES vii

ABSTRACT ix

CHAPTER I INTRODUCTION 1

Use of Water in Idaho 1

The Study Area 5

The Problem 8

Objectives 9

Procedure 9

Assumptions and Limitations 10

CHAPTER II METHODS OF ANALYSIS 12

Initial Investigation 12

Original Budget Formulation 13

Representative Budgets 14

Linear Programming 25

Parametric Analysis 28

Rotation Policy 28

Farm Organization 31

General Programming Model 32

CHAPTER III PRELIMINARY RESULTS 35

Optimal Resource Allocation 35

Enterprise Solution 41

Summary of Linear Programming Models 43

CHAPTER IV ADDITIONAL RESULTS 48
Results of a Water Decline 48
Net Return to Land and Management 50
Sprinkler Irrigation 57
Advantages and Disadvantages of Sprinkler Irrigation . . . 59
Variable and Fixed Costs for Sprinkler Irrigation 60
The Effect on Net Income 67
Final Results 68
CHAPTER V SUMMARY AND CONCLUSIONS 73
Summary 73
Conclusions and Policy Recommendations 75
BIBLIOGRAPHY 76
APPENDIX 1 79
APPENDIX 2 87
APPENDIX 3 89
APPENDIX 4 99

LIST OF FIGURES

Figure

1 Location of the Study Area 6

2 The Effect on a Feasible Area of a Parametric Alteration 29

3 Effect on Net Income of a Percentage Decrease in Water...Farm 1 Level 70

4 Effect on Net Income of a Percentage Decrease in Water...Farm 2 Level 71

5 Effect on Net Income of a Percentage Decrease in Water...Farm 3 Level 72

LIST OF TABLES

Table		
1	Irrigated Cropland Acreage Projections . . .	3
2	Consumptive and Farm Irrigation Requirements .	4
3	Individual Farm Budget for Alfalfa	14
4	Representative Farm Budget for Mixed Grain . .	16
5	Representative Farm Budget for Alfalfa . . .	17
6	Representative Farm Budget for Potatoes . .	18
7	Representative Farm Budget for Beef	22
8	Representative Farm Budget for Dairy . . .	23
9	Representative Farm Budget for Hogs	24
10	Linear Programming Model, Farm 2	25
11	Resources in Linear Programming Solution . . Farm 1	36
12	Resources in Linear Programming Solution . . Farm 2	37
13	Resources in Linear Programming Solution . . Farm 3	38
14	Range Over Which MVP is Relevent	39
15	Enterprises in Linear Programming Solution . Farm 1	.44
16	Enterprises in Linear Programming Solution . Farm 2	.45
17	Enterprises in Linear Programming Solution . Farm 3	.46
18	Total Return, Fixed Costs and Net Income . . 80 Acres	52
19	Total Return, Fixed Costs and Net Income . . 160 Acres	54

Table

20 Total Return, Fixed Costs and Net Income . . 56
320 Acres

21 Variable and Fixed Costs for Hand-Moved . . 61
Sprinkler System on 80 and 160 acres

22 Variable and Fixed Costs for Wheeled-Moved . .62
Sprinkler System on 80, 160 and 320 Acres

23 Variable and Fixed Costs for Center-Pivot. . 64
Sprinkler System on 160 and 320 Acres

24 Net Income After Incorporation of Sprinkler . 66
System at Each Representative Farm

ABSTRACT

This study analyzed the economic effects of solving a high water table problem in southeastern Idaho near the town of Rigby. The objectives were to analyze the present farm situation and then to determine the feasibility of solving the problem by decreasing water use at the farm level.

Two methods of decreasing on farm water use were discussed. One method involved the theoretical decrease of water availability without altérations to the present farm irrigation system. The second method involved the decrease of water by incorporating sprinkler systems to the area.

Primary and secondary information was collected and representative farm budgets of 80, 160, and 320 acres were developed. An optimum organization of farms was achieved with the aid of linear programming.

A parametric routine was then entered into the linear programming model and reduced the available water in 5 percent intervals. The effect of this reduction on income was substantial at both 25 and 50 percent reduction levels. The primary reason for this income loss was the fact that the reductions in water forced tillable land into unproductive status.

Budgets elaborating the variable and fixed costs required for a hand-moved, wheeled-moved and a center-pivot type sprinkler system were then developed. These costs were deducted from the linear programming solution and the effect on net income was analyzed.

The two methods were compared as to their effect on net income at each representative farm level. Sprinkler systems were shown to be more profitable than a water decline only at the 320 acre level.

CHAPTER I

INTRODUCTION

Use of Water in Idaho

The western United States has abundant natural resources, and of these resources water is one of the most important. This is especially true for Idaho which uses water to a great extent for the irrigation of agricultural lands. Idaho is dependent on agriculture as its primary industry and, therefore, must insure that water utilized for agriculture be used in such a way as to extract the most benefits from this valuable resource.

In accordance with this idea the Idaho Constitution, Article 15, Section 3 gives the right to divert water from natural streams only for beneficial uses.

This concept of beneficial use can be defined within the general criterion of economic use. It follows that water diverted for agriculture uses is commonly economic and, therefore, beneficial. In other words the growing of crops tends to benefit the society as a whole and, because water is a necessary ingredient, its diversion is beneficial. In the case of Idaho, water used for the purpose of irrigating arid lands has always been considered the most beneficial use.

To insure that water be used as economically as possible in this regard, Idaho Code 42-202 sets an upper limit of no more than 5 acre feet of water per acre of land. This is an ample amount considering most crops in Idaho require about 2 acre feet of water annually.[1]

---

[1]R. J. Sutter and G. L. Corey, Consumptive Irrigation Requirements for Crops in Idaho, Bulletin 516, (College of Agriculture, University of Idaho, Moscow, Idaho, 1970), p. 8.

In the future water will become more and more critical to the State of Idaho. The constant demand for more food will force additional acres into cultivation. The result will be increased use of water for irrigation.

Table 1 gives a general indication of this projected increase in irrigated crop land for the State of Idaho. Of particular interest is the Upper Snake 1 region which comprises the study area for this research. It can be seen that the projected increase of over 1,000,000 irrigated acres (from 1,034,000 in 1966 to 2,074,000 in 2070) will be a tremendous increase for the area. Referring to Table 2 the same area will require an additional 1,420,000 acre feet of water by the year 2070 for the purpose of irrigating the new crop land.[2]

This additional water requirement relates directly to the beneficial use aspect mentioned above. In other words farming areas must insure that water be used efficiently to allow for the anticipated increase in water use. For this to occur individual farms must try to incorporate into their organization the proper production techniques and application procedures that will utilize water at its highest efficiency.

There are many such areas in Idaho that are efficient and utilize water economically. For example Cheline (3) concluded that the farms in the Oakley Fan area were near optimum in the efficient use of inputs.

On the other hand there are some areas that tend to misallocate

---

[2]The National Efficiency Method A was used to approximate the Agricultural needs presented in Table 1 and 2. An alternate method B based on regional development was also contained in the reference. These tables should not be construed to reflect accurate figures for the years cited. They are presented only as a general forcast for the future.

TABLE 1

IRRIGATED CROPLAND ACREAGE PROJECTIONS
IN 1000 ACRES FOR EACH SUB-BASIN OF IDAHO BY YEARS

Sub-basin	1966	1980	2000	2020	2070
Bear River	145	148	155	172	218
Upper Snake 1	1,034	1,126	1,182	1,363	2,074
Upper Snake 2	968	1,026	1,057	1,182	1,756
Southwest Idaho	753	924	1,048	1,304	2,181
Salmon	129	129	131	131	158
Clearwater	3	4	6	7	30
Panhandle	21	25	34	46	153
State Total	3,053	3,382	3,613	4,205	6,570

Source: Idaho Water Resource Board, Agricultural Water Needs, Consumptive Irrigation Requirements, Planning Report Number Five, (Department of Agricultural Engineering, University of Idaho, Moscow, Idaho, 1971), p. 32.

TABLE 2

CONSUMPTIVE AND FARM IRRIGATION REQUIREMENTS
FOR IDAHO IN 1000 ACRE FEET BY YEARS

Sub-basin	1966	1980	2000	2020	2070
Bear River	174	179	189	215	273
Upper Snake 1	1,380	1,493	1,576	1,840	2,800
Upper Snake 2	1,506	1,567	1,640	1,822	2,722
Southwest Idaho	1,333	1,616	1,858	2,350	3,925
Salmon	161	161	165	166	198
Clearwater	4	5	8	9	39
Panhandle	28	33	45	61	203
State Total	4,586	5,054	5,481	6,463	10,160

Source: Idaho Water Resource Board, Agricultural Water Needs, Consumptive Irrigation Requirements, Planning Report Number Five, (Department of Agricultural Engineering, University of Idaho, Moscow, Idaho, 1971), p. 34.

water within their farming operations and, therefore, are not near optimum in the beneficial use of water. One area in southeastern Idaho near the upper reaches of the Snake river appears to fall in this latter category. The area is commonly referred to as the Snake River Fan Country and has been chosen as the study area for the economic analysis contained herein.

The Study Area

The study area is located in southeastern Idaho near the town of Rigby and comprises about 100,000 acres. It is bounded on the north, west and east by a large bend in the Snake river and on the south by the Jefferson-Bonneville county line. See Figure 1.

The topography is extremely variable owing to the fact that a major part of the area was once a river bottom. Several areas have ten to twenty feet of top soil whereas other areas have only a few inches. The soil type is basically a clay loam though many outcroppings of gravelly soil are readily seen in the area. On the whole the soil is quite porous and retains water poorly.

The basic crops consist of alfalfa and mixed grain with the balance generally in irrigated pasture. Potatoes and sugar beets have declined in recent years and now only comprise a limited number of acres. A recent study by Brockway (2) indicated that of the total acreage alfalfa comprised about 38.8 percent, mixed grain 31.1 percent, potatoes 8.1 percent and sugar beets one percent. Other crops and irrigated pasture made up the remaining 21 percent.

The irrigation of the area is totally dependent on a canal system

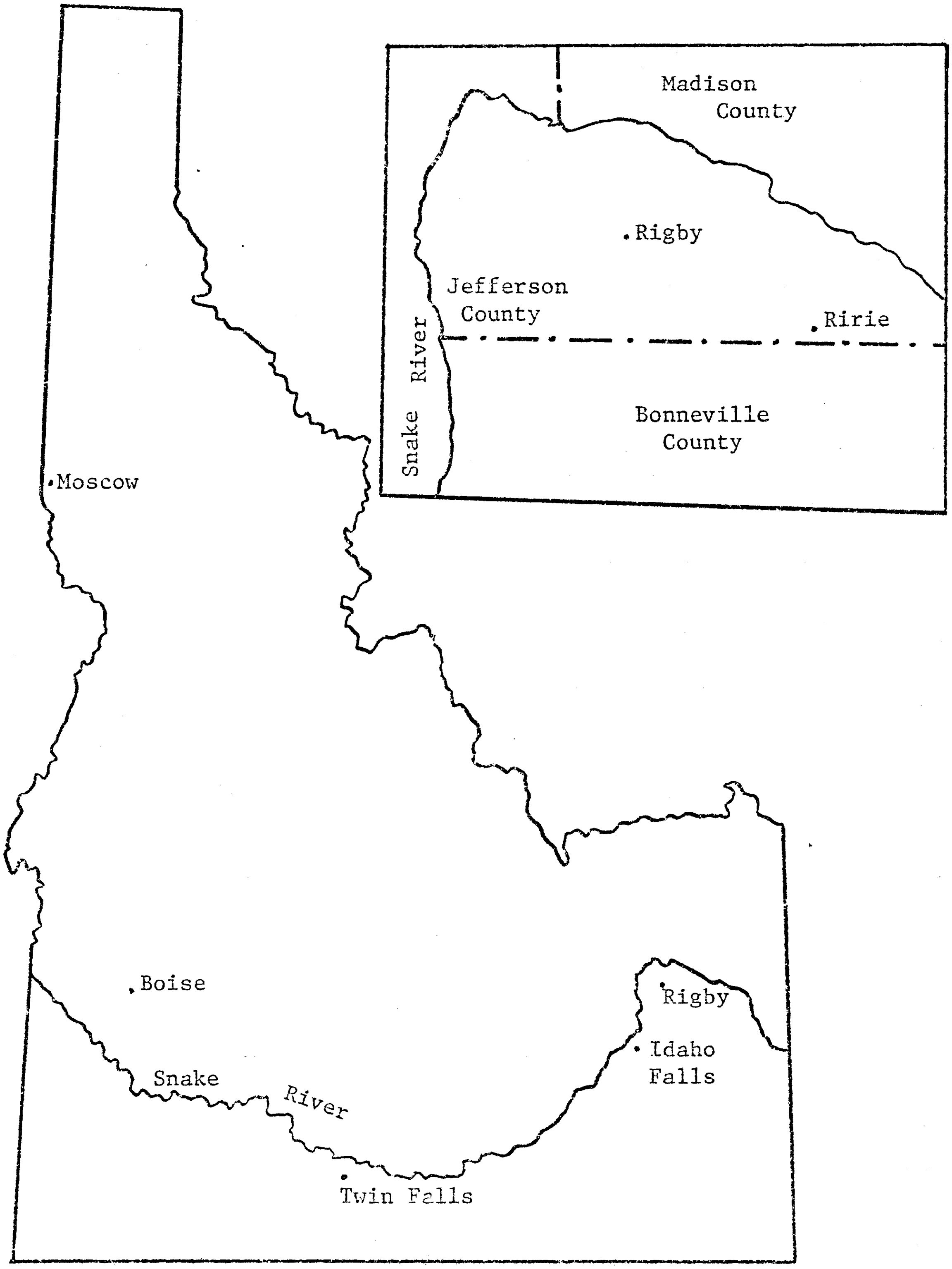

Figure 1. Location of the study area.

that delivers water from the Snake river.[3] The system itself was begun in the late 1890's and has been periodically updated and improved over the years. There appears to be no systematic or planned expansion of the canal network and consequently the area is myriad with canals and ditches. The management of the water and the maintenance of the canals appear to be as varied as the canals themselves.

Border irrigation is the primary method of water application and is used on about 90 percent of the fields. Furrow and some sprinkler irrigation comprise the remaining 10 percent.

The delivery of water throughout the area is accomplished by several canal companies diverting water from the Snake river into the canal system mentioned above. For this service the individual farmer pays an average of $1.55 per acre to the canal company that is responsible for his water.

The efficiency with respect to water use at the farm level is very low. Galinato (6) concluded that even though furrow irrigation efficiency was about 50 percent, border irrigation averaged only 24 percent with some efficiencies as low as 10 percent.[4] Both Brockway and Galinato further concluded that long irrigation runs and the high intake soils were the basic reasons for this low efficiency at the farm level.

---

[3]For a more complete description and history of the canal system see: Gary W. Gneiting, An Economic History and Analysis of the Great Feeder Canal of Southwest Idaho, (Master's Thesis, Utah State University, Logan, Utah, 1972).

[4]Irrigation efficiency is that percentage of irrigation water delivered to the farm headgate that is available for consumptive use by the plants.

The Problem

When considering the topography and the soil type, the canal system used and the general farming practices that will be further explained in the body of this study, the area presents a problem that is exhausting the economic capabilities of the area. Simply, the problem is that too much water is being diverted from the Snake river. The large volume of water diverted is needed to compensate for the low efficiencies at the farm level. In addition the canals themselves have a high seepage factor and much of the water is lost before it even gets to the farm. All together, so much water is being diverted to account for the seepage and the low efficiencies that serious drainage difficulties have developed. The subwater has risen extensively and is interferring with cultivation and the general habitation of the area.

In order to determine the actual cause of the subwater problem the Agricultural Research Service in conjunction with the Water Resources Research Institute conducted a study in the project area. (2) It was apparent in the report that the high water table itself stemmed from both canal seepage and excessive water application to crop land. The conclusion indicated that a 20 percent or greater reduction in net irrigation diversion could alleviate the problem. Specifically this reduction could be achieved by consolidating certain canals, lining specific reaches of some canals or by decreasing on farm water use.

Any rehabilitation of the area to bring about this net reduction in irrigation diversion might require a large change in the water delivery system and application techniques. But the economic ability of the area to foster improvements of any kind is virtually unknown at the present time. Therefore, a valid economic problem arises:

Is it possible for the present farm organization in the area to financially support major changes in the present irrigation system?

Objectives

The objectives of this study are as follows:

1. To determine the basic economic situation in the area at the present time with respect to farm organization, cropping patterns and income.

2. To determine the effect on the present situation of a decline in the water that is presently available at the farm level.

3. To determine the feasibility of introducing a new water application method to the area.

Procedure

The initial procedure in attempting to achieve the first objective is to develop budgets for the enterprise activities in the area. By grouping these budgets into farm sizes and averaging figures, representative or "typical" farm budgets will be developed. Linear programming in conjunction with a parametric programming routine will be used to analyze these representative budgets. An optimal farm organization of 80, 160 and 320 acres will be developed. Cropping patterns will be established and income at each farm level will be determined with the use of the MPS/360 computer program.

With respect to the second objective the parametric routine will decrease water availability in 5 percent intervals and will analyze the effect on income and organization at each interval. In this way actual cost figures and crop reorganizations can be viewed as predicted effects in the area if the water available to the farmer was decreased.

In the event that these effects are substantial, a new water application system would be advisable for the area and objective three would be achieved. Sprinkler irrigation was chosen as a common and efficient method that could be used more in the area. Initial investment and variable cost budgets will be developed for a hand-moved and wheeled-moved system on the 80 and 160 acre representative farms. Budgets for a wheeled-moved and a center-pivot system will be developed for the 320 acre representative farm. These budgets will be incorporated into each linear programming solution after fixed costs have been deducted. A complete analyses of the overall effect of this additional cost will be made and a policy recommendation will be presented.

Assumptions and Limitations

A major assumption for this study was that most farmers in the study area were attempting to maximize profits. However, there is a possibility that many farmers are in the area for other reasons. For example, some farmers interviewed were only part-time farmers and others were in the area simply to retire. If this is a general trend, then the profit maximizing concept could be somewhat limiting.

Further limitations occur by the very nature of grouping farms and taking averages in order to obtain a cross section of the population. In addition, the representative budgets used in this study typify a general farming practice, which may not be found on any given farm in the area.

Other assumptions and limitations will be outlined as they occur in the study.

CHAPTER II

METHOD OF ANALYSIS

Initial Investigation and Data Gathering

In order to obtain first hand knowledge of the study area a total of 51 farmers were interviewed during the summers of 1972 and 1973. Information pertaining to soil type, cropping patterns, irrigation methods and amounts, labor, livestock, fertilizers and chemicals, crop yields, equipment and general operating procedures was obtained. The information elicited in this way constituted the major source of primary information.

Two limitations were evident concerning the information obtained from the farmers. First, the sample of 51 was small in relation to the total number of farmers in the area. It was, however, considered adequate for a cross sectional analysis of the area. Secondly, the sample was not taken in a purely random fashion. Only farmers on file with the Soil Conservation Service were interviewed and only the above average managers were included in the sample.

Other primary information was obtained through county agents, soil conservation personnel, fertilizer companies and sprinkler irrigation dealers.

Some of the information necessary for budget formulation were obtained through secondary sources. This information was gathered from various sources such as: Idaho Agricultural Statistics, 1973 (20); Agricultural Prices, Annual Summary 1972 (17) and Selected U.S. Crop Budgets, Northwest Region (21). These sources provided cost data on crops that are generally found in the study area.

Original Budget Formulation

The information obtained from primary and secondary sources was used to formulate budgets. Each of the farmers interviewed was numbered and each of his enterprises was budgeted separately. For example, Farm 1 had 142 acres of irrigated crop land. Of this, 90 acres were in alfalfa and 52 acres in mixed grain. A budget was formulated for each crop on a per acre basis using as much primary information as possible and supplementing where necessary with secondary data. In the case of most farms, the actual costs of seed, fertilizer, insecticide, weed spray, labor and yields were obtained from the questionnaire, whereas, the cost of machinery, harvesting and hauling was obtained through secondary sources. An example of an original budget for an alfalfa enterprise is presented in Table 3.

A total of 38 separate budgets of grain were formulated, 43 of alfalfa, 11 of potatoes and 2 of sugar beets for an overall total of 93 separate enterprise budgets.

Representative Budgets

In order to utilize the information contained in the original budgets, a representative budget system was adopted. In this way a representative enterprise was used to represent a whole group of similar enterprises.

To categorize the enterprises into representative budgets, the farms were listed in order of size. The first category of farms, 15 in all, had a total acreage ranging from 30 to 100 with a mean of 73.3 acres. From this it was decided that a representative farm would be

TABLE 3

INDIVIDUAL FARM BUDGET FOR AN ALFALFA ENTERPRISE
IN RIGBY, IDAHO 1973

Item	Unit	Quantity	Unit Price	Value or Cost
Production				
Alfalfa (90 acres)	ton	6	$28.80	$172.80
Inputs (Variable costs)				
Seed	lbs	10/3	.65	$ 2.17
Fertilizer				11.26
1) Nitrogen 11%	lbs applied	200	.56	
2) Phosphate 48%	lbs applied	200	.56	
Insecticide				4.00
Haul-stack				19.80
Machinery				6.60
Harvest				18.00
Labor	hrs	5.5	2.00	11.00
Farm (misc.)				6.00
	Total Variable Costs			$78.83
Inputs (Fixed costs)				
Irrigation costs				$ 1.67
Building depreciation				2.50
Land and building taxes				4.84
Insurance				1.25
	Total Fixed Costs			$10.26
	Total Cost			$89.09
	Net Income or Net Return to Management and Interest on Land			$83.71

about 80 acres.

A second group was developed for farms ranging from 101 - 204 acres. Twenty three farms were in this category and the mean average was 156.0 acres. A representative farm for this category was 160 acres.

The last category contained 13 farms and ranged from 240 to 500 acres. The mean acreage for these farms was 395.4 and a representative farm was chosen to be 320 acres.

The distribution of the sample could easily be projected to the entire study area. Approximately 30 percent of the study area is comprised of farms about 80 acres, 45 percent about 160 acres and 25 percent about 320 acres.

Once these representative farms were established, each major enterprise, mixed grain, alfalfa, potatoes and sugar beets, was budgeted within the farm sizes of 80, 160 and 320 acres. Table 4 gives an example of a completed representative budget for a mixed grain enterprise on 80 acres. The costs and amounts in this budget are commensurate with the average or representative costs and amounts associated with the 15 farms within the 30 - 100 acre category. Other examples of representative budgets are contained in Tables 5 and 6. These budgets were compiled to reflect the present farming situation in the area. Further budgets are presented in Appendix 3.

The costs within each representative budget reflect only the per acre variable costs of production. In this way the programming model, that will be explained in the next section, maximizes net returns to fixed cost and management.

Of these variable costs, seed was included and reflected an

TABLE 4

REPRESENTATIVE FARM BUDGET FOR A MIXED GRAIN ENTERPRISE ON 80 ACRES IN RIGBY, IDAHO 1973

Gross revenue per acre		
73 bushels @ $1.81 per bushel		$132.13
Variable input costs per acre		
Seed	$ 4.15	
Fertilizer	9.69	
Weed spray	2.06	
Haul	.73	
Machinery	10.40	
Harvest	9.00	
Labor (irrigation, 2.7 hr @ $2.00/hr)	5.40	
Labor (all other, 4.5 hr @ $2.00/hr)	9.00	
Farm misc.	6.00	
Interest on working capital (8%, 6 mo.)	2.25	
Total variable costs	$58.68	
Return to fixed factors and management		$ 73.45

TABLE 5

REPRESENTATIVE FARM BUDGET FOR AN ALFALFA ENTERPRISE ON 160 ACRES IN RIGBY, IDAHO 1973

Gross revenue per acre		
4.8 tons @ $28.80 per ton		$138.24
Variable input costs per acre		
Seed	$ 2.17	
Fertilizer	9.87	
Insecticide	2.02	
Haul-stack	19.80	
Machinery	6.60	
Harvest	18.00	
Labor (irrigation, 2.9 hr @ $2.00/hr)	5.80	
Labor (all other, 5.5 hr @ $2.00/hr)	11.00	
Farm misc.	6.00	
Interest on working capital (8%, 6 mo)	3.25	
Total variable costs	$84.51	
Return to fixed factors and management		$ 53.73

TABLE 6

REPRESENTATIVE FARM BUDGET FOR A POTATO ENTERPRISE ON 320 ACRES IN RIGBY, IDAHO 1973

Gross revenue per acre		
225 cwt @ $2.47 per cwt		$555.75
Variable input costs per acre		
Seed	$ 52.50	
Fertilizer	18.97	
Insecticide and weed spray	7.50	
Land prep. and other pre harvest cost	36.00	
Machinery	38.04	
Harvest	54.12	
Haul (@ $.12/cwt)	27.00	
Labor (irrigation, 6.0 hr @ $2.00/hr)	12.00	
Labor (all other, 10.6 hr @ $2.00/hr)	21.20	
Farm misc.	6.00	
Interest on working capital (8%, 6 mo)	10.93	
Total variable costs	$284.26	
Return to fixed factors and management		$271.49

average amount used for the various crops of grain, potatoes and sugar beets. A typical alfalfa stand in the area averaged 3 to 4 years so the cost of alfalfa seed was spread over 3 years.

The use of fertilizer varied extensively throughout the area. For each original farm enterprise budget the amount of fertilizer (lbs. available) and the type (e.g. 0-48-0, 16-20-0) were obtained from the questionnaire. Prices were taken from secondary sources and were averaged over a three year period (1970 - 1972). The approximate cost of fertilizer was obtained for each crop and these costs were then averaged for each category to obtain a representative price figure for fertilizer. It should be noted that several farmers in the area did not use fertilizer. Fertilizer is considered an element of a good farming operation and is more typically used than not used. Consequently, the average cost of fertilizer is an average of the users, not simply an average per farm.

Chemicals on the farm, like insecticide and weed spray, varied in use from farm to farm. An average cost for each category, excluding non-users, was used to reflect the price of these chemicals.

Machinery costs were obtained through secondary sources. These costs include repair, gas and oil, general maintenance and depreciation for the machinery used in all operations other than harvesting and hauling. The cost figures shown in the budgets do not account for economies of scale and are, therefore, constant for each crop. In other words the per acre machinery cost for 80 acres of grain is the same as the per acre machinery cost for 160 and 320 acres of grain.

Hauling costs represent repair, gas and oil, general maintenance and depreciation for the machinery used to haul grain, potatoes and sugar beets. The cost of hauling potatoes and sugar beets are constant costs, reflecting the same per acre costs for 80, 160 and 320 acres. The cost of hauling grain to storage was computed on a yield basis and a typical cost for the area was about 1 cent per bushel.

Haul-stack is a term used to indicate the per acre cost of hauling and stacking alfalfa. The cost includes repair, gas and oil, general maintenance and depreciation of the machinery used in this operation. Per acre costs are the same for the 80, 160 and 320 acre farms.

Harvest costs include the repair, gas and oil, general maintenance, and depreciation expenses on the machinery used to harvest each crop. These costs were obtained from secondary sources and are expressed in constant cost terms as explained above.

Labor costs were divided into two categories, labor hours for irrigation and labor hours for all other operations. Primary data were used to obtain an average number of hours needed for irrigation and secondary data were used to obtain information on the hours needed for all other operations. In each case the cost of an hour of labor was set at $2.00.

Total variable costs of each budget constituted working capital. An interest rate of 8% for 6 months was applied to this working capital.

Primary data on the yield of each crop came from the original 51 farms. These yields were averaged to obtain a typical yield for price enterprise for each representative farm. A five year average price (1969 - 1973) for each crop was used to reflect a current base price.

Some type of livestock operation was present on nearly every farm. Representative budgets were developed for the three most common types of livestock: cattle, dairy cows and hogs. The information utilized in forming these budgets was obtained almost exclusively from secondary data. Previous livestock studies and consultations with animal industry personnel at the University of Idaho formed the basis of these budgets.

The most typical cattle feeding operation in the study area was a finishing type operation where the animals were purchased at about 650 lbs., fed for 200 days and then sold. The representative budget contained in Table 7 relates the variable costs and feed requirements per animal for this type of operation. All items in the non-feed variable costs are adjusted from other studies to reflect 1973 costs. The feed requirement for one animal for 200 days was computed to be 64 bushels of grain and .3 tons of alfalfa. Refer to Appendix 4, Table 1 for further explanation of the feed requirement.

The dairy operation entailed the selling of milk, cull cows and calves. The milk production of 9760 pounds per cow is a five year average (1969 - 1973) for Idaho consisting of an average of 3.63 percent milk fat. The cull cows and replacement heifers were assumed to be 25 percent of the herd to allow for the entire herd replacement in 4 years. All non-feed variable costs were adjusted from previous studies to reflect 1973 costs. The feed requirement for one cow for one year consisted of 120 bushels of grain and 5.35 tons of alfalfa. For a complete analysis of the feed requirements refer to Appendix 4, Table 1.

The hog operation is budgeted in terms of one unit, one unit consisting of one sow and two litters. An average of 7.1 pigs were weaned per litter with 1.0 pigs retained for replacement and a .2 pig death loss factor for a total of 13 pigs and one sow. The variable costs and feed

TABLE 7

REPRESENTATIVE FARM BUDGET FOR A BEEF OPERATION[1]
IN RIGBY, IDAHO 1973

Gross revenue per head		
500 lb increase @ $34.26 per cwt[2]		$171.30
Non feed variable costs per head		
Insurance	$ .72	
Taxes on cattle	1.25	
Veterinary expense	1.12	
Insecticide	.26	
Labor (15 hr @ $2.00/hr)	30.00	
Death loss	1.80	
Interest on cattle investment (8%, 6 mo)	8.90	
Total variable cost[3]	$44.05	
Return to fixed factors and management		$127.25

[1]Information adjusted from: Economics of Scale in Farm Cattle Feedlots of Kansas - An Analysis of Nonfeed Costs, Bulletin #145, (Kansas State University, Manhattan, Kansas, 1966).

[2]Price quoted is averaged (1969-1973)

[3]The price of feed is an imputed value estimated from the linear programming model. Actual feed requirement consists of 64 bushels of grain and 0.3 tons of alfalfa per head.

TABLE 8

REPRESENTATIVE FARM BUDGET FOR A DAIRY OPERATION[1]
IN RIGBY, IDAHO 1973

Gross revenue per cow		
9760 pounds of milk @ \$5.77/cwt[2]		\$563.15
Cull cows @ 25% of herd (1400 lbs @ \$22.60/cwt)[2]		79.10
Calves (95% @ \$34.26/cwt)[2]		32.55
Non feed variable costs per cow		
Replacement heifers (25% @ \$378.00/head)	\$ 94.50	
Property taxes	12.00	
Repairs and equipment	15.00	
Electricity	10.00	
Fuel	8.00	
Bedding	6.50	
Breeding fees	8.20	
D.H.I.A.	6.00	
Veterinary and drugs	6.00	
Dairy supplies	4.00	
Labor (72 hrs @ \$2.00/hr)	144.00	
Misc.	10.00	
Interest on working capital (8%, 6 mo)	12.96	
Total variable costs[3]	\$337.16	
Return to fixed factors and management		\$337.64

[1]Information adjusted from: Estimated Costs and Returns for a 100 Cow Drylot Dairy Enterprise in the Columbia Basin of Washington, 1970, E. M. 3417, (Washington State University, Pullman, Washington, 1970).

[2]Price quoted is averaged (1969-1970)

[3]The price of feed is an imputed value estimated from the linear programming model. Actual feed requirement consists of 120 bushels of grain and 5.35 tons of alfalfa per cow.

TABLE 9

REPRESENTATIVE FARM BUDGET FOR A HOG ENTERPRISE[1]
IN RIGBY, IDAHO 1973

Gross revenue per animal unit[2]		
13 hogs (230 lbs ea. @ $25.08/cwt)[3]		$749.89
1 sow (400 lbs @ $22.00/cwt)		88.00
Non feed variable costs per unit		
Repairs	$ 5.33	
Insurance	6.47	
Veterinary service and vaccine	18.00	
Breeding charges	7.20	
Labor (50 hrs @ $2.00/hr)	100.00	
Bedding	7.44	
Marketing	8.88	
Hauling	12.20	
Taxes	2.40	
Misc.	6.00	
Interest on working capital (8%, 6 mo)	11.04	
Sub total	$184.96	
Feed supplement costs per unit		
Protein supplement	$ 64.80	
32% protein, vit. D. medicated additive	36.00	
Salt and minerals	1.27	
Sub total	$102.07	
Total variable costs[4]	$287.03	
Return to fixed factors and management		$550.86

[1]Information adjusted from: Oluwole Famure, The Income Contributions of Agriculture to Idaho's Economy and the Economic Interrelationships in Agriculture: An Input-Output Model, (Master's Thesis, University of Idaho, Moscow, Idaho, 1974).

[2]An animal unit consists of 1 sow and 13 hogs

[3]Price quoted is averaged (1969-1973)

[4]The price of feed is an imputed value estimated from the linear programming model. Actual feed requirement consists of 200 bushels of grain and 1 ton of alfalfa per unit.

requirements contained in Table 9 are on this per unit basis. Pigs are sold after about 100 days of feeding and constitute the major source of income for this operation. The variable costs are adjusted from previous studies to reflect 1973 costs. Feed requirements of 200 bushels of grain and 1 ton alfalfa are further explained in Appendix 4, Table 1.

Linear Programming

The method employed to analyze the various relationships within this study is Linear Programming. Linear programming is defined in the User's Manual for the MPS/360 applications (22) as follows:

> "Linear programming is a mathematical technique designed to analyze the potentialities of alternate business activities and to choose those that permit the best use of resources in the pursuit of a desirable objective. . . . In addition it has the capability to analyse capital, raw materials, manpower, plant and storage facilities. . . to allocate, assign, schedule, select or evaluate possibilities. . . to blend, mix, distribute, control, order, budget, bid, cut, trim, price, purchase, plan and to deduce the most profitable method of transportation."

This study will not utilize all of these capabilities. Primarily, the MPS system will be used to allocate among various enterprise activities, the most profitable distribution of resources. Information contained in the representative budgets will be used to form a system of equations. These equations can be solved by an algorithm that is basic to the linear programming model.

The equations are usually stated in the form:

$$\text{Maximize } Z = C'X \text{ subject to}$$

$$AX \underset{>}{\leqq} B,\ X > 0 \quad \text{where}$$

C' is a transposed column vector of prices used to weigh each x activity.

X is a vector of activities.

A is a matrix of technical coefficients relating the per unit amount of each resource or restriction necessary for each x activity.

B is a vector of available resources or other restriction.

In concise form the whole system can be rewritten as:

Maximize $Z = c_j x_j$ subject to

$a_{ij} x_j \leq b_i$

$x_j > 0$

The computer utilizes a modified simplex procedure in systematically analyzing the entire set of linear equations. By forming a unit basis of n columns and m rows, a starting point is achieved and the simplex method then begins interchanging columns in a finite number of steps or iterations. Each iteration is at least as profitable or more profitable than the previous one. The end result of this method is an optimum plan which maximizes the objective function subject to the various restraints or restrictions.

There are obviously a great many advantages to linear programming. Primarily, it has the capability to solve a system of equations with many unknowns. A modern computer facility can easily handle a program with literally thousands of unknowns.

There are limitations, however. First of all it is only a tool and only as accurate as the information supplied. In addition there are several assumptions associated with linear programming: Additivity and

Linearity, Divisibility, Finiteness and Single-value Expectations.

Additivity and linearity refer to the fact that the total product must equal the sum of the individual products. This assumption is limiting in that there is difficulty providing for economies and diseconomies of size. When assuming that each additional unit of output will require an equal amount of input, then there is no provision for the generally held belief that the per unit cost of 100 acres is less than the per unit cost of 50 acres.

Divisibility refers to the fact that amounts can be expressed in fractional units, e.g., 4.2 dairy cows or 1.7 hired men. This assumption is not limiting for larger acreages or larger operations where rounding off from 100.7 cows to 101 is not a problem. For smaller operations the rounding principle can be serious if the additional cow significantly effects the operation.

Finiteness is an assumption that limits or restricts the possible activities to some definite number.

Single-value expectations require that resource restrictions be known with certainty. Often times it is difficult to know exactly how much of any one thing will be available in the future and, therefore, a margin of error is advisable. But because of the single-value expectation assumption a margin of error is not allowed and supply estimates must be free from standard error.

A final limitation is that computer facilities are often a necessary part of the calculations.

Parametric Analysis

In addition to the linear programming analysis, a parametric routine will be entered into the program. Parametric programming is a post optimal program that determines the effects of variations in the supply of resources or in the objective function. For the purpose of this study parametric programming will be used to determine the effect on the optimal program when alterations occur in the supply of resources.

Figure 2 shows the effect graphically in a simple situation where land, labor and water are three resource restrictions in the production of Product X and Product Y. In the first situation, line 1, 1, the feasible area is a b c 0. When the water supply is decreased as in line 2, 2, then it effects the original feasible area and changes it to a d e c 0. The more the water supply is decreased the more of a restrictive element it becomes as evidenced by line 3, 3, where water is the only restrictive resource.

Rotation Policy

Basic to setting up the programming model was the assumption that most farmers in the study area conformed to some type of rotation policy. These rotation policies were set to include grain and alfalfa in rotation 1; grain, alfalfa and potatoes in rotation 2; grain, alfalfa and sugar beets in rotation 3. These rotations were chosen because almost all farms surveyed had acreage in grain and alfalfa. Rotations 2 and 3 were included to provide for an additional cash crop in potatoes or sugar beets.

These rotations were further partitioned within the 80 acre representative farm to reflect the area as closely as possible. Rotation 1

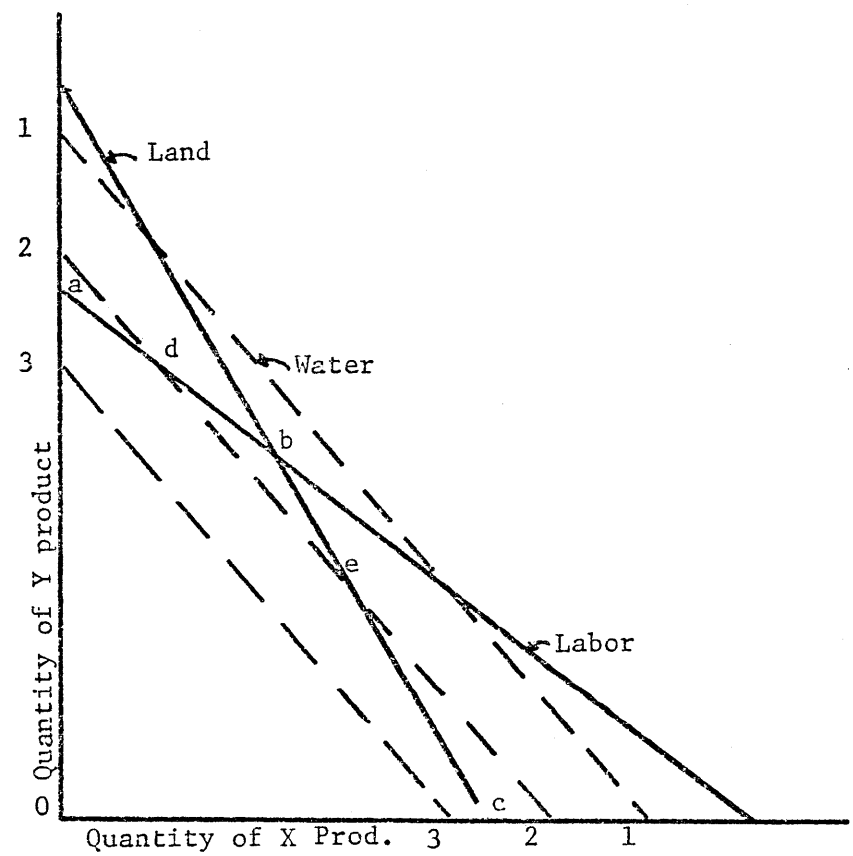

Figure 2. The effect on a feasible area of a parametric alteration.

included 50 percent grain and 50 percent alfalfa. Rotation 2 included 40 percent grain, 40 percent alfalfa and 20 percent potatoes. Rotation 3 included 40 percent grain, 40 percent alfalfa and 20 percent sugar beets.

The rotations for the 320 acre representative farm were partitioned as follows: Rotation 1 included 50 percent grain and 50 percent alfalfa; Rotation 2 included 33 percent grain, 33 percent alfalfa and 33 percent potatoes; Rotation 3 included 33 percent grain, 33 percent alfalfa and 33 percent sugar beets.

The 160 acre farm was set up differently. The crops for this representative farm were entered individually as follows: 100 percent grain, 100 percent alfalfa, 100 percent potatoes and 100 percent sugar beets. The lower limit for alfalfa was set at 20 acres and potatoes were set to enter at any amount less than 50 acres.

By developing the three representative farms in this way a general representation of the farming methods was achieved. The 80 acre farms were limited in their ability to have much flexibility in their cropping patterns, therefore, a strict rotation policy was chosen. The 320 acre farms have a great deal of flexibility. However, it is the general practice in the area to divide these larger farms into equal parts for the purpose of growing two or three crops. Consequently, a rotation policy reflecting this idea was chosen. The 160 acre farm was different in that the farmers could produce crops with respect to either the 80 acre rotation policy or the 320 acre rotation policy. It was decided to allow the crops "freedom to enter" into the program provided alfalfa was greater than 20 acres and potatoes were less than 50 acres.

In all models there is a minimum requirement for alfalfa. Most all farmers in the study area had some acreage in alfalfa for soil building purposes. A maximum acreage for cash crops was included to reflect the fact that few farmers in the area would risk their entire acreage solely in potatoes or sugar beets.

Farm Organization

No one model can accurately reflect the entire situation within the study area. Therefore, several different resource allocations schemes were chosen for each farm size.

Farm 1 (80 acres)[5] was changed to reflect four different farm Organizations. Situation 1 provides only for the growing and selling of crops, with no livestock operation. Situation 2 provides for a beef and hog operation in addition to the crops. Cattle are bounded by a minimum of 25 and a maximum of 75 head. Hog units must be between 25 and 50 animal units. Situation 3 includes a beef and dairy operation with cattle between 25 and 75 head and dairy cows between 5 and 20 head. Situation 4 includes only a beef operation in addition to crops. Cattle are bounded by a minimum of 50 and a maximum of 100 head. The bounding figures for each situation were chosen with regard to area averages and capabilities of an 80 acre farm.

Farm 2 (160 acres) was changed to reflect four different situations that are similar to the 80 acre farm. Situation 1 provides only for the

[5]For the remainder of the study the 80 acre representative farm will be referred to as Farm 1, the 160 acre farm as Farm 2 and the 320 acre farm as Farm 3.

production of crops with no livestock operation. Situation 2 includes a beef and hog operation where the cattle are bounded between 100 and 150 head. The hogs are bounded between 25 and 50 animal units. Situation 3 includes a beef and dairy operation with cattle bounds at a minimum of 100 and a maximum of 150. Dairy cows must be between 5 and 50 cows. Situation 4 includes only a beef operation in addition to crop production. In this case only a minimum of 100 head was applied. It was decided that when profitable, a 160 acre farm could handle a large number of cattle. The bounds chosen for these situations reflect the area averages and capabilities of a 160 acre farm.

Farm 3 (320 acres) was changed to reflect only two different situations. Situation 1 provided only for the production of crops with no livestock operation. Situation 2 provided for a beef operation in addition to crop production. A minimum of 150 head was included. On the larger farms very little evidence of livestock other than cattle was found. Consequently, only a beef operation was included as a possible livestock operation.

General Programming Model

A programming model was developed for each situation within each farm size. Table 10 presents an example of the program used for Farm 2 (160 acres) Situation 2. There are four crop activities: grain, alfalfa, potatoes and sugar beets. Of the three livestock activities associated with grain selling, alfalfa selling, potato selling, sugar beet selling, grain buying and alfalfa buying. These activities provide an option for the farmer to either grow crops to sell, grow crops to for feed or when necessary to buy feed.

The restraints or row restrictions include Land; Labor which is divided into three sections: April-May, June-July and August-September; Irrigation and Crop Transfers. For further explanation of the labor coefficients used in the programs see Appendix 1. Irrigation requirements are further explained in Appendix 2.

As explained above potatoes and alfalfa were set at a maximum of 50 acres and minimum of 20 acres respectively. Bounds for cattle and hogs were also included. The bounds for this example indicate that cattle must be between 100 and 150 heads and hogs must be between 25 and 50 animal units.

For each program a parametric routine was included. As explained earlier, parametric analysis is a tool that enables the researcher to alter certain equations at certain set intervals. The program will optimize at each interval and, therefore, alterations in the program can be observed as a result of a change in price or a change in supply. The primary purpose of parametric programming for this study will be in relation to objective 2, which is concerned with the effect of water decline.

The supply of water for each farm size was set to decrease at 5 percent intervals to a maximum of 75 percent decrease. The effect of this parametric routine will alter the original optimization in some way as water becomes less available.

The entire program is set to maximize returns to the fixed factors of production and management.

TABLE 10

LINEAR PROGRAMMING MODEL, FARM 2, SITUATION 2.

Row Identification	Grain	Alfalfa	Potatoes	Sugarbeets	Cattle	Dairy	Hog	Grain Sell	Alfalfa Sell	Potato Sell	Bet Sell	Grain Buy	Alfalfa Buy	Resource Supply	Change Column
Land	1.0	1.0	1.0	1.0										≤ 160 acres	
Apr-May labor	.97	1.26	2.60	2.32	2.50	12.0	8.4							≤ 925 hours	
Jun-Jul labor	2.01	2.60	5.38	4.80	2.50	12.0	8.4							≤ 925 hours	
Aug-Sep labor	1.62	2.10	4.33	3.87	2.50	12.0	8.4							≤ 925 hours	
Irrigation	56.99	64.66	59.66	61.99										≤ 10000 acre inches	-1.0
Grain transfer	-85.00				64.00	120.0	200.0	1.0				-1.0		= 0	
Alfalfa transfer		-4.80			.3	5.4	1.0		1.0				-1.0	= 0	
Potato transfer			-220.00							1.0				= 0	
Sugarbeet transfer				-18.00							1.0			= 0	
Alfalfa bound		1.0												≥ 20 acres alfalfa	
Potato bound			1.0											≤ 50 acres potatoes	
Hog1 bound							1.0							≤ 50 hogs	
Hog2 bound							1.0							≥ 25 hogs	
Cattle1 bound					1.0									≤ 150 cattle	
Cattle2 bound					1.0									≥ 100 cattle	
Dairy bound						1.0								= 0	
Obj. Function	-58.17	-85.51	-292.07	-210.57	127.25	337.64	550.86	1.81	28.80	2.47	15.18	-1.81	-28.80		

CHAPTER III

PRELIMINARY RESULTS

Optimal Resource Allocation

Linear programming was used in this study to allocate the available resources in the most productive way. By chosing the most profitable activities and distributing the scarce resources, the programming model maximized the return attainable for each situation at each farm level.

Table 11 indicates the amount of resources used for each optimum farm organization with respect to each situation at the Farm 1 (80 acre) level. In situation 1 (no livestock), situation 3 (including a beef and dairy operation) and in situation 4 (including a beef operation), land is the only limiting factor. Situation 2 (including a beef and hog operation) indicates that both land and June-July labor are used to maximum amounts.

In each situation where a resource is used at the limit, the Marginal Value Product (MVP) is given. The MVP indicates the amount the program would change if that particular resource was increased or decreased by one unit. For example, if the amount of land in situation 3 was decreased by one acre, the total income of the program would decrease by $86.91. The range over which these MVP's are relevant is explained in Table 14.

Tables 12 and 13 contain the amount of resources used for each situation at the Farm 2 (160 acre) and Farm 3 (320 acre) levels. Land is limiting in all situations and June-July labor is limiting when a livestock operation is included.

TABLE 11

RESOURCES INCLUDED IN LINEAR PROGRAMMING SOLUTION
FARM 1 (80 ACRES)

Resource	Amount used	Resource	Amount used
Situation 1		Situation 2	
Land	80 acres*($86.91)**	Land	80 acres*($83.48)**
Irrigation	4835 acre inches	Irrigation	4835 acre inches
Labor		Labor	
Apr-May	120 hours	Apr-May	622 hours
Jun-Jul	247 hours	Jun-Jul	750 hours*($1.11)**
Aug-Sep	200 hours	Aug-Sep	702 hours
Situation 3		Situation 4	
Land	80 acres*($86.91)**	Land	80 acres*($86.91)**
Irrigation	4835 acre inches	Irrigation	4835 acre inches
Labor		Labor	
Apr-May	367 hours	Apr-May	370 hours
Jun-Jul	495 hours	Jun-Jul	497 hours
Aug-Sep	447 hours	Aug-Sep	450 hours

*denotes a restraint at the limit level
**denotes the Marginal Value Product for each limiting resource.

TABLE 12

RESOURCES INCLUDED IN LINEAR PROGRAMMING SOLUTION
FARM 2 (160 ACRES)

Resource	Amount used	Resource	Amount used
Situation 1		Situation 2	
Land	160 acres*($95.68)**	Land	160 acres*($2.84)**
Irrigation	9405 acre inches	Irrigation	9376 acre inches
Labor		Labor	
Apr-May	242 hours	Apr-May	648 hours
Jun-Jul	501 hours	Jun-Jul	925 hours*($46.19)**
Aug-Sep	404 hours	Aug-Sep	834 hours
Situation 3		Situation 4	
Land	160 acres*($93.45)**	Land	160 acres*($93.45)**
Irrigation	9405 acre inches	Irrigation	9405 acre inches
Labor		Labor	
Apr-May	665 hours	Apr-May	665 hours
Jun-Jul	925 hours*($1.11)**	Jun-Jul	925 hours*($1.11)**
Aug-Sep	827 hours	Aug-Sep	827 hours

*denotes a restraint at the limit level.
**denotes the Marginal Value Product for each limiting resource.

TABLE 13

RESOURCES INCLUDED IN LINEAR PROGRAMMING SOLUTION
FARM 3 (320 ACRES)

Resource	Amount used	Resource	Amount used
Situation 1		Situation 2	
Land	320 acres*($144.82)**	Land	320 acres*($141.68)**
Irrigation	19,400 acre inches	Irrigation	19,400 acre inches
Labor		Labor	
Apr-May	438 hours	Apr-May	905 hours
Jun-Jul	907 hours	Jun-Jul	1375 hours*($1.11)**
Aug-Sep	730 hours	Aug-Sep	1197 hours

*denotes a restraint at the limit level.
**denotes the Marginal Value Product for each limiting resource.

TABLE 14

RANGE OVER WHICH MVP IS RELEVENT FOR EACH REPRESENTATIVE FARM

Limiting Resource	MVP	Range
Farm 1 (80 acres)		
Situation 1		
Land	$86.91	0 - 82.7 acres
Situation 2		
Land	$83.48	46.0 - 82.7 acres
Jun-Jul labor	$ 1.11	730.2 - 797.7 hours
Situation 3		
Land	$86.91	28.6 - 82.7 acres
Situation 4		
Land	$86.91	17.4 - 82.7 acres
Farm 2 (160 acres)		
Situation 1		
Land	$95.68	70.0 - 170.4 acres
Situation 2		
Land	$ 2.84	141.6 - 171.3 acres
Jun-Jul labor	$46.19	813.2 - 961.9 acres
Situation 3		
Land	$93.45	154.1 - 170.4 acres
Jun-Jul labor	$ 1.11	837.3 - 936.9 hours
Situation 4		
Land	$93.45	70.0 - 170.4 acres
Jun-Jul labor	$ 1.11	800.7 -1022.6 hours

TABLE 14
(continued)

RANGE OVER WHICH MVP IS RELEVENT
FOR EACH REPRESENTATIVE FARM

Limiting Resource	MVP	Range
Farm 3 (320 acres)		
Situation 1		
Land	$144.82	0 - 330.9 acres
Situation 2		
Land	$141.68	82.2 - 330.9 acres
Jun-Jul labor	$ 1.11	1278.6 - 1552.1 hours

Enterprise Solution

The activities that enter the optimal solution are commensurate with the highest income attainable. This means that no other combination of activities can produce a higher income with the given resource restrictions. Consequently, the activity allocations shown in the following tables are the most profitable for the study area given the available resources and farming practices at the present time.

Table 15 presents the enterprise solution for each situation at the Farm 1 (80 acre) level. It is evident that Rotation 2 (grain, alfalfa and potatoes) is the most profitable cropping pattern.

In situation 1 (no livestock) the three crops of Rotation 2 are sold resulting in a return of $6,953.00. The major determinent of this income is the selling of potatoes.

In situation 2 (including a beef and a hog operation) the grain produced and bought is fed to the livestock which includes 33 head of cattle and a maximum of 50 hog units. The hog units contribute over half the total return of $15,047.00.

In situation 3 (including a beef and a dairy operation) cattle entered the solution at the maximum allowed and dairy cows entered at the minimum of 5 cows. Total return is $6,992.00 of which potato selling contributes nearly half.

Situation 4 (including a beef operation) indicates that cattle enter the solution at the maximum allowed. Potatoes contribute significantly to the total income of $7,230.00.

Rotation 3 (grain, alfalfa and sugar beets) did not enter the solution for two reasons. First, the cost of producing grain, alfalfa and sugar beets was high in relation to its income producing potential. Secondly, the selling price of sugar beets was too low. The program range analysis indicated that, if the selling price of sugar beets increased from $15.18 per ton to $24.50, Rotation 3 would be as profitable as Rotation 2.

Table 16 presents the enterprise solution at the Farm 2 (160 acres) level. Grain, alfalfa and potatoes are produced in each situation indicating that these are the most profitable activities under the resource restrictions.

In situation 1 (no livestock) potatoes contribute significantly to the overall income of $22,252.00. A sugar beet activity would have entered the solution had its production costs decreased by $33.01 or its selling price increased by $1.83 per ton.

In situation 2 (including a beef and hog operation) the livestock operations both entered at the minimum level allowed. Acreage in grain increased from situation 1 and acreage in potatoes has decreased. Both hogs and potatoes are major sources of the total income of $24,826.00. Sugar beets would have entered the solution had its production costs decreased by $161.87 per acre or had its selling price increased by $8.99 per ton.

In situation 3 (including a beef and a dairy operation) and situation 4 (including a beef operation) total income of $22,486.00 and $22,721.00 are realized respectively. In both cases potatoes contributed nearly half the income. Dairy cows entered at a minimum of 5 cows and cattle entered at 145 head for situation3. Cattle entered at 169.2 in situation 4. Sugar beets would have entered in either situation had the production costs decreased by $36.10 per acre or had the selling price increased by $2.01 per ton.

Table 17 indicates the enterprise solution at the Farm 3 (320 acre) level. Rotation 2 (grain, alfalfa and potatoes) is the most profitable rotation at this level. In each situation potato selling is the primary determinent of income. An optimal cattle operation includes about 190 head at this level. Incomes for situation 1 (no livestock) and stiaution 2 (including a beef operation) are $46,343.00 and $46,861.00 respectively. In order for sugar beets to be as profitable as potatoes, the cost of raising sugar beets must decrease $205.00 per acre or the selling price must increase $11.39 per ton.

Summary of Linear Programming Models

The previous tables indicate several typical operations on three representative farms in the study area. There are several conclusions associated with each farm size. They are:

1. On the 80 acre representative farm a cash crop is necessary to provide a basic income. Livestock can contribute to increase income if desired. This increase is nominal with either a beef or a beef and dairy operation. With a beef and hog operation there is a significant increase in income. Implications are that hogs are the most profitable form of livestock, cattle next and dairy cows the least profitable.

Each farmer could increase profit by increasing the size of his farm. In addition, extra labor during the months of June and July would be advantageous.

Average returns to fixed costs and management for an 80 acre farm

TABLE 15

ENTERPRISES INCLUDED IN LINEAR PROGRAMMING SOLUTION
FARM 1 (80 ACRES)

Enterprise	Amount	Enterprise	Amount
Situation 1		Situation 2	
Rotation 2		Rotation 2	
Grain	32 acres	Grain	32 acres
Alfalfa	32 acres	Alfalfa	32 acres
Potatoes	16 acres	Potatoes	16 acres
Grain selling	2336 bushels	Alfalfa selling	77.7 tons
Alfalfa selling	137.6 tons	Potato selling	3200 cwt
Potato selling	3200 cwt	Grain buying	9770 bushels
Total return	$6,953	Cattle	32.9 head
		Hogs	50 units
		Total return	$15,047
Situation 3		Situation 4	
Rotation 2		Rotation 2	
Grain	32 acres	Grain	32 acres
Alfalfa	32 acres	Alfalfa	32 acres
Potaotes	16 acres	Potatoes	16 acres
Alfalfa selling	88.3 tons	Alfalfa selling	107.6 tons
Potato selling	3200 cwt	Potato selling	3200 cwt
Grain buying	3064 bushels	Grain buying	4064 bushels
Cattle	75 head	Cattle	100 head
Dairy cows	5 cows	Total return	$7,230
Total return	$6,992		

TABLE 16

ENTERPRISES INCLUDED IN LINEAR PROGRAMMING SOLUTION
FARM 2 (160 ACRES)

Enterprise	Amount	Enterprise	Amount
Situation 1		Situation 2	
Grain	90 acres	Grain	100.9 acres
Alfalfa	20 acres	Alfalfa	20 acres
Potatoes	50 acres	Potatoes	39.1 acres
Grain selling	7650 bushels	Alfalfa selling	41 tons
Alfalfa selling	96 tons	Potato selling	8591 cwt
Potato selling	11000 cwt	Grain buying	2819 bushels
Total return	$22,252	Cattle	100 head
		Hogs	25 units
		Total return	$24,827
Situation 3		Situation 4	
Grain	90 acres	Grain	90 acres
Alfalfa	20 acres	Alfalfa	20 acres
Potatoes	50 acres	Potatoes	50 acres
Alfalfa selling	25.6 tons	Alfalfa selling	45.2 tons
Potato selling	11000 cwt	Potato selling	11000 cwt
Grain buying	2245 bushels	Grain buying	3181 bushels
Cattle	145 head	Cattle	169.2 head
Dairy cows	5 cows	Total return	$22,721
Total return	$22,486		

TABLE 17

ENTERPRISES INCLUDED IN LINEAR PROGRAMMING SOLUTION
FARM 3 (320 ACRES)

Enterprise	Amount	Enterprise	Amount
Situation 1		Situation 2	
Rotation 2		Rotation 2	
Grain	107 acres	Grain	107 acres
Alfalfa	107 acres	Alfalfa	107 acres
Potatoes	107 acres	Potatoes	107 acres
Grain selling	9493 bushels	Alfalfa selling	477 tons
Alfalfa selling	533 tons	Potato selling	24000 cwt
Potato selling	24000 cwt	Cattle	186.9 head
Total return	$46,343	Grain buying	2869 bushels
		Total return	$46,861

are about $7,000 or $87.50 per acre. When a beef and hog operation is included, the income is about $15,000 or $187.50 per acre.

2. On the 160 acre representative farm a cash crop in potatoes is advisable and could provide half the attainable income.

Livestock provides no significant increase in income. A beef and hog operation increases income only 10 percent. When cattle are allowed to enter the program at any level above 100, as in situation 4, they enter at 169.2 indicating an optimum size cattle herd for the 160 acre farm.

An increase both in land and June-July labor would contribute to increased income.

Average returns to fixed factors and management for the 160 acre farm with or without livestock are about $23,100 or about $144.00 per acre.

3. On the 320 acre representative farm, potatoes are necessary for high income. Sugar beets could enter the solution if the selling price increased about 75 percent or if the production costs of Rotation 3 were reduced significantly.

A livestock operation in cattle contributes only about 1 percent to total returns. Both land and June-July labor are limiting and, therefore, additions to these could increase income.

Average returns to fixed factors and management for the 320 acre farm are about $46,600 or about $146.00 return per acre.

CHAPTER IV

ADDITIONAL RESULTS

Results of a Water Decline

As mentioned earlier, Brockway (2) completed a hydrologic study in the area in 1973 and concluded that a 20 percent or greater reduction in net diversion of irrigation water would solve the high water table problem. He went on to say that this reduction in net diversion could be achieved by:

1. System consolidation to reduce canal seepage.
2. Lining specific reaches of the canals, or
3. Decreasing on farm water use.

The remainder of this study will be primarily concerned with the economic aspects of the third alternative. Specifically, what economic effects on income and organization will result from a 20 percent or greater reduction in water application at the farm level? In addition, can the farmers in the area adapt to a significant decrease in water without major changes in their water application techniques?

To analyze the effect of a decrease in water availability, a parametric routine was used in conjunction with linear programming. The parametric routine decreased the available water at the farm level in 5 percent increments to a maximum decrease of 75 percent.

To analyze the effect at each 5 percent level would be cumbersome. Consequently, only two percentage figures were chosen to represent a decrease in water. The first, a 25 percent decline in water was chosen to represent the "20 percent or greater" reduction referred to in the Brockway study. The second, a 50 percent decline was chosen to represent a significant decrease in water availability.

The decline in water had a significant effect on each of the representative farms. The most significant effect was that relating to income.

For all situations in the 80 acre representative farm, a 25 percent decrease in available water for irrigation resulted in an average income loss of $19.31 per acre. A 50 percent decrease resulted in an income loss of over $40.00 per acre.

On the 160 acre representative farm the income loss at the 25 percent level was approximately $20.00 per acre and at the 50 percent level the loss was about $45.00 per acre. However, in Situation 2 (including a beef and hog operation), the income loss was less significant. Only $5.96 per acre loss was incurred at the 25 percent level and only $21.69 was lost per acre at the 50 percent level. This occurred because the hog operation increased in number as water available for crops was decreased. This increase in hog units effectively compensated for any major decrease in income.

This could not occur at the 80 acre farm level because hog units entered the optimum solution at the maximum allowed.

The 320 acre representative farm incurred a $32.50 income loss per acre at the 25 percent level and about $68.00 per acre was lost when water was decreased by 50 percent.

The primary cause of this income loss is a result of idle land. As water is decreased in the area, land is pulled out of cultivation. When water is decreased it is more profitable for a representative farm to have idle land than to change to any less water using rotation or cropping pattern.

At the 25 percent declination level, approximately 22 percent of the tillable land is left unproductive. At the 50 percent level almost half the available land is unproductive.

A solution of this type, taking large areas of land out of cultivation with the resultant decrease in income, is by no means a realistic solution to the problem of a high water table. It is only an indication that the area cannot adapt to a situation of decreased water without some change in water application techniques.

It is apparent that within a representative farm no amount of reorganization can be accomplished if the area continues to utilize water at a 30 percent irrigation efficiency rate. Therefore, only with a change in irrigation techniques to improve this efficiency can the area sustain full utilization of tillable land in a period of water decline.

Net Return to Land and Management

Prior to the examination of any alternative irrigation method, an analysis of the identifiable fixed costs is necessary. Fixed costs are those costs that do not vary with the level of production. These costs will be incurred even if the farm is not in operation.

In the linear programming solution the income for each representative farm was in terms of return to fixed cost and management. By deducting the fixed costs applicable in the study area, a net income or net return to management and land can be approximated. It is from this net income figure that the farmer must pay for any improvement in his irrigation system.

These fixed costs include: irrigation costs, building depreciation, land and building taxes and insurance.

The irrigation costs comprise the total bill paid out to the canal companies in the area. An average figure for most farmers surveyed was about $1.55 per acre.

Building depreciation is that applied to the standing operating structures on the farm, e.g., silos and barns. A $2.50 charge per acre was an average from secondary sources.

Land and building taxes was computed to be $4.84 per acre. Information from the Jefferson County Tax Assessor indicated that the assessed value per acre was approximately $66.50 and the local mill level for irrigated crop land was 72.8 mills.

Insurance was taken from secondary sources and totaled $1.25 per acre.

These per acre fixed costs were deducted from the total return that was obtained from the linear programming solution. The net income or net return to management and interest on land is presented in tables 18, 19 and 20.

The net income for each representative farm provides a basis from which the feasibility of funding rehabilitation can be concluded. In addition, the net income after incorporation of any new system, will provide an idea as to what representative farms are capable of rehabilitating.

TABLE 18

TOTAL RETURN, FIXED COSTS AND NET INCOME ON AN 80 ACRE REPRESENTATIVE FARM

Situation 1 (no livestock)		
Total return (from table 15)[1]		$6,953
Fixed costs		
irrigation cost @ $1.55	$124	
building depreciation @ $2.50	200	
land and building taxes @ $4.84	387	
insurance @ $1.25	100	
Total fixed costs	$811	
Net Income		$6,142
Situation 2 (including a beef and hog operation)		
Total return (from table 15)[1]		$15,047
Fixed costs		
irrigation cost @ $1.55	$124	
building depreciation @ $2.50	200	
land and building taxes @ $4.84	387	
insurance @ $1.25	100	
Total fixed costs	$811	
Net Income		$14,236

[1]Total return is equal to gross return less variable costs

TABLE 18
(continued)

TOTAL RETURN, FIXED COSTS AND NET INCOME
ON AN 80 ACRE REPRESENTATIVE FARM

Situation 3 (including a beef and dairy enterprise)		
Total return (from table 15)[1]		$6,992
Fixed costs		
irrigation costs @ $1.55	$124	
building depreciation @ $2.50	200	
land and building taxes @ $4.84	387	
insurance @ $1.25	100	
Total fixed costs	$811	
Net Income		$6,181
Situation 4 (including a beef operation)		
Total return (from table 15)[1]		$7,230
Fixed costs		
irrigation cost @ $1.55	$124	
building depreciation @ $2.50	200	
land and building taxes @ $4.84	387	
insurance @ $1.35	100	
Total fixed costs	$811	
Net Income		$6,419

[1] Total return is equal to gross return less variable costs.

TABLE 19

TOTAL RETURN, FIXED COST AND NET RETURN ON A 160 ACRE REPRESENTATIVE FARM

Situation 1 (no livestock)		
Total return (from table 16)[1]		$22,252
Fixed costs		
irrigation @ $1.55	$248	
building depreciation @ $2.50	400	
land and building taxes @ $4.84	774	
insurance @ $1.25	200	
Total fixed costs	$1,622	
Net Income		$20,630
Situation 2 (including a beef and hog enterprise)		
Total return (from table 16)[1]		$24,827
Fixed costs		
irrigation @ $1.55	$248	
building depreciation @ $2.50	400	
land and building taxes @ $4.84	774	
insurance @ $1.25	200	
Total fixed cost	$1,622	
Net Income		$23,205

[1]Total return is equal to gross return less variable costs.

TABLE 19
(continued)

TOTAL RETURN, FIXED COST AND NET INCOME
ON A 160 ACRE REPRESENTATIVE FARM

Situation 3 (including a beef and dairy enterprise)		
Total return (from table 15)[1]		$22,486
Fixed costs		
irrigation @ $1.55	$248	
building depreciation @ $2.50	400	
land and building taxes @ $4.84	774	
insurance @ $1.25	200	
Total fixed costs	$1,622	
Net Income		$20,864
Situation 4 (including a beef enterprise)		
Total return (from table 15)[1]		$22,721
Fixed costs		
irrigation @ $1.55	$248	
building depreciation @ $2.50	400	
land and building taxes @ $4.84	774	
insurance @ $1.25	200	
Total fixed costs	$1,622	
Net Income		$21,099

[1] Total return is equal to gross return less variable costs.

TABLE 20

TOTAL RETURN, FIXED COST AND NET INCOME ON A 320 ACRE REPRESENTATIVE FARM

Situation 1 (no livestock)			
Total return (from table 17)[1]			$46,343
Fixed costs			
irrigation cost @ $1.55		$ 496	
building depreciation @ $2.50		800	
land and building taxes @ $4.84		1549	
insurance @ $1.25		400	
	Total fixed cost	$3,245	
	Net Income		$43,098
Situation 2 (including a beef enterprise)			
Total return (from table 17)[1]			$46,861
Fixed costs			
irrigation cost @ $1.55		$ 496	
building depreciation @ $2.50		800	
land and building taxes @ $4.84		1549	
insurance @ $1.25		400	
	Total fixed cost	$3,245	
	Net Income		$43,616

[1]Total return is equal to gross return less variable costs.

Sprinkler Irrigation

This study will consider one method of rehabilitating the water application techniques at the farm level. The method is commonly referred to as sprinkler irrigation and can, when properly designed, provide 60 to 70 percent efficiency in the use of water. In accomplishing this efficiency only about half the water presently used in the study area would be needed at the farm level. This could, therefore, not only solve the subwater problem but could also provide the area with a modern and efficient system of irrigation.

There are several different types of sprinkler systems. For this study the hand-moved, wheeled-moved and center pivot type will be examined.

The hand-moved system will be considered for the 80 and 160 acre representative farms. The system consists of aluminum laterals that are moved by hand. Each lateral has quick changing couplings that allow for easy handling. The design of the system for 80 acres will be a buried mainline and three, 1,320 foot laterals. The hand-moved system for 160 acres will consist of a buried mainline and six, 1,320 foot laterals. A 320 acre hand-moved system was not considered for it was assumed that the labor hours for moving the necessary laterals would be prohibitive at this level.

A wheeled-moved system was considered for each representative farm of 80, 160 and 320 acres. The design is the same as the hand-moved system except that wheels are attached to the laterals for easy movement. A small gas engine propels the lateral down the field, thus eliminating much of the labor required for the hand-moved system.

Consultation with agricultural engineers at the University of Idaho revealed that very little economies of size with respect to capital investment can be achieved with either the hand-moved or wheeled-moved system. The small economies of size that may exist result from the amount of labor saved at each farm level.

The center pivot type of sprinkler system will be considered for the 160 and 320 acre representative farms. The 80 acre farm was excluded from this analysis for it was believed that capital investment of the center pivot system was too large for small acreages.

The center pivot system is designed to revolve around a central pivot point. It is self propelled by either hydralic cylinders or by electricity. The labor required for the actual irrigation is zero, but labor is required for repair and maintenance. Because of its circular motion, the corner region of a square field is not irrigated. The design of the system, however, provides adequate irrigation to all but about 18.4 acres on a 150 acre field.[6]

Economies of size are very apparent in the center pivot system. This results from the fact that the cost of the system is proportional to the square of the length of the system. These economies of size

---

[6]This 18.4 acres cannot be considered totally lost when considering the center-pivot system. The reason is that, with any other form of sprinkler irrigation, only 95 percent of the potential crop land is irrigated. The center pivot system can provide a full 100 percent utilization of the land it irrigates. Therefore, when comparing sprinkler systems, only the amount of land in excess of 5 percent is considered a loss. For an additional comment see: Samual M. Doran and James C. Holland, The Cost of Owning and Operating Six Semi-portable Sprinkler Systems in the Columbia Basin, Washington, College of Agriculture, E.M. 2760, Washington State University, Pullman, Washington, 1967, page 6.

are only attainable up to about 160 acres. The laterals designed for the 160 acre field usually are at the maximum length. Therefore, for a 320 acre field, two pivot systems would be necessary and the economies of size would not be realized.

There is a possibility that one system could be used on 320 acres, however. In this case the one system could be towed from one 160 acre field to the other. In an area where soils have high intake rates this plan is not too workable, for the maximum amount of water the center pivot system can deliver in a season is about 40 acre inches. If this amount of water is divided between two fields, there would not be enough water to meet the irrigation requirement of the crops in the study area.

Advantages and Disadvantages of Sprinkler Irrigation

There are several advantages and disadvantages to the sprinkler systems mentioned above.

Concerning the disadvantages the primary one is cost. A very high initial investment is required. In addition, increased power costs and other variable costs would be increased with the incorporation of a sprinkler system. Wind is a disadvantage if it is unusually strong. However, most sprinkler systems are designed to operate efficiently in normal wind conditions.

The advantages are numerous and include:

1. Little or no land leveling.

2. Uniform application of irrigation water.

3. Water can be controlled to the exact amount needed for a particular crop.

4. Less land for ditches and borders, allowing more land to be cultivated.

5. Many fertilizers and herbicides can be applied directly to the irrigation water and run through the system.

6. Frost protection and heat protection.

7. Irrigation labor hours are reduced with the wheeled and center pivot systems.

It should be noted that the move to sprinkler irrigation is but one alternative for this area in alleviating the high water table. It was chosen because of its proven effectiveness, its ability to provide efficient use of water and its relative ease of installation and handling. An additional advantage not listed above is that with sprinkler irrigation the individual farmer is solving his own problem as opposed to a situation like lining some reaches of some canals or consolidation of canals where the community as a whole must participate.

Variable and Fixed Costs for Sprinkler Irrigation

Table 21 presents the budget costs for the hand-moved sprinkler system on 80 and 160 acres. Table 22 presents the budget costs for the wheeled-moved system on 80, 160 and 320 acres. Table 23 indicates the costs associated with the center pivot system on 160 and 320 acres. All information contained in these budgets was obtained through interviews with sprinklter irrigation dealers and secondary sources (4) (11).

In order to incorporate the various sprinkler systems into each representative farm budget, an average net income for each farm was used.

In Farm 1 (80 acres) the net income for situation 1 was $6,142,

TABLE 21

VARIABLE AND FIXED COSTS OF A HAND-MOVED SPRINKLER SYSTEM ON 80 AND 160 ACRE FARMS

Acres: 80		
Capital Investment: $9,300		
Variable Input Costs		
Maintenance (3% of investment)	$279	
Electricity (1.2¢ per KWH @ 61,000 KWH)	732	
Labor (4.6 hr/acre @ $2.00/hr)	736	
Interest (8%, 6 mo)	70	
Fixed Costs		
Depreciation (15 yr, straight line)	$620	
Interest (8% on ½ investment)	372	
Total cost	$2,809	$35.11/acre
Acres: 160		
Capital Investment: $16,160		
Variable Input Costs		
Maintenance (3% of investment)	$ 485	
Electricity (1.2¢ per KWH @ 122,000 KWH)	1,464	
Labor (4.6 hr/acre @ $2.00/hr)	1,472	
Interest (8%, 6 mo)	137	
Fixed Costs		
Depreciation (15 yr, straight line)	$1,077	
Interest (8%, on ½ investment)	646	
Total cost	$5,281	$33.01/acre

TABLE 22

VARIABLE AND FIXED COSTS OF A WHEELED-MOVED SPRINKLER SYSTEM ON 80, 160 AND 320 ACRE FARMS

Acres: 80		
Capital Investment: $14,880		
<u>Variable Costs</u>		
Maintenance (3% of investment)	$ 446	
Electricity (1.2¢ per KWH @ 61,000 KWH)	732	
Labor (2.7 hr/acre @ $2.00/hr)	432	
Interest (8%, 6 mo)	64	
<u>Fixed Costs</u>		
Depreciation (15 yr, straight line)	$ 992	
Interest (8% on ½ investment)	595	
Total costs	$3,261	$40.76/acre
Acres: 160		
Capital Investment: $26,720		
<u>Variable Costs</u>		
Maintenance (3% of investment)	$ 802	
Electricity (1.2¢ per KWH @ 122,000 KWH)	1,464	
Labor (2.7 hr/acre @ $2.00/hr)	864	
Interest (8%, 6 mo)	125	
<u>Fixed Costs</u>		
Depreciation (15 yr, straight line)	$1,781	
Interest (8% on ½ investment)	1,069	
Total costs	$6,105	$38.16/acre

TABLE 22
(continued)

VARIABLE AND FIXED COSTS OF A WHEELED-MOVED SPRINKLER SYSTEM ON 80, 160 AND 320 ACRE FARMS

Acres: 320		
Capital Investment: $53,440		
Variable Costs		
Maintenance (3% of investment)	$1,603	
Electricity (1.2¢ per KWH @ 244,000 KWH)	2,928	
Labor (2.7 hr/acre @ $2.00/hr)	1,728	
Interest (8%, 6 mo)	250	
Fixed Costs		
Depreciation (15 yr, straight line)	$3,563	
Interest (8% on ½ investment)	2,138	
Total costs	$12,210	$38.16/acre

TABLE 23

VARIABLE AND FIXED COSTS OF A CENTER-PIVOT SPRINKLER SYSTEM ON 160 AND 320 ACRE FARMS

Acres: 160		
Capital Investment: $31,200		
Variable Costs		
Maintenance (3% of investment)	$ 936	
Electricity (1.2¢ per KWH @ 116,000 KWH)	1,392	
Labor (.55 hr/acre @ $2.00/hr)	176	
Interest (8%, 6 mo)	100	
Fixed Costs		
Depreciation (15 yr, straight line)	$2,080	
Interest (8% on ½ investment)	1,248	
Other		
Loss of crop land (10.4 acres @ $94/acre)[1]	$ 978	
Total cost	$6,910	$43.19/acre

[1]Charge for loss of crop land in excess of 5 percent. $94.00 is the Marginal Value Product (MVP) of land at the 160 acre level.

TABLE 23
(continued)

VARIABLE AND FIXED COSTS OF A CENTER-PIVOT SPRINKLER SYSTEM ON 160 AND 320 ACRE FARMS

Acres: 320		
Capital Investment: $62,400		
Variable Costs		
Maintenance (3% of investment)	$1,872	
Electricity (1.2¢ per KWH @ 232,000 KWH)	2,784	
Labor (.55 hr/acre @ $2.00/hr)	352	
Interest (8%, 6 mo)	200	
Fixed Costs		
Depreciation (15 yr, straight line)	$4,160	
Interest (8% on ½ investment)	2,496	
Other		
Loss of crop land (20.8 acres @ $144/acre)[1]	$2,995	
Total Cost	$14,859	$46.44/acre

[1]Charge for loss of crop land in excess of 5 percent. $144 is the Marginal Value Product (MVP) of land at the 320 level.

TABLE 24

NET INCOME OR THE NET RETURN TO MANAGEMENT AND INTEREST ON LAND AFTER THE INCORPORATION OF A SPRINKLER SYSTEM ON EACH REPRESENTATIVE FARM

Organization	Net Income[1]	Net Income/acre
Farm 1 (80 acres)		
At the present	$6,247	$ 78.09
With a hand-moved system	$4,488	$ 56.10
With a wheeled-move system	$4,035	$ 50.44
Farm 2 (160 acres)		
At the present	$21,500	$134.38
With a hand-move system	$17,845	$111.53
With a wheeled-move system	$17,021	$106.38
With a center-pivot system	$16,211	$101.32
Farm 3 (320 acres)		
At the present	$43,357	$135.49
With a wheeled-move system	$34,114	$106.60
With a center-pivot system	$31,465	$ 98.32

[1]Net income refers to return to management and interest on land.

situation 2, $14,236; situation 3, $6,181 and situation 4 was $6,419. Excluding situation 2 as a spurious example, the average net income for Farm 1 was $6,247.

In Farm 2 (160 acres) the average net income for all situations was $21,500.

The average net income for Farm 3 (320 acres) was $43,357.

Prior to the deduction of the sprinkler irrigation costs, two items were added to the net income.

1. To limit double counting, the cost of border irrigation labor that is no longer needed with sprinkler irrigation was added to net income (see Appendix 1 - Part C).

2. An average of 5 acres for all farm sizes is presently used for canals and ditches. It was assumed that these could be converted to tillible land when sprinkler irrigation was used. The value of these acres in terms of MVP of land at each representative farm level was added to net income.

The cost of sprinkler irrigation was then deducted from the total net income. The overall result is presented in Table 24 which shows the net income or net return to management and interest on land for each representative farm when a sprinkler system is included in the farm organization.

The Effect on Net Income

The effect of a water decline in the area to solve the subwater problem was examined earlier in this chapter. The result of the water decline had a significant effect on the income at each farm level.

The incorporation of sprinkler irrigation to solve the subwater problem was also examined and it, too, had a significant effect on Net Income at each farm level.

Figure 3, 4 and 5 graphically portray the effect on Net Income of both of these methods.

Figure 3 shows that at the Farm 1 (80 acre) level, it is more profitable for the farmer to reduce water application by 25 percent than to incorporate any sprinkler system.

The 25 percent reduction in water application effectively reduces tillable land by approximately 22 percent. This method is still more profitable than the incorporation of either a hand-moved or a wheeled-moved sprinkler system.

Figure 4 also shows that the reduction in water by 25 percent to solve the problem is more advantageous than the incorporation of a sprinkler system at the 160 acre farm level.

Figure 5 shows that the wheeled-moved system is more profitable than a 25 percent decrease in water at the 320 acre level.

Final Results

This study presented two methods of alleviating the high water table in the study area. The first method to be analyzed was that of decreasing on farm water use without changing the present irrigation application techniques. The second method analyzed the feasibility of incorporating sprinkler irrigation to the study area.

With regard to the first method it has been shown that decreasing water availability forces land into unproductive status and, therefore, there is a significant effect on income. This effect on income at the 80 and 160 acre level, however, is not as severe as the effect of incorporating the least expensive sprinkler system. It appears that for these two farm sizes the incorporation of sprinkler irrigation is not the best method to alleviate the problem.

At the 320 acre level, however, a wheeled-moved sprinkler system is more profitable to the farmer than a decrease in water availability. It is, therefore, more advantageous at this level to solve the problem with sprinkler systems than to decrease water by 25 percent.

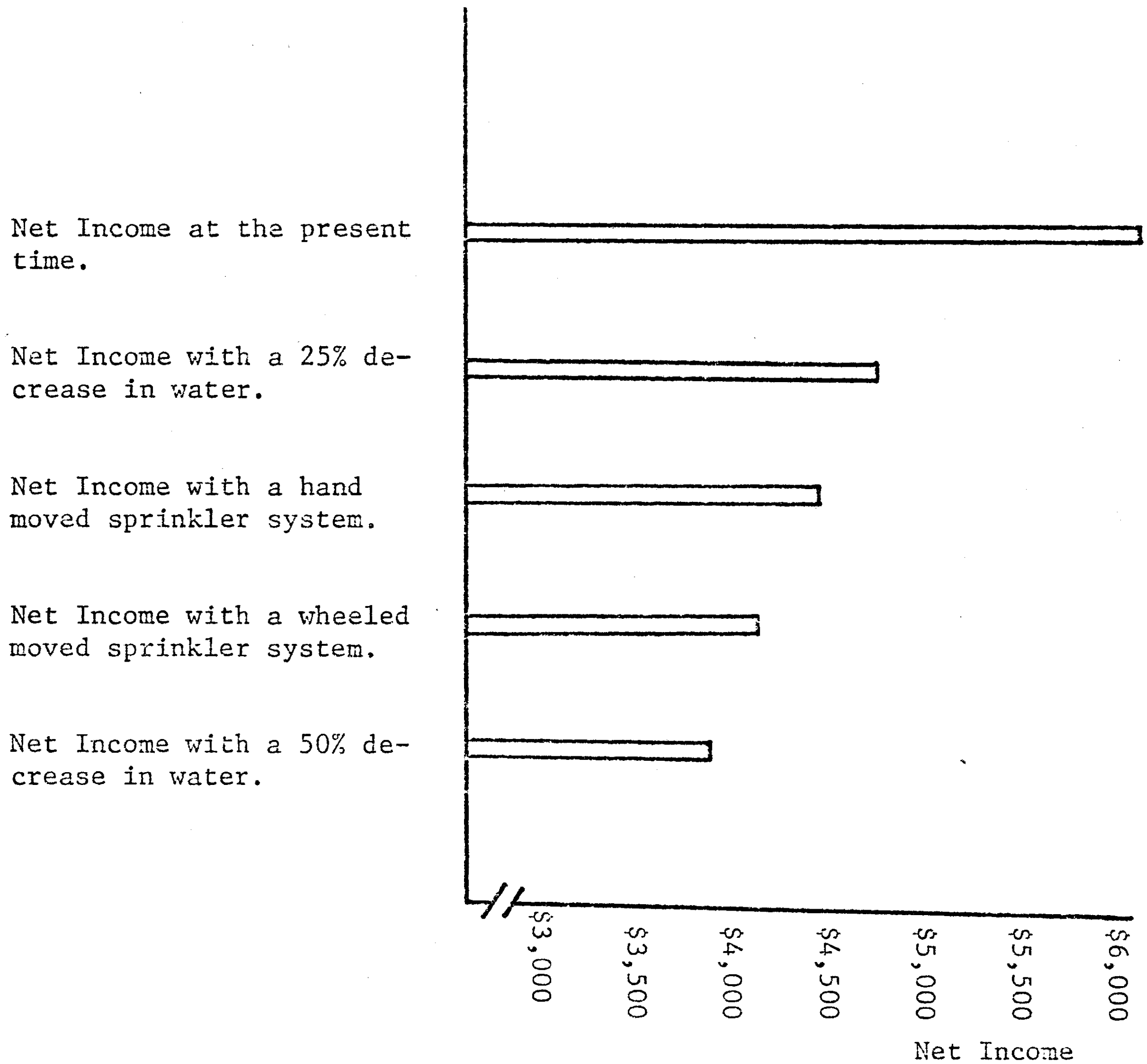

Figure 3. Effect on the Net Income of a Percentage Decrease in Water and/or the Effect of the Incorporation of a Specific Sprinkler System at the Farm 1 (80 acre) Level.

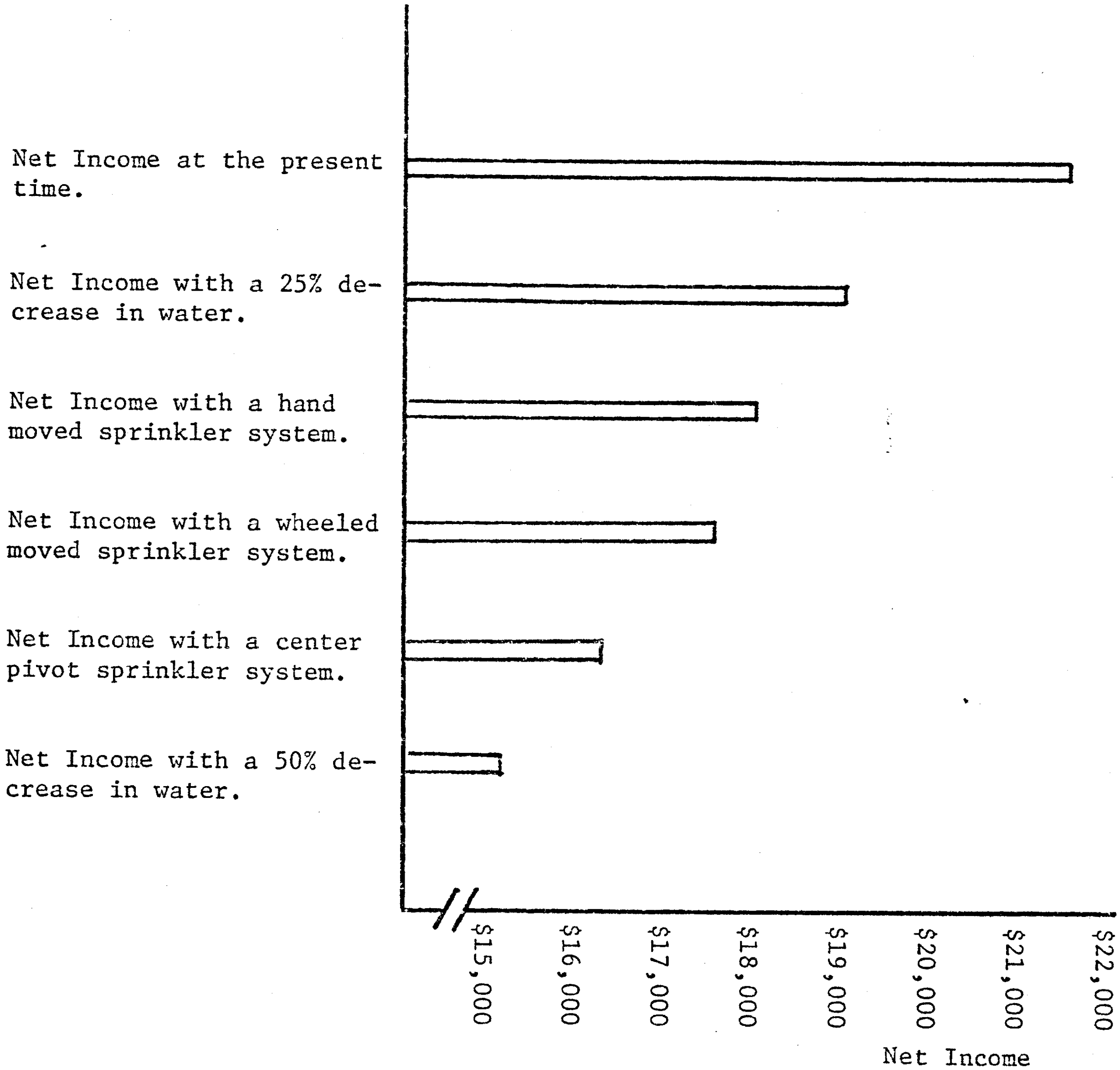

Figure 4. The Effect on the Net Income of a Percentage Decrease in Water and/or the Effect of the Incorporation of a Specific Sprinkler System at the Farm 2 (160 acre) Level.

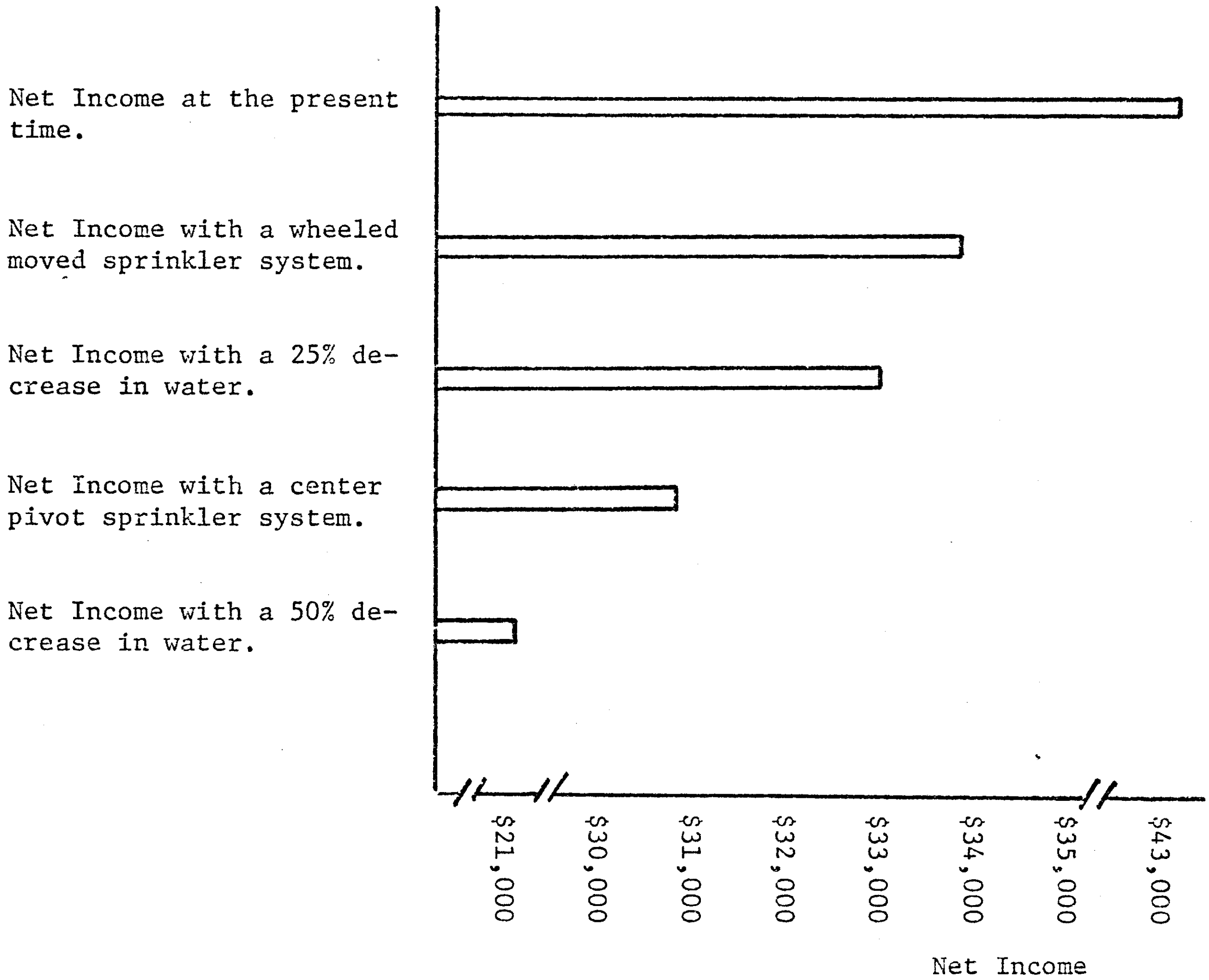

Figure 5. Effect on the Net Income of a Percentage decrease in Water and/or the Effect of the Incorporation of a Specific Sprinkler System at the Farm 3 (320 acre) Level.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

This study was developed to analyze the economic effects of solving a high water table problem in southeastern Idaho near the town of Rigby. The objectives were to analyze the present farm situation and then to determine the feasibility of solving the problem by decreasing water use at the farm level.

Two methods of decreasing on farm water use were discussed. One method involved the theoretical decrease of water availability without alterations to the present farm irrigation system. The second method involved the decrease of water by incorporating sprinkler systems to the area.

In relation to these objectives and methods, farmers in the study area were interviewed to gather information about the area. Other primary and secondary information was collected and representative farm budgets of 80, 160 and 320 acres were developed. These representative farms were analyzed with the aid of linear programming. An optimum organization of farms was achieved at the highest attainable return. In this way the general farming practices and income potential was approximated for the area.

With regard to the first method of decreasing on farm water use, a parametric routine was entered into the linear programming model. This theoretically reduced the available water from the linear programming solution in 5 percent intervals to a maximum of 75 percent. The effect of this reduction on the optimum organization and income was analyzed at the 25 percent and 50 percent reduction levels.

There was considerable income loss at both the 25 percent and 50 percent levels. The primary reason for this income loss was the fact that the reductions in water forced tillable land into unproductive status. It was concluded that this method of solving the sub water problem, by taking large areas out of cultivation, was not a realistic solution.

The second method, that of introducing sprinkler systems to the area, was then considered. This method was analyzed because it had the ability to decrease water up to 50 percent and still provide adequate irrigation for full utilization of the tillable land.

Budgets elaborating the variable and fixed costs required for a hand-moved, wheeled-moved and a center-pivot type sprinkler system were developed. These costs were then deducted from the linear programming solution and the effect on net income was analyzed.

The two methods were compared as to their effect on net income at each representative farm level.

The results showed that at the 80 and 160 acre representative farm levels, alleviating the problem by decreasing water by 25 percent was more profitable than the incorporation of any sprinkler system.

At the 320 acre representative farm level the wheeled-moved sprinkler system was shown to be more profitable than decreasing water and taking land out of cultivation.

Conclusions and Policy Recommendations

The conclusions to this study relate to the economic ability of the area farmers to solve the high water table problem.

With regard to this problem, the use of sprinkler irrigation at the 80 and 160 acre farm level is not the most economical solution. The introduction of sprinklers at these farm levels is too expensive. Sprinkler irrigation may be applicable to a few high profit farms, but as a whole the farmers do not have the capability from the farm business to provide the necessary funding at the small farm level.

In the advent of a situation where water becomes critical to this area, the removal of some land from cultivation would be less expensive at the small farm level than the move to sprinkler irrigation.

At the 320 acre level the problem can best be solved by incorporating sprinkler irrigation. The best system to use at this level is the wheeled-moved sprinkler system as compared with the center-pivot system.

It is recommended that at the 80 and 160 acre farm level, the present system of border irrigation be improved as much as possible to increase the water application efficiency.

It is also recommended that further study be initiated to analyze how the canal companies in the area can administer tighter controls on water at the farm level. Further study should also be directed toward the economic aspects of lining some reaches of the canals themselves.

For all further studies, emphasis should be placed on determining how the community as a whole can fund major projects.

It is further recommended that, where possible, small farms should incorporate into larger units. When these farm sizes approach 320 acres, then some type of sprinkler irrigation should be considered.

BIBLIOGRAPHY

References

1. Beneke, Raymond R. and R. D. Winterboer. Linear Programming Applications to Agriculture. Iowa State University Press, Ames, Iowa, 1973.

2. Brockway, C. E. Systems Analysis of Irrigation Water Management in Eastern Idaho. Water Resources Research Institute, University of Idaho, Moscow, Idaho, 1973.

3. Cheline, Richard J. An Economic Approach to the Agricultural Use of Ground Water in the Oakley Fan Area of Cassia County, Idaho. Master's Thesis, University of Idaho, Moscow, Idaho, 1968.

4. Doran, Samuel M. and J. C. Holland. The Cost of Owning and Operating Six Semi-portable Sprinkler Systems in the Columbia Basin Washington. College of Agriculture, E.M. 2760, Washington State University, Pullman, Washington, 1967.

5. Famure, Oluwole. The Income Contributions of Agricultural Commodities to Idaho's Economy and the Economic Interrelationships in Agriculture: An Input-Output Model. Master's Thesis, University of Idaho, Moscow, Idaho, 1974.

6. Galinato, Guillermo C. Evaluation of Irrigation Systems in the Snake River Fan, Jefferson County, Idaho. Master's Thesis, University of Idaho, Moscow, Idaho, 1974.

7. Gneiting, Gary W. An Economic History and Analysis of the Great Feeder Canal of Southeastern Idaho. Master's Thesis, Utah State University, Logan, Utah, 1972.

8. Heady, Earl O. Linear Programming Methods. Iowa State University Press, Ames, Iowa, 1958.

9. Lindeborg, Karl H. The Cost of Operating Farm Machinery. College of Agriculture, University of Idaho, Moscow, Idaho, 1967.

10. McCoy, J. H. and H. C. Wakefield. Economies of Scale in Farm Cattle Feedlots of Kansas - An Analysis of Non-feed Costs. Kansas State University of Agriculture, Technical Bulletin 145, Manhattan, Kansas, 1966.

11. McMartin, Wallace and Ronald O. Bergan. Irrigation, Practices and Costs in North Dakota. Agricultural Experiment Station, Bulletin 474, North Dakota State University, Fargo, North Dakota, 1968.

12. Sutter, R. J. and G. L. Corey. Consumptive Irrigation Requirements for Crops in Idaho. College of Agriculture, University of Idaho, Bulletin 516, Moscow, Idaho, 1970.

13. Thomas, Wayne C. and L. F. Rogers. Estimated Costs and Returns for a 100-Cow Drylot Dairy Enterprise in the Columbia Basin of Washington, 1970. College of Agriculture, E.M. 3417, Washington State University, Pullman, Washington, 1970.

14. Thorfinnson, T. S. et al. Cost of Distribution of Irrigation Water by Different Methods. College of Agriculture, Bulletin 432, University of Nebraska, Lincoln, Nebraska, 1955.

15. Withers, R. V. and R. D. Watson. Production Costs for Idaho Potatoes. College of Agriculture, Progress Report 168, University of Idaho, Moscow, Idaho 1973.

16. Whittlesey, Norman K. and R. E. Oehlschlaeger. Cost of Production Budgets for Dryland Crops in Eastern Washington. Agricultural Experiment Station, Circular 501, Washington State University, Pullman, Washington, 1969.

Governmental and State Documents

17. Agricultural Prices, 1972 Annual Summary, Statistical Reporting Service, U.S. Department of Agriculture, Washington, D.C., 1973.

18. Agricultural Water Needs, Consumptive Irrigation Requirements, State of Idaho Water Resource Board, Planning Report 5, Department of Agricultural Engineering, University of Idaho, Moscow, Idaho, 1971.

19. Annual Farm Labor Report, Idaho 1971. Department of Employment, State of Idaho, 1971.

20. Idaho Agricultural Statistics, 1973, Idaho Statistical Reporting Service, Boise, Idaho, 1973.

21. Selected U.S. Crop Budgets, Yields, Inputs and Variable Costs, Volume IV, Northwest Region, Economic Research Service, U.S. Department of Agriculture, Washington, D.C., 1971.

Other

22. Linear and Separable Programming User's Manual, Mathematical Programming System 360. Form H20-0290-2, IBM Corporation, White Plains, New York, 1967.

APPENDICES

APPENDIX 1 Farm Labor

APPENDIX 2 Irrigation Labor

APPENDIX 3 Representative Farm Budgets

APPENDIX 4 Livestock Feed Requirements

APPENDIX 1

Farm Labor

a. Farm Labor Requirements

b. Farm Labor Supply

c. Border Irrigation Labor

FARM LABOR

a. Farm Labor Requirement

The annual farm labor for Idaho is apportioned in the following way:

TABLE 1

SEASONAL HIRED WORK FORCE PER MONTH IN IDAHO
1971

Month	Number employed
January	700
February	800
March	1400
April	4600
May	8200
June	12500
July	12900
August	10800
September	10200
October	13600
November	4600
December	1500
Total	81800

Source: Annual Farm Labor Report, Idaho 1971, p. 19

April-May = 15 percent of the total

June-July = 31 percent of the total

Aug-Sept = 25 percent of the total

The following tables apply these percentages to the total farm labor required for each farm size. For example in Table 2, 9.0 hours of total labor are required to produce one acre of alfalfa. Of these 9.0 hours, 1.35 are needed in April and May. 9.0 X .15 = 1.35.

TABLE 2

FARM LABOR REQUIREMENT FOR FOUR CROPS ON AN 80 ACRE FIELD

Farm labor requirement		Hours of labor in Apr-May	June-July	Aug-Sept
Grain				
Labor (irrigation)	2.7 hrs			
Labor (all other)	4.5 hrs			
Total labor	7.2 hrs	1.08	2.23	1.80
Alfalfa				
Labor (irrigation)	3.5 hrs			
Labor (all other)	5.5 hrs			
Total labor	9.0 hrs	1.35	2.79	2.25
Potatoes				
Labor (irrigation)	7.0 hrs			
Labor (all other)	10.6 hrs			
Total labor	17.6 hrs	2.64	5.45	4.40
Sugar Beets				
Labor (irrigation)	8.0 hrs			
Labor (all other)	8.5 hrs			
Total labor	16.5 hrs	2.47	5.11	4.12

TABLE 3

FARM LABOR REQUIREMENT FOR FOUR CROPS
ON A 160 ACRE FIELD

Farm labor requirement		Hours of labor in Apr-May	June-July	Aug-Sept
Grain				
Labor (irrigation)	2.0 hrs			
Labor (all other)	4.5 hrs			
Total labor	6.5 hrs	.97	2.01	1.62
Alfalfa				
Labor (irrigation)	2.9 hrs			
Labor (all other)	5.5 hrs			
Total labor	8.4 hrs	1.26	2.60	2.10
Potatoes				
Labor (irrigation)	6.7 hrs			
Labor (all other)	10.6 hrs			
Total labor	17.3 hrs	2.60	5.38	4.33
Sugar Beets				
Labor (irrigation)	7.0 hrs			
Labor (all other)	8.5 hrs			
Total labor	15.5 hrs	2.32	4.80	3.87

TABLE 4

FARM LABOR REQUIREMENT FOR FOUR CROPS
ON A 320 ACRE FIELD

Farm labor requirement		Hours of labor in Apr-May	June-July	Aug-Sept
Grain				
Labor (irrigation)	1.8 hrs			
Labor (all other)	4.5 hrs			
Total labor	6.3 hrs	.94	1.95	1.57
Alfalfa				
Labor (irrigation)	2.8 hrs			
Labor (all other)	5.5 hrs			
Total labor	8.3 hrs	1.24	2.57	2.07
Potatoes				
Labor (irrigation)	6.0 hrs			
Labor (all other)	10.6 hrs			
Total labor	16.6 hrs	2.49	5.15	4.15
Sugar Beets				
Labor (irrigation)	6.0 hrs			
Labor (all other)	8.5 hrs			
Total labor	14.5 hrs	2.17	4.49	3.62

b. Farm Labor Supply

The questionaires provided the information used to average the supply of labor for each farm.

80 acre farm The indication was that little or no extra labor other than the immediate family was hired. The owner, his wife and their children comprise the total work force on the 80 acre farm. 1.5 men were deemed appropriate to account for the total family labor.

160 acre farm In addition to the owner and his family, an average of 2.1 extra man months of hired labor was supplied during the critical summer months. These hired workers were included in the total supply by assuming a man month comprised a 10 hour day and 25 days per month.

320 acre farm In addition to the owner and his family about 7.5 extra man months were hired during the critical months on this size farm. The same 10 hour day and 25 days per month was applied to this labor.

The following page indicates the total supply of labor for each farm during the critical periods.

80 acres a. 1.5 men per farm (man and wife and/or children)

10 hr X 6 days X 50 weeks X 1.5 men = 4500 hours

4500/6 = 750 hours of labor per 2 month periods.

Total labor supply

April-May	750 hours
June-July	750 hours
Aug-Sept	750 hours

160 acres a. 1.5 men per farm (man and wife and/or children)

10 hr X 6 days X 50 weeks X 1.5 men = 4500 hours

b. 2.1 extra man months hired summer labor

10 hr X 25 days X 2.1 months = 525 hours

525/3 = 175 additional labor per period.

Total labor supply

April-May	925 hours
June-July	925 hours
Aug-Sept	925 hours

320 acres a. 1.5 men per farm (man and wife and/or children)

10 hr X 6 days X 50 weeks X 1.5 men = 4500 hours

b. 7.5 extra man months hired summer labor

10 hr X 25 days X 7.5 months = 1875

1875/3 = 625 additional labor per period.

Total labor supply

April-May	1375
June-July	1375
Aug-Sept	1375

c. Border Irrigation

The cost of border irrigation for each representative farm solution is as follows:

Farm 1 (80 acres)

32 acres of grain @ 2.7 hours/acre = 86.4 hours

32 acres of alfalfa @ 3.5 hours/acre = 112.0 hours

16 acres of potatoes @ 7.0 hours/acre = 112.0 hours

Total: 310.4 hours @ $2.00/hr = $620.80

Farm 2 (160 acres)

90 acres of grain @ 2.0 hours/acre = 180.0 hours

20 acres of alfalfa @ 2.9 hours/acre = 58.0 hours

50 acres of potatoes @ 6.7 hours/acre = 337.5 hours

Total: 575.5 hours @ $2.00/hr = $1,151.00

Farm 3 (320 acres)

106 acres of grain @ 1.8 hours/acre = 190.8 hours

106 acres of alfalfa @ 2.8 hours/acre = 296.8 hours

106 acres of potatoes @ 6.0 hours/acre = 636.0 hours

Total: 1,123.6 hours @ $2.00/hr = $2,247.20

APPENDIX 2

Irrigation Requirement

IRRIGATION REQUIREMENT

The irrigation requirement for the various crops was taken from:

Sutter and Corey, Consumptive Irrigation Requirements for Crops in Idaho, College of Agriculture, Bulletin 516, University of Idaho, 1970, p. 8.

The irrigation requirement is that amount of water that is artificially applied. It is the consumptive use requirement less the amount of precipitation in the area.

The following table gives the irrigation requirement (IR) for four crops in the study area at several different efficiency rates. Figures are given in acre inches.

TABLE 1

IRRIGATION EFFICIENCY IN ACRE INCHES
FOR FOUR DIFFERENT CROPS AT FOUR DIFFERENT EFFICIENCY RATES

Irrigation Requirement	Grain	Alfalfa	Potato	Sugar Beet
IR at 100% efficiency	17.10	19.40	17.90	18.60
IR at 70% efficiency	24.42	27.70	25.56	26.56
IR at 50% efficiency	34.20	38.80	35.80	37.20
IR at 30% efficiency	56.99	64.66	59.66	61.99

APPENDIX 3

Representative Farm Budgets

TABLE 1

REPRESENTATIVE FARM BUDGET FOR A MIXED GRAIN ENTERPRISE ON 160 ACRES IN RIGBY, IDAHO 1973

Gross revenue per acre		
85 bushels @ $1.81		$153.85
Variable input costs per acre		
Seed	$ 4.15	
Fertilizer	9.94	
Weed spray	2.60	
Haul	.85	
Machinery	10.40	
Harvest	9.00	
Labor (irrigation, 2.0 hr @ $2.00/hr)	4.00	
Labor (all other, 4.5 hr @ $2.00/hr)	9.00	
Farm misc.	6.00	
Interest on working capital (8%, 6 mo)	2.23	
Total variable costs	$58.17	
Net return to fixed factors and management		$ 95.68

TABLE 2

REPRESENTATIVE FARM BUDGET FOR A MIXED GRAIN ENTERPRISE ON 320 ACRES IN RIGBY, IDAHO 1973

Gross revenue per acre		
89 bushels @ $1.81		$161.09
Variable input costs per acre		
Seed	$ 4.15	
Fertilizer	11.06	
Weed Spray	1.73	
Haul	.89	
Machinery	10.40	
Harvest	9.00	
Labor (irrigation, 1.8 hr @ $2.00/hr)	3.60	
Labor (all other, 4.5 hr @ $2.00/hr)	9.00	
Farm misc.	6.00	
Interest on working capital (8%, 6 mo)	2.23	
Total variable costs	$58.06	
Net return to fixed factors and management		$103.03

TABLE 3

REPRESENTATIVE FARM BUDGET FOR AN ALFALFA ENTERPRISE ON 80 ACRES IN RIGBY, IDAHO 1973

Gross revenue per acre		
4.3 tons @ $28.80		$123.84
Variable input costs per acre		
Seed	$ 2.17	
Fertilizer	9.59	
Insecticide	2.25	
Haul-stack	19.80	
Machinery	6.60	
Harvest	18.00	
Labor (irrigation, 3.5 @ $2.00/hr)	7.00	
Labor (all other, 5.5 @ $2.00/hr)	11.00	
Farm misc.	6.00	
Interest on working capital (8%, 6 mo)	3.35	
Total variable costs	$85.76	
Net return to fixed factors and management		$ 38.08

TABLE 4

REPRESENTATIVE FARM BUDGET FOR AN ALFALFA ENTERPRISE ON 320 ACRES IN RIGBY, IDAHO 1973

Gross revenue per acre		
5 tons @ $28.80		$144.00
Variable input costs per acre		
Seed	$ 2.17	
Fertilizer	10.58	
Insecticide	1.07	
Haul-stack	19.80	
Machinery	6.60	
Harvest	18.00	
Labor (irrigation, 2.8 hr @ $2.00/hr)	5.60	
Labor (all other, 5.5 hr @ $2.00/hr)	11.00	
Farm misc.	6.00	
Interest on working capital (8%, 6 mo)	3.23	
Total variable costs	$84.05	
Net return to fixed factors and management		$ 59.95

TABLE 5

REPRESENTATIVE FARM BUDGET FOR A POTATO ENTERPRISE ON 80 ACRES IN RIGBY, IDAHO 1973

Gross revenue per acre		
200 cwt @ $2.47/cwt		$494.00
Variable input costs per acre		
Seed	$52.50	
Fertilizer	7.16	
Insecticide and weed spray	16.00	
Land prep. and other pre-harvest costs	36.00	
Machinery	38.04	
Harvest	54.12	
Haul (@ 12¢/cwt)	24.00	
Labor (irrigation, 7 hr @ $2.00/hr)	14.00	
Labor (all other, 10.6 hr @ $2.00/hr)	21.20	
Farm misc.	6.00	
Interest on working capital (8%, 6 mo)	10.76	
Total variable costs	$279.78	
Net return to fixed factors and management		$214.22

TABLE 6

REPRESENTATIVE FARM BUDGET FOR A POTATO ENTERPRISE ON 160 ACRES IN RIGBY, IDAHO 1973

Gross revenue per acre		
220 cwt @ $2.47/cwt		$543.40
Variable input costs per acre		
Seed	$52.50	
Fertilizer	23.83	
Insecticide and weed spray	9.25	
Land prep. and other pre-harvest costs	36.00	
Machinery	38.04	
Harvest	54.12	
Haul (12¢/cwt)	26.40	
Labor (irrigation, 6.7 hr @ $2.00/hr)	13.50	
Labor (all other, 10.6 hr @ $2.00/hr)	21.20	
Farm misc.	6.00	
Interest on working capital (8%, 6 mo)	11.23	
Total variable costs	$292.07	
Net return to fixed factors and management		$251.33

TABLE 7

REPRESENTATIVE FARM BUDGET FOR A SUGAR BEET ENTERPRISE ON 80 ACRES IN RIGBY, IDAHO 1973

Gross revenue per acre		
17.5 tons @ $15.18		$265.65
Variable input costs per acre		
Seed	$ 1.93	
Fertilizer	22.50	
Weed spray	1.50	
Insecticide	3.50	
Machinery	32.85	
Hoe and thinning labor	33.00	
Harvest	53.19	
Haul	18.00	
Labor (irrigation, 8.0 hr @ $2.00/hr)	16.00	
Labor (all other, 8.5 hr @ $2.00/hr)	17.00	
Farm misc.	6.00	
Interest on working capital (8%, 6 mo)	8.22	
Total variable costs	$213.69	
Net return to fixed factors and management		$ 51.96

TABLE 8

REPRESENTATIVE FARM BUDGET FOR A SUGAR BEET ENTERPRISE ON 160 ACRES IN RIGBY, IDAHO 1973

Gross revenue per acre		
18.0 tons @ $15.18		$273.24
Variable input costs per acre		
Seed	$ 1.93	
Fertilizer	22.50	
Weed spray	1.00	
Insecticide	3.00	
Machinery	32.85	
Hoe and thinning labor	33.00	
Harvest	53.19	
Haul	18.00	
Labor (irrigation, 7.0 hr @ $2.00/hr)	14.00	
Labor (all other, 8.5 hr @ $2.00/hr)	17.00	
Farm misc.	6.00	
Interest on working capital (8%, 6 mo)	8.10	
Total variable costs	$210.57	
Net return to fixed factors and management		$ 62.67

TABLE 9

REPRESENTATIVE FARM BUDGET FOR A SUGAR BEET ENTERPRISE ON 320 ACRES IN RIGBY, IDAHO 1973

Gross revenue per acre		
18.0 tons @ $15.18		$273.24
Variable input costs per acre		
Seed	$ 1.65	
Fertilizer	20.00	
Weed spray	4.50	
Insecticide	1.00	
Machinery	32.85	
Hoe and thinning labor	33.00	
Harvest	53.19	
Haul	18.00	
Labor (irrigation, 6.0 hr @ $2.00/hr)	12.00	
Labor (all other, 8.5 hr @ $2.00/hr)	17.00	
Farm misc.	6.00	
Interest on working capital (8%, 6 mo)	7.97	
Total variable costs	$207.16	
Net return to fixed factors and management		$ 66.08

APPENDIX 4

Livestock Feed Requirements

TABLE 1

FEED REQUIREMENT FOR LIVESTOCK[1]

Animal	Type feed needed	Requirement per day	Number of days	Total
Feeder cattle	grain	.32 bushels	200	64 bushels
	alfalfa	3 lbs	200	.3 tons
(Total requirement: 64 bushels of grain and 0.3 tons alfalfa)				
Dairy cow				
lactation	grain	.4 bushels	300	120 bushels
	alfalfa	30 lbs	300	4.5 tons
dry period	alfalfa	20 lbs	65	.85 tons
(Total requirement: 120 bushels of grain and 5.35 tons alfalfa)				
Hogs				
1. Sow				
a. dry period	grain	.1 bushels	300	30 bushels
	alfalfa	6 lbs	300	.9 tons
b. litter	grain	.3 bushels	65[2]	19.5 bushels
2. Pigs				
a. creeps	grain	.02 bushels	35	.7 bushels
b. 40-125 lbs	grain	.12 bushels	40	4.8 bushels
c. 125-230 lbs	grain	.16 bushels	40	6.4 bushels
(Total requirement: 204 bushels of grain and 1 ton alfalfa)[3]				

[1]Information obtained from consultation with Animal Industry personnel at the University of Idaho, College of Agriculture, 1974.

[2]Five weeks per litter, two litters for a total of about 65 days.

[3]Requirement includes 1 sow and 13 pigs.