THE ANALYSIS OF IRRIGATED AGRICULTURAL DEVELOPMENT, MOUNTAIN HOME DIVISION, SOUTHWEST IDAHO WATER DEVELOPMENT PROJECT

A Thesis

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AUTHORIZATION TO PROCEED WITH THE FINAL DRAFT

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Richard L. (Dick) Reid was born at Orofino, Idaho and spent the first years of his life on a farm on Central Ridge of the NezPerce Prairie south of the Clearwater River. He received his primary education through the Nezperce Public School System, graduating in 1965.

Upon graduation from high school, he enrolled in the University of Idaho. In the spring of 1970 he received a Bachelor of Science degree in Agriculture with a major in Agricultural Economics.

After an interlude of one semester, the author returned to the University of Idaho for graduate work of which this thesis is a part.

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It is impossible to perceive beforehand the amount of effort, guidance, and assistance required by the author in the preparation of this thesis. It is also impossible immediately upon completion of this thesis to recall those individuals, both faculty members and businessmen, who deserve recognition for their support and assistance.

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ABSTRACT

The purpose of this thesis was to determine the primary effects of agricultural production to the immediate area as a result of developing arid lands of the Mountain Home Desert in Ada and Elmore Counties, Idaho, for commodity production.

An interview-type survey was obtained from the study area located in Ada and Canyon Counties, Idaho, for the purpose of completing partial farm budgets. Regression analysis applied to this data resulted in a unit cost curve showing slight economies of size for large farm acreages as opposed to smaller acreages.

The unit cost curve was incorporated in the objective function of a linear programming model utilizing land, labor, and water as real restrictions. Artificial resources were included in the activity analysis as restrictions to determine the optimum allocation of these resources for commodity production on 160, 320, 480, and 640 acre model farms. The outcome showed that the allocation of the resources for commodity production resulted in positive net returns for the three larger model farms. Also the activity analysis resulted in water being the most limiting resource. But the value of the irrigation water was shown to be comparable to water costs of other Southern Idaho irrigation areas. Projections of income and population changes resulting from primary agricultural production on the project lands were also estimated.

The data of the activity analysis were adapted to a parametric linear programming analysis to research the effect of varying potato and sugar beet commodity prices has on the resource allocation and production plans of the model farms. The conclusion of this analysis was that production of these two commodities is stable as large commodity price changes are necessary to alter the current resource allocation for changes in the production of either potatoes or sugar beets.

CHAPTER I

INTRODUCTION

Background

Natural resources have long been an important factor in the development of mankind. Although the Neanderthal man was not faced with a serious choice of the uses he made of the natural resources around him, he was still dependent upon them--caves for his protection against the elements and soil and water for sustenance of the game he sought. From this primitive life, man has developed a far deeper dependence on natural resources or the alteration of them for his survival. From using agricultural commodities for bartering for those items he did not produce himself, man has progressed to an era of using agricultural production to partially affect national trading positions of the world community, to an era of national agricultural surpluses in developed countries.

The populous of the United States has progressed even further. Americans are now beginning to analyze these scarce natural resources for their esthetic value as well as their economic benefits realized through altering the native state. Even though many citizens are presently voicing environmental and ecological questions concerning economic activities utilizing these scarce resources, many of these same people depend, at least in an indirect way, on these same natural resources for their livelihood. And the people of Idaho are no different.

Problem

Idaho is substantially dependent upon these natural resources of mining, forest production, and agricultural production for its economic base and position among the other states of the Northwest and the nation as a whole. Lawson and Rice's factor analysis of Idaho's economy in 1969 indicates that of the seventeen Western states compared, Idaho was one of the least economically developed. Their study gave Idaho a comparative ranking of thirteenth.[1] Furthermore, their study indicated that although Idaho forestry is more important than agriculture to this western region, Idaho's agriculture is more important than its forestry to the state's economy.[2] Although total agricultural employment has decreased almost nine percent in the ten-year period 1961-1971, agriculture still ranks as the number one labor user in Idaho with the annual average for 1971 being 46,300 workers representing 16 percent of the total Idaho labor force.[3] Another indication of the importance of agriculture to Idaho is the fact that normal trends of regular hired agricultural workers leaving for more profitable urban jobs were reversed, at least stalemated, in 1971.[4] It is also well known that southern Idaho is a livestock producing area requiring importations of cereal grains for livestock feed. Recent projections claim there will be a changing of the

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[1]R. D. Lawson and C. W. Rice, Jr., "Comparative Economic Factor Analysis of Idaho and Idaho Counties," Bureau of Business and Economic Research, University of Idaho, Monograph 9, 1969, p. 22.

[2]*Ibid.*, p. 22.

[3]R. D. Lawson and C. W. Rice, Jr., *Annual Farm Labor Report*; Idaho, 1971, Department of Employment, Boise, 1971, p. 21.

[4]*Ibid.*

importance of producing roughages for dairying toward the increase of cereal grain production because of the sharp increase of beef production.[5]

For the above reasons, intelligent decision-makers must have adequate data as a basis for determination of the uses of Idaho's natural resources in order to maintain and continue its economic growth whether it be for recreation or for primary production. Because of Idaho's dependence upon agriculture as an economic base, this area of the economy must expand to provide funds for the increased demands for the development and maintenance of recreational facilities and the ever-growing demands on the state treasury.

Idaho has abundant supplies of certain natural resources. In the past decade the arid southwestern United States has viewed with envy the abundant supply of water from the upper Snake River basin in Idaho. California, for example, has several plans to supplement its own short water supply. One of these is the diversion of Snake River waters via the Colorado River to southern California.[6] However, with the immense acreage suitable for irrigation in southwestern Idaho, California was not the first to study the water resources of the Snake River drainage. As early as 1920 the United States Bureau of Reclamation studied the possibilities of irrigating the Mountain Home desert.[7]

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[5] Agricultural Projections for 1975 and 1985, Production and Consumption of Major Foodstuffs, Organization of Economic Co-operation and Development, Paris, 1968, pp. 15, 17.

[6] "Idaho Agricultural Science," College of Agriculture, University of Idaho, 1964, p. 2.

[7] "A Plan for Progress, The Southwest Idaho Water Project," The Southwestern Idaho Development Association, Boise.

And in 1966, as a result of a two-year study, the Bureau published its "Southwest Idaho Water Development Project, Idaho."[8] This study divides southwestern Idaho into four divisions: Garden Valley, Bruneau, Weiser River, and Mountain Home, including all or a portion of Ada, Adams, Boise, Canyon, Elmore, Gem, Payette, Owyhee, and Washington Counties, Idaho. This area encompasses 15,500 square miles or approximately ten million acres of land, some 650,000 acres now irrigated and 1.4 million acres which have characteristics suitable for irrigation development. This project identifies some 560,000 acres, 60,000 of which are in need of a supplemental water supply only; the remaining irrigable acres are too high above the water supply to be feasibly irrigated at our current technological state of development.

Because of the above mentioned threats of water exportation, the state legislature created the Idaho Water Resource Board for the purpose of preparing a water resources inventory and a state water plan.[9,10] Although Federal, state, and local agencies supported the Bureau of Reclamation project, prospects of Federal authorization and funding were slim. Because of this fact, the Idaho Water Resource Board has joined with Idaho Power Company to implement the initial phase of the overall project. In so doing it is hoped Federal appropriations will be forthcoming for the remainder of the overall project.[11]

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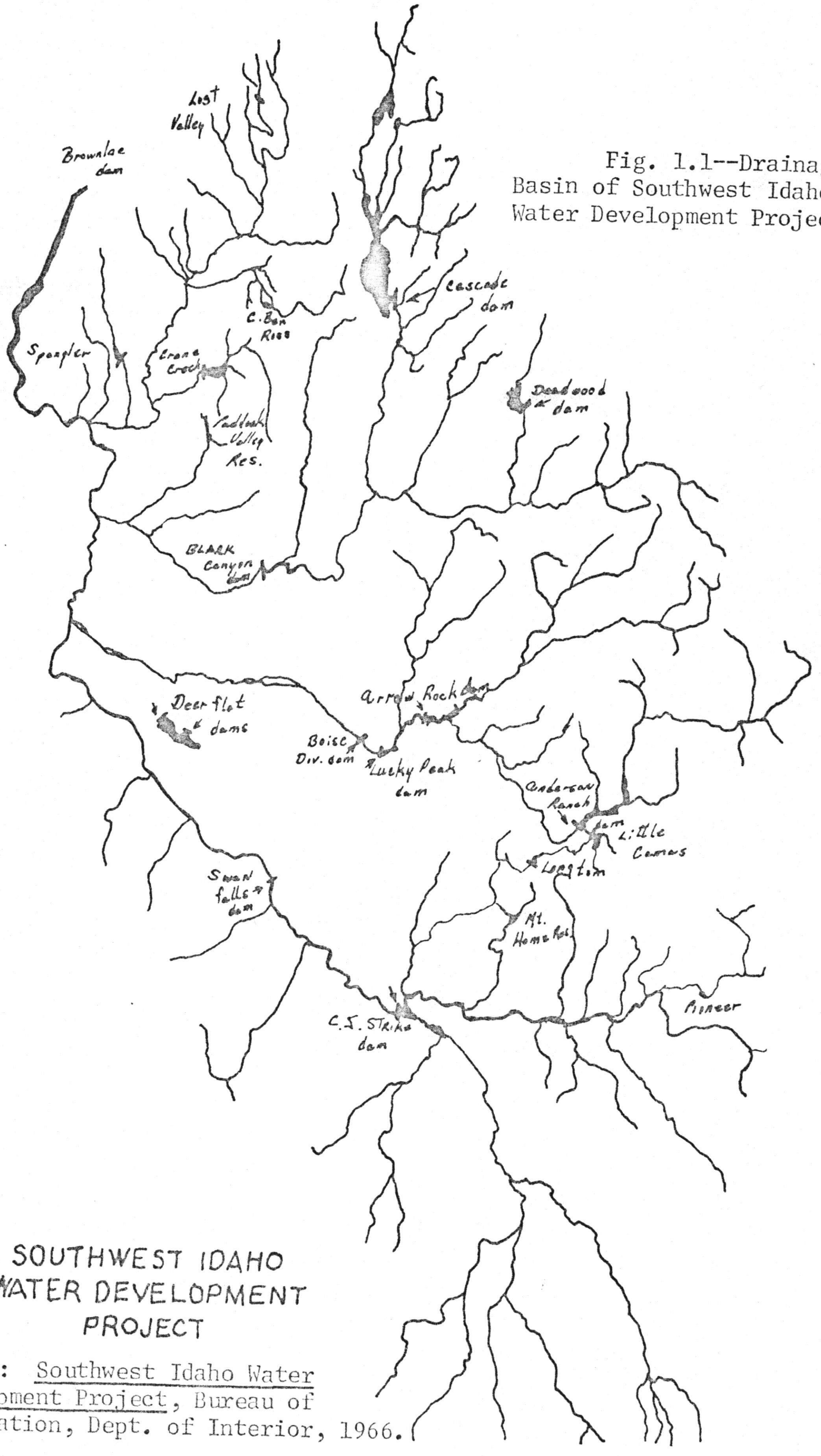
[8]Southwest Idaho Water Development Project, Idaho, U.S. Department of Interior, Bureau of Reclamation, Region 1, Boise, 1966.

[9]Idaho Session Laws; Regular 1965 and Extraordinary 1964 and 1965, Caxton Printers, Ltd., Caldwell, Idaho, p. 22.

[10]Ibid., pp. 901-902.

[11]"A Plan for Progress."

Fig. 1.1--Drainage Basin of Southwest Idaho Water Development Project.



Source: Southwest Idaho Water Development Project, Bureau of Reclamation, Dept. of Interior, 1966.

The Joint Venture Project (page 7 is a map of this project) is on the Mountain Home Desert with approximately 150,000 acres of land, 9,300 acres of which need a supplemental water supply only, planned for reclamation with the reconstruction of Swan Falls Dam below C. J. Strike Dam and the construction of Guffey Dam, a re-regulating dam. Ownership of the dams will be in the hands of the Idaho Water Resource Board and the power facilities will be owned by Idaho Power Company. Through the rental payments to the Idaho Water Resource Board by Idaho Power, the reclamation project will be funded with approximately 15,000 acres planned for reclamation annually.[12]

Objectives

The objectives of this thesis are listed as follows:

1. Determine the optimum allocation at the farm level of various resources for different farm sizes.

2. Determine the resulting effect upon commodity production as a result of varying commodity prices.

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[12] *Ibid*.

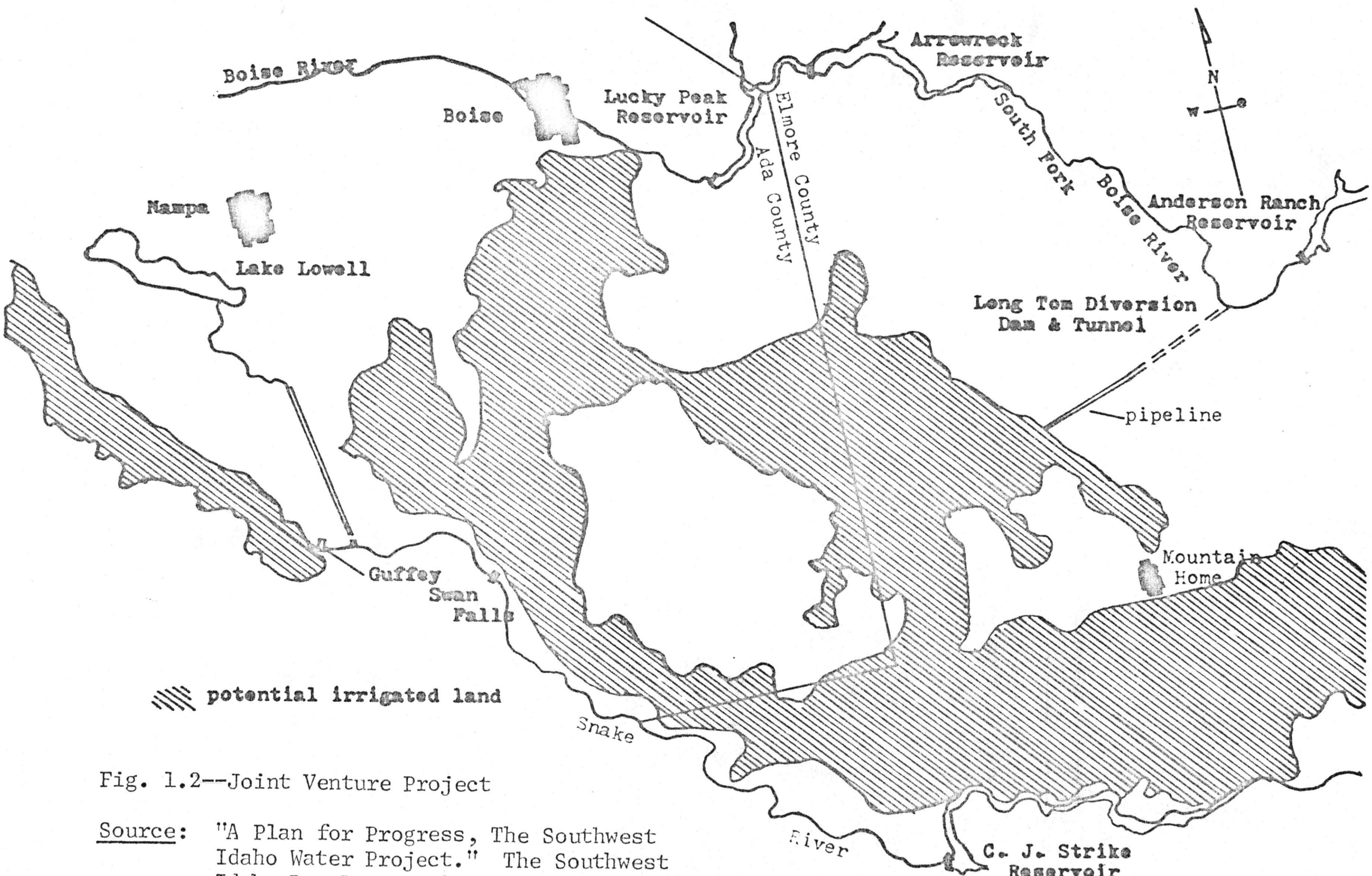

Fig. 1.2--Joint Venture Project

Source: "A Plan for Progress, The Southwest Idaho Water Project." The Southwest Idaho Development Assn., P.O. Box 581, Boise.

CHAPTER II

METHODOLOGY

The Sample

Primary data were used as an intermediate product in the process of reaching the primary objective. Because these data were not being used for a probability statement, no intentions of gathering a statistically proper sampling were attempted. Rather, a study area was selected including individual farm operations utilizing land which had the maximum amount of irrigation development in terms of topographic considerations to those operations which had only the minimal development completed necessary for irrigated farm operations. Another intentional limitation to a statistically accurate sample was the desire for the study area to be in close proximity to the proposed reclamation project. These limitations were introduced to accommodate the assumption that the actual data were transferable to the project lands.

Assumptions were also applied to the operators interviewed, which also limited a statistical sample. First, the operators whose interviews were used in the compilation of the data were assumed to be representative farmers. This implies their farming practices were similar to the majority of farm operators of the area. No limitations were attached to the amount of custom work or equipment rentals any one operation utilized. Also because small farming operations were intentionally included in the sample, no limitations were placed on the amount of income coming from sources other than farming, with the restriction that farm income appeared to be the major income producer for the operation. Many of the managers of the smaller operations interviewed obtained part-time seasonal outside employment. These limitations and restrictions mentioned above were introduced to facilitate the assumption that the operations were those of cost minimization or that of maximization of profit.

With these assumptions and limitations in mind, the agricultural areas of Meridian, Kuna, and Melba, Idaho were selected as the study area, which is west of the project lands. From lists available through the University of Idaho, operators were contacted by telephone and those who were cooperative answered questions during a personal interview. Questions pertained to such items as rotations, factor and commodity data, machinery inventories, and a detailed, step-by-step summary of farm operations performed throughout one year for each commodity grown. Also answers to questions relating to machinery size and the amount of labor spent for machinery operation and irrigation were collected.

Of the many operations contacted, 45 managers cooperated with the personal interview and of these, 39 operations were used in the final compilation of the data.

Theoretical Basis

Regression

So that the first objective retains the existing study area's range of managerial ability and economies due to the various farm sizes, regression analysis is introduced. A unit cost curve will be utilized to distribute the factor costs of production of the model farms to be developed later, in the same proportion as the factor costs of the study area. This will be done prior to optimizing the allocation of the various resources among the different enterprises of the model farms.

Size economies are defined as the changing per unit decrease in costs as output associated with these cost increases. Generally, as production increases, the cost incurred per unit of output declines to an ultimate minimum and then begins to rise. For purposes of this study, size economies are associated with varying farm acreages. Therefore, if economies of size exist, a farm of 500 acres has lower production costs per unit of output than a farm of only 100 acres.

Several reasons exist as an explanation for the existence of economies of size. Although the purpose of this thesis is not to explain this phenomenon, some reasons that can individually, or collectively, explain economies of size are given. The best known is the fixed costs, costs incurred regardless of production spread over a larger base as acreage increases. Other reasons are those arising from discounts for purchases of larger quantities of factors, identified as internal economies of size. External economies may also be a reason for economies of size, such as a personal friendship with a supplier of factors of production.

A simple curvilinear regression equation: $Y' = \frac{1}{a + bx}$, will be used to estimate the relationship between cost per dollar of farm income (Y') and acres of each farm (X). This relationship is used because interest is generated in maintaining a simple equation form rather than the predictability of the equation. The coefficient "b" represents the relationship between acres and income. A positive "b" will indicate size economies exist, the result of which will be a to the right, downward sloping curve (see Figure 2.1). This equation allows the comparison among different sized individual farms even though each farm may not produce equal acreages, amounts, or even the same combination, of various commodities by dealing primarily with cost data.

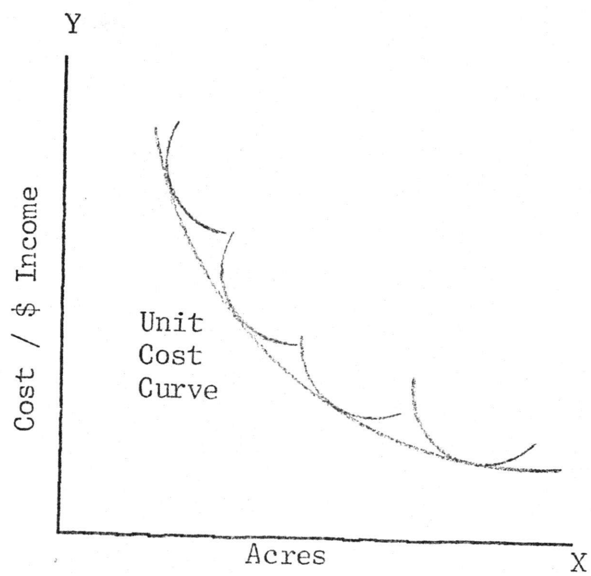

Fig. 2.1--Long Run Average Cost Curve

Activity Analysis

To optimize the various resources--land, labor, and water--in conjunction with the chosen enterprises--alfalfa, corn, mixed grain, mint, potatoes, and sugar beets--linear programming will be used. This is a purely mathematical technique that economists use to indicate what ought to be rather than what is.[13] As a result of being mathematical, no statistical confidence can be associated with the program solution. And this technique varies from pure calculus or marginal analysis in that the data utilized can be identified or classified into specific nonnegative inequalities only.[14]

This procedure combines the use of matrix algebra with these nonnegative inequalities into a method that can be described as a highly refined technique of trial and error problem solving. Highly refined in the sense each trial is closer to the final optimum solution than the previous trial.[15] The procedure is best explained in mathematical terms. Consider the following set of inequalities:

$$A_{11} + B_{12} + C_{13} + \cdots + K_{1j} \lesseqgtr X$$

$$A_{21} + B_{22} + C_{23} + \cdots + K_{2j} \lesseqgtr Y$$

$$\vdots \qquad\qquad\qquad\qquad \vdots$$

$$A_{i1} + B_{i2} + C_{i3} + \cdots + K_{ij} \lesseqgtr Z$$

The column vector to the right of the inequalities is the restrictions or constraints limiting the final solution. To the left of the inequalities is a matrix composed of rows representing point values of related functional equations and each column being the variables or real activities

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[13] William J. Baumol, Economic Theory and Operations Analysis, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1965, 2nd. ed., p. 71.

[14] J. M. Henderson and R. E. Quandt, Microeconomic Theory, A Mathematical Approach, McGraw-Hill Book Co., 2nd ed.,

[15] Boumal, op. cit., p. 74.

under investigation. To be solvable, the inequalities must be removed through the use of disposal activities. These are additional columns attached to the left side of the matrix. The number of additional columns is equal to the number of inequalities of the original functions and each vector is called a slack variable. These are introduced when maximizing the objective function to accommodate any portion of the restrictions not utilized in the optimum solution as a result of another restriction disallowing the total use of some other resource. The problem arises when the restricted resources can be used in the production of several different commodities but available resources are not sufficient to produce the desired amounts of all the commodities.

Parametric Programming[16]

Utilizing the optimal solution of the linear program as the basis, parametric programming is a tool to perform various post optimal procedures. Resource restrictions may be varied to obtain information concerning normative changes in the optimal solution as resources change in price. Another post optimal procedure allows the varying of the objective function. This thesis is primarily interested in this aspect: variable price programming.

The outcome of such a post optimal procedure yields much information. First the outcome allows the derivation of a normative, stepped supply function. It is normative in that this supply curve predicts how farmers should react to commodity price changes to maintain

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[16]Earl O. Heady and W. Candler, Linear Programming Methods, Iowa State University Press, Ames, Iowa, 1958, Ch. 8.

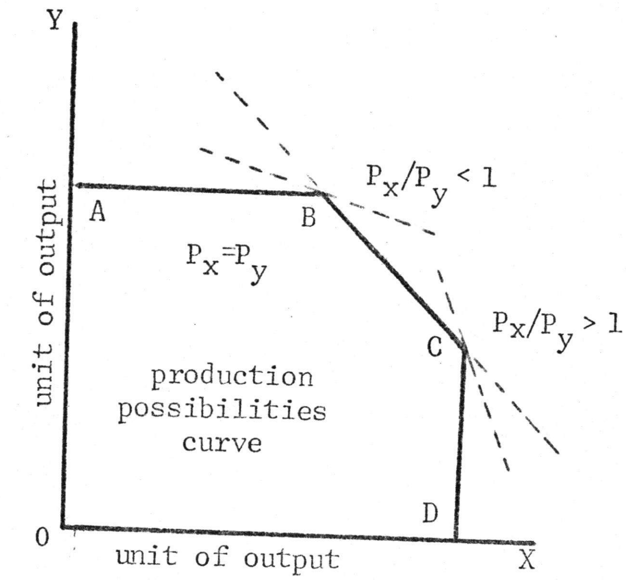

Fig. 2.2--Product/Product Graph

maximum income. It is stepped because linear programming, unlike marginal analysis, is not a continuous function but rather point values of an undetermined function.

More importantly variable pricing allows the investigation of the effect the changing of prices has on the activities. For every critical price a new optimum solution is presented in which the results are utilized in the construction of a price map.

The simplest method to explain price mapping is to begin with a simple product-product relationship and from this an uncomplicated price map can be developed. Figure 2.2 is a graph of a production possibilities curve; i.e., line ABCD, where the marginal rate of substitution of commodity X for commodity Y is equal to one. (Line segment BC has a 45 degree slope.) Considering the price ratios the three dashed lines represent the various points or corners at which income from production will be different. When the ratio P_x/P_y (Price of "x" over Price of "y") equals one, production will occur any place on the line between corners

B and C. Along this segment the price of X equals the price of Y. When the price of Y is higher than the price of X the plan at point B yields the higher income; the MRS of X for Y is greater than the X/Y price ratio. Conversely, when the price of commodity Y is less than the price of X, the plan at corner C is the optimum; i.e., the X/Y price ratio is greater than one.

Figure 2.3 contains the results of Figure 2.2. The price boundary is a 45 degree line, any point thereon represents equal prices of the two commodities, X and Y, and therefore the price ratio equals one. Any point above the price boundary line has a price ratio of less than one for P_x/P_y. This area corresponds to the corner solution "B" of Figure 2.2. That area below the price boundary line represents the optimum corner solution "C" of the preceding graph. Here the P_x/P_y ratio is greater than one.

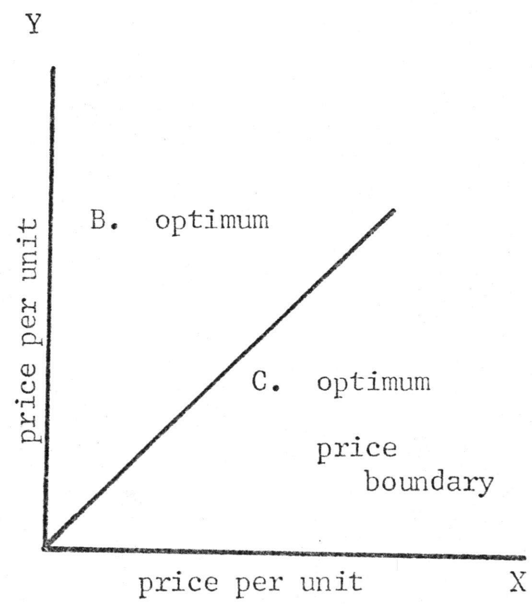

Fig. 2.3--Price Map: One Variable

It is evident that price mapping when only one or two prices of the objective function are varied is not difficult to compute or interpret. But when three or more prices are varied, the results of the linear optimum solution become very complicated and interpretation of these results is quite involved.

Data Source

Secondary data is the source of information for all the relationships, equations, and functions developed in reaching the objective of this thesis excluding the data used for the regression analysis as previously stated. Major sources are the "Annual Farm Labor Report, Idaho 1971"; "1970 Idaho Agricultural Census"; "Southwest Idaho Water Development Project"; publications of the Statistical Reporting Service, Boise; and unpublished departmental studies. The data have been analyzed, tabulated and re-arranged from their original presentation forms.

CHAPTER III

PRESENTATION OF DATA

Regression Analysis

To compare the various farms comprising the sample, a basis is necessary. The unit cost curve is a possible basis for this comparison but some data analysis is necessary before such a comparison can be of any value. Not one of the farms may be assumed to be an exact duplicate of any other farm. Each has its own combination of crops and its own acreage allotments for the specific commodities produced. The fact that some of the commodities are grown as cash crops, crops produced for immediate sale, and other crops are used in the production of other farm commodities, the value of these various crops is not equal. Nor are the production expenses associated with these various commodities equal. The income from a crop such as mint may be 300 per cent above the gross income of an equal acreage of alfalfa. But on the expenditure side, the mint may be 500 percent above the expenditures for the crop of alfalfa. In developing cost per dollar of farm income for each farm, a meaningful comparison is made by giving the high valued crops and the low valued crops the same weight.

Expenditures

The source of this primary data is the interviews with farm operators of the sample area discussed in Chapter II. The interviews were arranged for the purpose of obtaining actual data of the farm operations. Through the interviews detailed tillage practices and hourly requirements for these practices were obtained for each commodity grown by the operator. Hourly requirements were expressed in terms of the number of acres each implement was capable of tilling in one hour with a specific tractor. Also an inventory of farm equipment for each operator was obtained.

This information of tillage practices, hourly requirements, and equipment inventories, plus acres utilized in the production of each commodity is required to determine the equipment costs associated with the production of each crop. These costs are developed through the use of "Cost of Operating Farm Machinery."[17] The coefficients of this publication, which are expressed in terms of size (i.e., footage or horsepower), are increased ten percent to account for inflationary price increases occurring since the 1967 publication data. These equipment operating costs, expressed as costs per hour of operation, are composed of both fixed costs such as storage, depreciation, and insurance expenses and variable costs including expenses for fuel, repairs, and maintenance.

Once the total hours required for each tillage operation is determined, total machinery cost for each tillage operation is calculated. Repeating this procedure for each operation performed in the production of the commodity yields total machinery cost. Total machinery cost is calculated for each crop of the individual farms.

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[17]Karl H. Lindeborg, "Cost of Operating Farm Machinery," University of Idaho College of Agriculture, 1967, mimeograph.

Other factors used in the production of the various crops and the amount of application are computed. Factor costs for seed, fertilizer, and other chemicals applied are the sample area average costs incurred for the purchase of these factors. Using the operator's reported rates of application and these average factor costs, the expenditures for these factors are determined for each crop.

For the regression analysis no estimate is made for property taxes since these will most likely be different from tax liabilities existing on production lands of the sample area. No value is placed on irrigation maintenance or the cost of the water for the regression analysis. Nor is any estimate computed for the cost of the system necessary to move the water from the initial impoundment to the farm through canals and waterways. As stated previously, the state envisions the use of the dam lease payments as funds for reclamation. Because of this, difficulty arises in determining what portion of the cost of the irrigation system prospective operators will be required to incur.

Income

Table 3.1 contains coefficients used to determine incomes from the production of the various crops. Production yields are averages computed from yields reported to the interviewer. These averages are used because yield is partially dependent on the tillage practices performed by the operator. On the other hand, prices received for their production are state averages. Because some operators have facilities to store commodity production, they may speculate on commodity prices; therefore, the reported prices received for production varied

TABLE 3.1

AVERAGE IDAHO COMMODITY PRICES AND OBSERVED YIELDS OF SAMPLE AREA

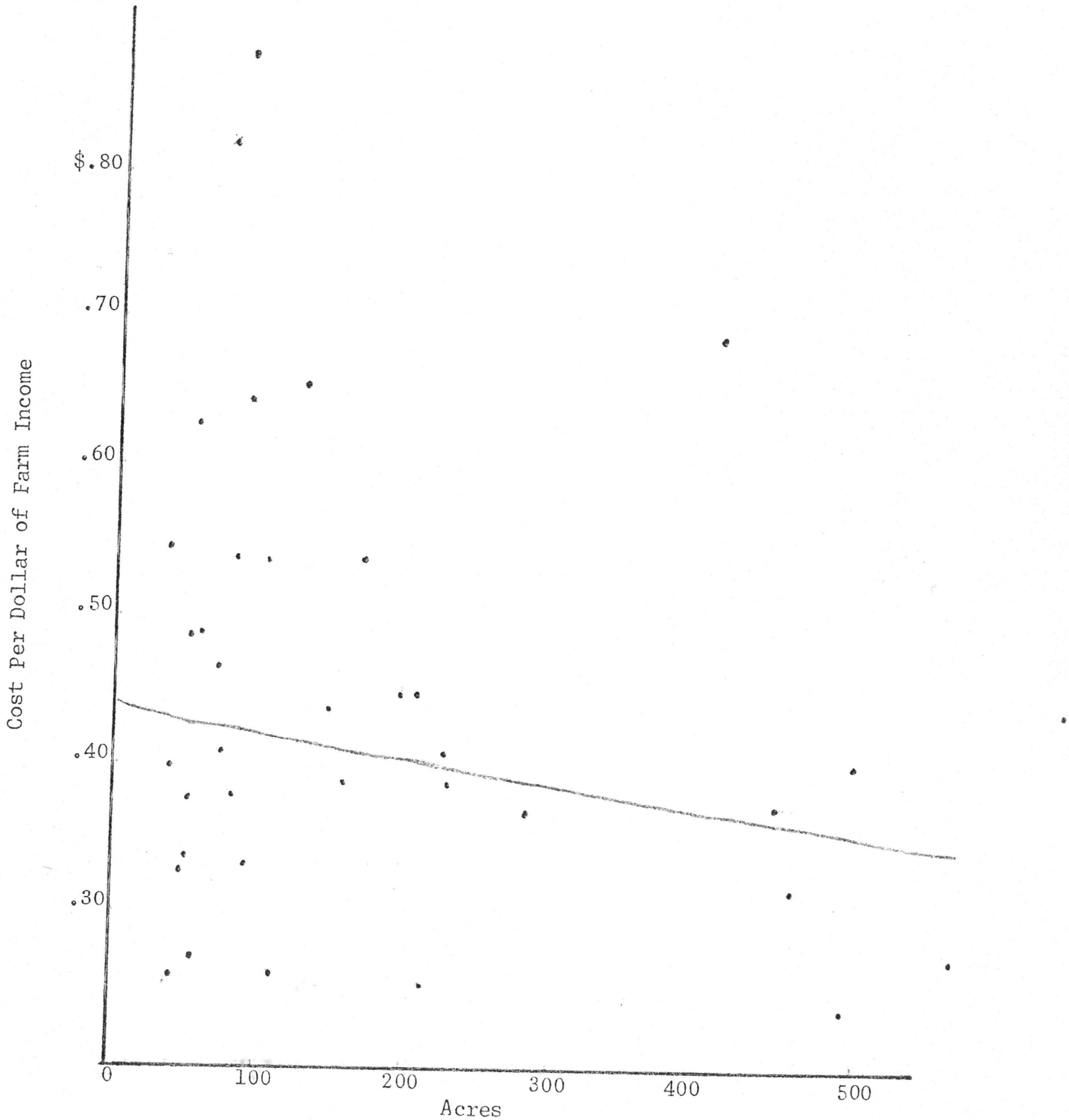
Commodity	Yield	Sales Price*
Alfalfa	5.4 T	$19.00 / T*
Silage corn	23.2 T	5.00 / T+
Mixed grain	82.1 bu.	1.07 / bu.*-
Mint	80.2 lbs	5.20 / lb.*
Potatoes	323.3 cwts.	1.61 / cwt.*
Sugar beets	22.4 T	15.40 / T+

*Source: "Idaho Annual Crop Summary, 1967," USDA, SRS.
+Personal data.
-Three commodity average.

considerably. As an attempt to eliminate this aspect from the regression analysis, average prices from state data are used. Another justification for eliminating storage is that very few of the prospective farm managers will have such facilities during the initial release of the project lands.

From the calculations of costs and incomes for the various crops of the individual farms, gross expenditures and gross income by farm is determined. Once these gross figures are calculated, division of expenditures by income produces cost per dollar of farm income which is the dependent variable of the unit cost curve. Figure 3.1 is a presentation, in the form of a scatter diagram, of the individual operator's cost per dollar of farm income. Included in the scatter diagram is the unit

Fig. 3.1--Observed Sample Area Costs Per Dollar Income and the Resulting Unit Cost Curve



cost curve developed from the regression analysis. The mathematical equation for this curve is:

$$Y' = \frac{1}{2.25616 + 0.00102X}$$

where (Y') is the cost per dollar of farm income and (X) is the acres used for the production of the commodity in question.

Activity Analysis

As discussed in Chapter II, the linear program operates as a set of homogeneous, non-negative inequalities. These inequalities are set in matrix algebra form for problem solving. The final set of inequalities combined for the linear program of this thesis is presented at the end of this section. Reference to this linear program will aid the reader in understanding the following discussions of this section.

Matrices are sets of numbers arranged in rows and columns. The matrix of the linear program developed for this thesis has columns representing various commodities or the real activities and factor coefficients comprising the rows. Besides these factor coefficients, each row has restrictions on the right-hand side of the inequality signs. These rows, including both the factor coefficients and the right-hand side restrictions, determine the optimum combination of the real activities in conjunction with the objective function.

Real Activity Selection

With various commodities being the real activities, the optimum solution will yield information pertinent to the entire project. Analysis of this information will give estimates concerning how the project lands could be distributed among the various commodities. By the inclusion of certain other aspects (which will be discussed later) as rows of the matrix, indications of income generated from agricultural production in the immediate project and estimates of population changes due to project development will be available.

Besides determining certain aspects pertinent to the entire project, information concerning the individual farm operations comprising the project would be desirable. For this information, a re-alignment of the real activities is necessary. To incorporate this aspect into the existing real activities. the various commodities are defined in terms of farm sizes. Thus two ideas are included in the real activities. This re-alignment is best explained as still defining the real activities as commodities, only now each commodity has sub-divisions of various farm sizes. Comprehension of this explanation will be enhanced by referring to Table 3.8 which presents the linear program developed for this thesis.

The idea was to include three generally assumed non-cash crops and three cash crops as the real activities of the linear program. Rather than arbitrarily select six commodities, a review of the questionnaires showed a majority of the operations were diversified into the non-cash commodity production of alfalfa, silage corn, and mixed grain. As non-cash crops these commodities are generally considered to be of more value in the production of other farm commodities, such as meat and milk, than the value of income generated through holding the commodities for immediate sale. The cash crops selected for the linear program were mint, potatoes, and sugar beets.

To give further credibility to this selection, production data of the ES-223 Reporting Area (the thirty-two county area of Idaho south of Idaho County, Idaho, and excluding Lemhi and Custer Counties, Idaho) was analyzed. Using the "Idaho Census of Agriculture, 1969,"[18] the number of harvested acres for each of these six commodities was tabulated from county data. Total acres harvested within each of these thirty-two counties were also tabulated. The results of this tabulation are presented in Table 3.2. The tabulation showed 75 percent of the total acres harvested within this thirty-two county area was for the production of these six commodities.

TABLE 3.2

ES-223 DISTRICT PRODUCTION

Commodity	Harvested Acres	Percentage Distribution of Acres
Alfalfa	632,052	29.82
Silage corn	58,150	2.74
Mixed grain	452,532	21.35
Mint	7,132	0.34
Potatoes	268,748	12.68
Sugar beets	171,529	8.09
Others	529,240	24.98
	2,119,383	100.00

Source: "Idaho Census of Agriculture, 1969," Sec. 2, Tables 3, 11, 21, and 22.

[18] Census of Agriculture, 1969, U.S. Department of Commerce, Bureau of the Census, Washington, D.C., Vol. 1; Part 39, Sec. 1 Table 9 and Sec. 2 Tables 8 and 10.

The selection of the various acreage sizes was somewhat more arbitrary. Certain Federal laws limit the maximum acres any one farm can include when federally owned land is released for agricultural development. This maximum depends upon which Federal agency has control of the land; some agencies limit the maximum to 160 acres while others have 320 acre maximums. Including these two sizes in the linear program gave rise to continuing this 160 acre progration for two additional graduations. Thus the sub-divisions were chosen to be 160, 320, 480, and 640 acres.

Objective Function Formulation

The objective function is the combination of dependent variables (real activities) which are subject to minimization or (as is the case for this thesis) maximization.[19] The coefficients of these dependent variables are expressed as returns to fixed factors of production, water purchases, and the rewards to managerial abilities of the operator.

The derivation of these coefficients begins with Table 3.3 which is a listing of average costs of production encompassing all possible farm sizes. These costs are averages compiled from data gathered in five southwestern Idaho areas. But the desire for individual operation information has demanded these coefficients of the objective function reflect farm size. Economies of size theory, referring to acres for purposes of this thesis, suggest these costs decrease in some proportion as farm acreages increase.

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[19]Alpha C. Chaing, Fundamental Methods of Mathematical Economics. McGraw-Hill, Inc., 1967, p. 231.

TABLE 3.3

AVERAGE PRODUCTION COSTS PER ACRE

Cost	Alfalfa	Silage Corn	Mixed Grain	Mint	Potatoes	Sugar Beets
Variable	$ 80.54	$ 82.12	$ 61.31	$121.21	$243.46	$193.09
Fixed	43.35	45.58	45.98	57.95	60.03	62.46
Total	$123.89	$127.70	$107.29	$179.16	$303.49	$255.55

The unit cost curve discussed in the previous section is utilized to adjust these costs rather than using an arbitrary distribution process. This procedure, although complicated to explain, adjusted the coefficients of Table 3.3 to reflect declining production costs as farm size increases. Appendix A is a presentation of the procedure used to adjust the coefficients.

The coefficients of Table 3.4 represent returns to fixed factors, water, and management. Linear programming uses non-negative inequalities; thus, the negative values of Table A.5 of Appendix A will abrogate the optimum solution. By including the fixed costs of Table 3.3 with the appropriate coefficients of Table A.5, this procedural limitation is overpowered. The objective function that results from this procedure is given in Table 3.4.

Acre Restrictions

Of the previously mentioned 150,000 acres comprising the Joint Venture Project, 130,800 acres are suitable for agricultural production.

TABLE 3.4

PER ACRE RETURNS TO MANAGEMENT, WATER, AND FIXED FACTORS

Acres	Alfalfa	Silage Corn	Mixed Grain	Mint	Potatoes	Sugar Beets
160	$ 5.91	$16.60	$12.61	$276.30	$237.68	$118.83
320	14.59	25.25	20.12	293.60	258.83	136.71
480	22.43	33.70	26.91	299.74	278.05	152.89
640	29.45	40.97	32.99	309.70	295.25	167.36

This becomes the maximum acres the optimum solution of the linear program can include.

Table 3.2 gives the percentage each commodity contributes toward the total acres of production in southern Idaho. Assuming a distribution of production acres similar to that found in Table 3.2 will prevail on the project, these percentages were applied to the 130,800 acres. These restrictions are introduced as minimum requirements in the linear program. This means that at least a specified number of acres must be assigned to a specific commodity. But the examination of the objective function coefficients for mint gives evidence the production of mint will be included in the optimum solution in a far larger acreage than the average mint production in the ES-223 District data. The reasoning: the activity with the highest coefficient of the objective function enters the maximizing solution first. With 25 percent of the 130,800 acres unspecified, mint may consume the entire 32,700 acres. If mint production is allowed to consume only the same percentage of land found in the ES-223 District, its production could not exceed 445 acres. Including an assumption that no single commodity can increase more than 100 percent from the percentages of Table 3.2, the upper limit for mint production would be 890 acres. For purposes of simplification, the maximum acres for mint production is allowed to increase to 1,000 acres.

The same reasoning for including a maximum acreage limit for mint production is the basis for including a range in the acreage that any one farm size can encompass. Unless preventive steps are included, all production will occur on 640 acre farms because the coefficients of the objective function for this size are the highest. The "Idaho Census of Agriculture, 1969" is the basis for establishing maximum and minimum acreage restrictions for the various farm sizes. Table 3.5 is a presentation of these acreage ranges.

TABLE 3.5

ACREAGE RANGE LIMITS

Theoretical Farm Size	Acres*	Irrigated Idaho Farms*	Farm Numbers Distribution	Project Acres	Project Range	
					Lower	Upper
160 acres	140-179	1,734	30.74%	40,208	35,000	45,000
320 acres	260-499	2,414	42.80%	55,982	25,000	35,000
480 acres					25,000	35,000
640 acres	500-999	1,492	26.46%	34,610	30,000	40,000
Totals		5,640	100.00%	130,800		

*Source: "Idaho Census of Agriculture, 1969," Table 2, pp. 1-2.

One additional set of limits is necessary. Nothing as yet has been included in the linear program to prevent all the production of any of the commodities from occurring on only one farm size. Assuming the non-cash crops are included as a part of the production on all farms, limits are included as restrictions to the optimum solution. An indication of this assumption are the proportionately large percentages for alfalfa and mixed grain found in Table 3.2. To prevent the occurrence of this possibility, approximations of these percentages of Table 3.2 for alfalfa and mixed grain are applied to the lower range limits of Table 3.5. This forces the inclusion of these two commodities into the optimum solution of each farm size at a minimum number of acres.

Water Restraint

The amount of water available for purposes of agricultural irrigation on the project lands is estimated to be 470,000 acre-feet. This supply is available through the enlargement of Swan Falls Dam and the construction of Guffey Dam. This value, converted to acre-inches to conform with the real activity coefficients of water, becomes the maximum amount of water the optimum solution can include.

The source of the real activity water coefficients is the weather station at Mountain Home which is located on the eastern boundary of the project lands. Table 3.6 lists the reported water requirements by crop. Because the characteristic climatic and soil conditions of the area reduces the amount of water the plant has available for use, these amounts of consumptive use must be adjusted. In this area one unit of water has suffered an average 45 percent reduction in volume by the time

TABLE 3.6

WATER REQUIREMENTS BY CROP

Commodity	Average Annual Consumptive Use	Use Distribution	Total Required Diversion
Alfalfa	29.1 acre-in.	12.5%	52.91 acre-in.
Silage corn	21.0	9.0	38.18
Mixed grain	23.0	9.9	41.82
Mint	19.2	8.3	34.91
Potatoes	26.4	11.4	48.00
Sugar beets	27.9	12.0	50.73
Others	36.9	36.9	
Total	232.2 acre-in.	100.0%	

Source: R. J. Sutter and G. L. Corey, "Consumptive Irrigation Requirements for Crops in Idaho," University of Idaho, College of Agriculture Bulletin 516, July 1970.

the plant is reached.[20] Therefore, the water coefficients of the linear program are the consumptive use values increased 55 percent to reflect the total water requirement for crops on the project lands. Utilizing these coefficients for the commodities regardless of farm size implies the operators are equally capable of applying irrigation water effectively and efficiently.

Development of Labor Restraints

The final group of restrictions is the nine months of labor requirements for March through November inclusive. The inclusion of these restraints allows some population characteristics to be estimated.

[20] Op. cit., Southwest Idaho Water Development Project, p. 3-25.

Assuming labor supplies will be available from various sources in sufficient quantities, labor will not be a restrictive factor of the optimum linear programming solution. Given this assumption, questions may arise concerning the need to include labor as part of the program. The objectives of this thesis are concerned with the primary effect to the immediate area once this reclamation project becomes a reality.

Rather than estimate the availability of labor, more meaningful information concerning labor demand can be obtained. This is accomplished by allowing the supply column (the right-hand side of the inequalities) to be sufficiently large to prevent the optimum solution of the linear program from requiring more labor than is available. Thus the computer will list the necessary labor requirements for producing the six commodities given the specific optimum solution. Also an estimate of the value of additional labor requirements can be obtained by restricting the supply of labor to be somewhat less than the labor demand determined by the computer. These values are given in the optimum solution as marginal value products or shadow prices of labor. These values have meaning only when demand for labor exceeds the labor supply.

Derivation of the labor coefficients used in the real activities is described in Appendix B. Table 3.7 results from the Appendix B procedures. Logically these coefficients should be different for various farm sizes. This distribution is accomplished through an analysis of labor requirements for different irrigated farm sizes developed by the Idaho Water Resource Board. As a result of this analysis, the hourly labor coefficients for the various commodities

TABLE 3.7

HOURLY COMMODITY LABOR REQUIREMENTS BY ACRE

Month	Crop					
	Alfalfa	Silage Corn	Mixed Grain	Mint	Potatoes	Sugar Beets
March	0.420	1.130	0.342	3.040	2.712	2.245
April	0.300	0.806	0.277	2.517	4.180	3.550
May	0.515	0.738	0.433	4.359	3.391	8.965
June	1.375	1.278	0.749	8.501	2.646	13.663
July	1.946	3.285	0.931	8.920	6.133	14.542
August	1.748	3.076	0.579	1.547	6.121	9.182
September	0.984	1.705	0.165	0.813	6.121	4.073
October	0.333	0.358	0.042	0.464	9.253	7.326
November	0.309	1.478	0.177	1.945	1.028	13.320
	7.930	13.854	3.695	32.106	41.585	76.866

given in Table 3.7 are adjusted to the coefficients found in the matrix at the end of this section.

The above discussion appears to be in conflict at one point. First the labor coefficients of the right-hand side are described as being non-restrictive. Later in the same paragraph, these same coefficients are said to be somewhat less than labor demand; therefore, these coefficients are restrictive. The implication is that two programs were submitted to the computer. This is exactly what was done. The first program is given in Table 3.8. To determine the marginal value products of the labor restrictions a second program was submitted.

TABLE 3.8

LINEAR PROGRAMMING MODEL*

Row Identification	Alfalfa Model Farm Size				Silage Corn Model Farm Size				Mixed Grain Model Farm Size				Mint Model Farm Size				Potatoes Model Farm Size				Sugar Beets Model Farm Size				Resource Supply
	160	320	480	640	160	320	480	640	160	320	480	640	160	320	480	640	160	320	480	640	160	320	480	640	
Land	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	≤ 130,000 acres
Water	52.910	52.910	52.910	52.910	38.180	38.180	38.180	38.180	41.820	41.820	41.820	41.820	34.910	34.910	34.910	34.910	48.000	48.000	48.000	48.000	50.730	50.730	50.730	50.730	≤ 5,640,000 acre-inch
Labor																									
March	0.609	0.420	0.290	0.281	1.121	1.130	0.881	0.848	0.340	0.342	0.267	0.246	3.016	3.040	2.371	2.280	1.627	2.712	2.441	2.414	1.437	2.245	1.639	1.616	≤ 395,000 hours
April	0.435	0.300	0.207	0.201	0.800	0.806	0.629	0.604	0.276	0.277	0.216	0.199	2.497	2.517	1.963	1.880	2.508	4.180	3.762	3.720	2.272	3.550	2.591	2.556	≤ 545,000 hours
May	0.747	0.515	0.355	0.345	0.732	0.738	0.576	0.554	0.431	0.433	0.338	0.312	4.324	4.359	3.400	3.269	2.035	3.391	3.052	3.018	5.738	8.965	6.544	6.455	≤ 1,170,000 hours
June	1.994	1.375	0.949	0.921	1.268	1.278	0.997	0.959	0.745	0.749	0.584	0.539	8.433	8.501	6.631	6.376	1.588	2.646	2.381	2.355	8.744	13.665	9.974	9.837	≤ 1,785,000 hours
July	2.822	1.946	1.343	1.304	3.259	3.285	2.562	2.464	0.926	0.931	0.726	0.670	8.849	8.920	6.957	6.690	3.680	6.133	5.520	5.458	9.307	14.542	10.616	10.470	≤ 1,900,000 hours
August	2.535	1.748	1.206	1.171	3.051	3.076	2.399	2.307	0.576	0.579	0.452	0.417	1.535	1.547	1.207	1.160	3.673	6.121	5.509	5.448	5.874	9.182	6.703	6.611	≤ 1,200,000 hours
September	1.427	0.984	0.679	0.659	1.691	1.705	1.330	1.279	0.164	0.165	0.129	0.119	0.806	0.813	0.634	0.610	3.673	6.121	5.509	5.448	2.607	4.073	2.973	2.933	≤ 800,000 hours
October	0.483	0.323	0.230	0.223	0.355	0.358	0.279	0.268	0.042	0.042	0.033	0.030	0.460	0.464	0.362	0.348	5.552	9.253	8.328	8.235	4.689	7.326	5.348	5.275	≤ 1,200,000 hours
November	0.448	0.309	0.213	0.207	1.466	1.478	1.153	1.108	0.176	0.177	0.138	0.127	1.929	1.945	1.517	1.459	0.617	1.028	0.925	0.915	8.525	13.320	9.724	9.590	≤ 1,740,000 hours
Alfalfa	1.000	1.000	1.000	1.000																					≥ 39,000 acres
Silage corn					1.000	1.000	1.000	1.000																	≥ 3,600 acres
Mixed grain									1.000	1.000	1.000	1.000													≥ 28,000 acres
Mint													1.000	1.000	1.000	1.000									≤ 1,000 acres
Potatoes																	1.000	1.000	1.000	1.000					≥ 16,500 acres
Sugar beets																					1.000	1.000	1.000	1.000	≥ 10,500 acres
Range-1	1.000				1.000				1.000				1.000				1.000				1.000				≤ 45,000 acres
Range-2	1.000				1.000				1.000				1.000				1.000				1.000				≥ 35,000 acres
Range-3		1.000				1.000				1.000				1.000				1.000				1.000			≤ 35,000 acres
Range-4		1.000				1.000				1.000				1.000				1.000				1.000			≥ 25,000 acres
Range-5			1.000				1.000				1.000				1.000				1.000				1.000		≤ 35,000 acres
Range-6			1.000				1.000				1.000				1.000				1.000				1.000		≥ 25,000 acres
Range-7				1.000				1.000				1.000				1.000				1.000				1.000	≤ 40,000 acres
Range-8				1.000				1.000				1.000				1.000				1.000				1.000	≥ 30,000 acres
Crop-1	1.000																								≥ 10,500 acres
Crop-2		1.000																							≥ 7,500 acres
Crop-3			1.000																						≥ 7,500 acres
Crop-4				1.000																					≥ 9,000 acres
Crop-5									1.000																≥ 7,525 acres
Crop-6										1.000															≥ 5,375 acres
Crop-7											1.000														≥ 5,375 acres
Crop-8												1.000													≥ 6,450 acres
Objective Function	5.910	14.590	22.430	29.450	16.600	25.150	33.700	40.970	12.610	20.120	26.910	32.990	276.300	293.600	299.740	309.700	237.680	258.830	278.050	295.250	118.830	136.710	152.890	167.360	

*The number of rows exceeds the number of columns.

This program contained values of the labor coefficients somewhat less than the labor demand calculated by the Table 3.8 program. Also, prior to solving for these shadow prices the Table 3.8 matrix must be realigned.

A procedural limitation of the linear programming method demands there exist an equal or greater number of unknowns (columns or real activities) than rows. Even though this limitation is not met by Table 3.8, an optimum solution was obtained. This is because the nine rows of labor were purposely included with the right-hand side coefficients being sufficiently larger than necessary to prevent these rows from being restrictive. By doing this, the program overlooked this limitation. But shadow prices are calculated by this program only when the specific rows are restrictive. By eliminating (after the optimum solution is obtained) unnecessary rows of the first program, the limitation of columns equalling the number of rows is met. And with the inclusion of the right-hand side labor coefficients lower in value than the predetermined labor demand, the second solution should provide the desired shadow prices of labor.

Parametric Linear Programming

This procedure is used to estimate commodity supply and also to gain information concerning commodity prices. As mentioned in Chapter II computer programs become very complicated even to interpret if too many variables (columns) are included. To minimize confusion, the matrix used for this procedure is limited to those columns of the Table 3.8 linear programming model referring to the 320-acre model farm.

Besides reducing the overall matrix to include only one farm size, other changes are necessary. The minimum acreage limits are removed for the crops whose commodity prices are to be varied, in this case potatoes and sugar beets. The production of these commodities would be included in the solution even when prices are zero unless this precaution is taken. Failure to eliminate these restrictions forces the producer supply curve to be a constant horizontal line. The producer supply curve for these commodities would shift only when the commodity prices had risen sufficiently to change the acres the producers are willing to use in the production of these commodities. Other than these changes, the program submitted for this procedure is the same as the Table 3.8 linear programming model.

Prior to submitting the model for computer solution, additional calculations should be made. Figure 2.3 (page 15) shows a one variable price map and, as a result, only one price boundary line. For a two variable price map, two price boundary lines exist. Rather than allow the parametric linear programming solutions to follow arbitrary lines, these price boundary lines can be predetermined and by inserting these into the model, the solutions will follow these lines.

The calculation of these lines begins with the division of the resource supply coefficients (see Table 3.9) by the respective column coefficients of the real activities to be varied. (The zero coefficients of the objective function identifies those activities to be varied.) The quotient that is lowest indicates which resource is the most restrictive, and in both instances the water resource supply is the most restrictive. A second division of the specific row

TABLE 3.9

PARAMETRIC LINEAR PROGRAMMING MODEL

Row Ident.	Alfalfa	Silage Corn	Mixed Grain	Mint	Potatoes	Sugar Beets	Resource Supply
Alfalfa	1.000						≥ 39,000 acres
Silage corn		1.000					≥ 3,600 acres
Mixed grain			1.000				≥ 28,000 acres
Mint				1.000			≤ 1,000 acres
Acres	1.000	1.000	1.000	1.000	1.000	1.000	≤ 130,800 acres
Water	52.910	38.180	41.820	34.910	48.000	50.730	≤ 5,640,000 acre-ins.
March	0.420	1.130	0.342	3.040	2.712	2.245	≤ 395,000 hours
April	0.300	0.806	0.277	2.517	4.180	3.550	≤ 545,000 hours
May	0.515	0.738	0.433	4.359	3.391	8.965	≤ 1,170,000 hours
June	1.375	1.278	0.749	8.501	2.646	13.665	≤ 1,785,000 hours
July	1.946	3.285	0.931	8.920	6.133	14.542	≤ 1,900,000 hours
August	1.748	3.706	0.579	1.547	6.121	9.182	≤ 1,200,000 hours
September	0.984	1.705	0.165	0.813	6.121	4.073	≤ 800,000 hours
October	0.330	0.358	0.042	0.464	9.253	7.326	≤ 1,200,000 hours
November	0.309	1.478	0.177	1.945	1.028	13.320	≤ 1,740,000 hours
Objective function	14.590	25.250	20.120	293.600	0.000	0.000	
Changerow 1					1.057*	1.000	
Changerow 2					0.946*	1.000	

*Rounded

coefficients of water is completed for the two real activities. These quotients are the marginal rates of substitution of one real activity for the other and also represent the slope of the respective price boundary lines. The first price boundary line calculated is the marginal rate of substitution of potatoes for sugar beets.

$$50.730 \div 48.000 = 1.05687$$

This number says that for every one unit increase in sugar beet production, a 1.05687 unit decrease in potato production must occur. This is in terms of the water supply. The other marginal rate of substitution, sugar beets for potatoes, is:

$$48.000 \div 50.730 = 0.94618$$

For every one unit increase in potato production, a corresponding 0.94618 unit decrease in sugar beet production will occur, in terms of water supply.

The variable price programming model must be run twice for solution to handle both price boundary coefficients. The first run will utilize the coefficient of 1.05687. This coefficient is placed in a row identified as "changerow" and its position within that row is the potato real activity column. This row is more of a "control" row for the program rather than a row of the resources included in the model. The second run will substitute the coefficient 0.94618 for the previous coefficient and will occupy the same position within that row.

CHAPTER IV

ANALYSIS AND CONCLUSIONS OF RESULTS

Activity Analysis

The linear programming model developed in the previous chapter utilizes various mathematical expressions of production factors for land, labor, and water as determinants of the optimum combination of the six commodities alfalfa, silage corn, mixed grain, mint, potatoes, and sugar beets. The optimum solution of this programming model is listed in Table 4.1. Rechecking the coefficients on the right-hand side of the inequalities of Table 3.8 shows the water coefficient to be 5,640,000 acre-inches. The same coefficient appears in Table 4.1. This equality indicates that the predicted water supply for the project is the most limiting production factor of those considered. As a result, the optimum solution is most dependent upon the water supply.

Optimum Solution

Euler's theorem states that the dependent variable is composed of the sum product of the marginal value products and the respective input factors of the optimum solution. The only restriction to this theorem is the assumption that the model is one using constant returns to scale (size). In linear programming this means all the point elasticities of the included variables are equal to one. In terms of the study of this thesis, Euler's theorem states that the sum of the products of those row coefficients of the solution (the independent

TABLE 4.1

OPTIMUM SOLUTION FOR MODEL FARMS

Acres of Commodity Production		Labor Requirements by Month	
Alfalfa	39,000 acres	March	140,133 hours
Silage corn	3,600 acres	April	190,987 hours
Mixed grain	28,000 acres	May	560,598 hours
Mint	1,000 acres	June	293,718 hours
Potatoes	35,427 acres	July	449,471 hours
Sugar beets	10,500 acres	August	376,822 hours
Total	117,527 acres	September	284,782 hours
Water used	5,640,000 acre-in.	October	380,266 hours
		November	175,161 hours
Returns to fixed factors, management, and water			$12,947,124.68

variables) and the respective marginal value products equals the dependent variable (the income coefficient). Several of the row coefficients and the income coefficient are found in Table 4.1. Table 4.2 is a presentation of Euler's theorem applied to the problem of this thesis.

The marginal value products (MVP's) are expressed in dollar terms because the objective function is expressed in these terms. These marginal value products are the amount of change that occurs in the income coefficient ($12,947,124.68) as a result of a single unit change of any one of the input factors. In this model, a one unit increase in a factor having a positive MVP results in a decrease in

TABLE 4.2

ECONOMIC RETURNS TO INPUT FACTORS*

Factor Identity	Amount of Factor in Solution	Factor MVP	Economic Returns
Alfalfa	39,000 acres	$-265.24161	$-10,344,446.66
Silage corn	3,600 acres	-163.94677	- 590,209.73
Mixed grain	28,000 acres	-190.32656	- 5,329,155.98
Mint	1,000 acres	115.86714	115,867.14
Sugar beets	10,500 acres	-138.91234	- 1,458,582.94
Water	5,640,000 acre-inches	6.15104	34,691,865.00
Range 2	35,000 acres	- 54.30	- 1,900,500.00
Range 4	25,000 acres	- 36.42	- 910,500.00
Range 6	25,000 acres	- 17.20	- 430,000.00
Crop 2	7,500 acres	- 9.20	- 69,000.00
Crop 3	7,500 acres	- 20.58	- 154,350.00
Crop 4	9,000 acres	- 30.76	- 276,840.00
Crop 6	5,375 acres	- 10.37	- 55,738.75
Crop 7	5,375 acres	- 22.80	- 122,500.00
Crop 8	6,450 acres	- 33.92	- 218,784.00
Total			$ 12,947,124.68
Returns to fixed factors, management & water			$ 12,947,124.68

*Input factors with corresponding MVP's equal to zero are excluded from the table.

the income coefficient an amount equal to that MVP. For negative MVP's, a one unit increase in the factor use results in an increase equal to the respective MVP of the income coefficient.

In Table 4.2 only the two resources "mint" and "water" have positive values. These resources were included in the linear programming model with maximum restrictions. That is to say only a limited amount of each of these resources could be included in the optimum solution. The positive MVP's result from these resources being included at the maximum restriction in the optimum solution at a less than "best" combination of these two resources. This does not imply that the solution is not an optimum solution but this does indicate a more optimum solution is possible by the relaxation of these two resource restrictions.

The specific changes of the income coefficient resulting from changes in the resource mix of the optimum solution is valid over a relatively small range only. The MVP coefficients change if a significant change is allowed to occur in the resource mix of the optimum solution. This range over which the MVP's and, as a result, the income coefficient will remain stable is given in Table 4.3. Changing any one of these resource (row) coefficients of the optimum solution by an amount sufficient to move this resource outside the specified range results in a corresponding marginal value product changing. The possibility exists for several of the MVP's to change as a result of adjusting just one of the resource coefficients to be outside its range.

The result of this analysis is that the optimum solution is unstable. This is indicated by the relatively limited amount any of the resources can vary without altering the optimum solution. In all

TABLE 4.3

ALLOWABLE RANGE IN RESOURCES OVER WHICH THE OPTIMUM SOLUTION IS STABLE*

Resources	Amount of Resource in the Solution	Resource Range	
		Lower Limit	Upper Limit
Water	5,640,000 acre-inches	5,518,673	5,998,673
Land	117,527 acres	115,000	118,469
Labor			
March	140,133 hours	139,349	140,886
April	190,987 hours	189,729	192,150
May	560,598 hours	386,253	630,113
June	293,719 hours	288,866	311,488
July	449,472 hours	444,308	462,269
August	376,822 hours	373,526	380,778
September	284,782 hours	283,323	287,146
October	380,266 hours	377,633	384,177
November	175,162 hours	170,383	195,328

*Artificial resources (the other remaining rows) are excluded from this table.

but four of the resources--water and the months of labor May, June, and November--the difference between the upper and lower limits of each resource is limited to less than 2 percent of its optimum solution demand. In addition the amounts of resources demanded are relatively close to their lower range limits which indicates another restriction to the stability of the optimum solution.

TABLE 4.4

ALLOWABLE RANGE OF NET RETURNS PER ACRE OVER WHICH THE OPTIMUM SOLUTION REMAINS STABLE

Commodity	Model Farm Size	Commodity Per Acre Income at Solution	Per Acre Income Range	
			Lower Limit	Upper Limit
Alfalfa	160	$ 5.91	- $ 3.29	$ 271.15
	320	14.59	- infinity	23.79
	480	22.43	- infinity	43.01
	640	29.45	- infinity	60.21
Silage corn	160	$ 16.60	- $ 7.37	$ 180.55
	320	25.25	- infinity	34.48
	480	33.70	- infinity	53.70
	640	40.97	- infinity	70.90
Mixed grain	160	$ 12.61	$ 2.24	$ 202.94
	320	20.12	- infinity	30.49
	480	26.91	- infinity	49.71
	640	32.99	- infinity	66.91
Mint	160	$276.30	$275.72	+ infinity
	320	293.60	- infinity	$ 294.18
	480	299.74	- infinity	313.40
	640	309.70	- infinity	330.60
Potatoes	160	$237.68	- infinity	$ 240.95
	320	258.83	$255.56	261.87
	480	278.05	275.01	295.25
	640	295.25	289.48	1,096.62
Sugar beets	160	$118.83	$115.56	$ 119.41
	320	136.71	136.13	139.98
	480	152.89	- infinity	155.93
	640	167.36	- infinity	173.13

In addition to resources, the coefficients of the objective function can be subjected to the same analysis. These coefficients refer to the returns to fixed factors, water, and management. The result of the price sensitivity analysis indicates the optimum solution is unstable. Several of the coefficients at the optimum solution can change only a few dollars before the solution would be altered.

The results of the resource (Table 4.3) and price sensitivity (Table 4.4) analyses lead to the conclusion that the optimum solution of this linear programming model is very unstable. A relatively small fluctuation in a single resource or net returns coefficients could cause a noticeable alteration in the optimum solution. The change would be most noticeable in the real and artificial resource mix (the amounts each resource contributes in the solution) and secondly the income coefficient of the optimum solution. These noticeable changes are dependent on the exact structure of the linear programming model.

Throughout the following sections of analyses developed from this optimum solution, emphasis of the importance of this instability of the optimum solution should not be neglected. The data are valid for only a limited range in both resources and the coefficients of the objective function.

Commodity Production

Of the 130,800 acres available for agricultural production on the project, the available water supply limits the total production acreage to 117,527 acres. (The resulting limitation, as all other results of the linear programming model, is valid only in conjunction with the specific coefficients utilized in the model developed for this study.) Because insufficient water is available, production is limited to 89.85 percent of the available agricultural land of the project.

The results of the linear programming model provided a classification of the production acreage by model farm sizes. This classification is presented in Table 4.5. The idle acres of this table are derived from the 10.15 percent of the total acres left out of production as a result of inadequate irrigation water. The actual idle acreage for each model farm size is derived by applying the 10.15 percentage to the respective total production acreages of each model farm size.

TABLE 4.5

COMMODITY ACREAGES BY MODEL FARMS

Commodity	Model Farm Size				Totals
	160 Acre	320 Acre	480 Acre	640 Acre	
Alfalfa	15,000	7,500	7,500	9,000	39,000
Silage corn	3,600				3,600
Mixed grain	10,800	5,375	5,375	6,450	28,000
Mint	1,000				1,000
Potatoes		6,225	12,125	17,077	35,427
Sugar beets	4,600	5,900			10,500
Prod. Acres	35,000	25,000	25,000	32,527	117,527
Idle acres	3,952	2,823	2,823	3,674	13,272
Total acres	38,952	27,823	27,823	36,201	130,799

Analyzing Table 4.5 shows that as farm size increases the operators become more specialized in their farming practices. As farm size increases, the operators produce a lesser variety of commodities. (The percentages of Table 4.9 are the basis of these conclusions of commodity mix and the associated risks.) Also, more risk is absorbed by the operators as farm size increases. This is implied in two ways. First the production of fewer commodities increases the risks to the operator of income reductions through the possibility of crop failures and low commodity prices. Secondly, the risk of low commodity prices is increased further. As size of the model farms increases the percentage of land utilized for cash crops also increases (see Table 4.9). As a result, the opportunity to reduce or regain this possible loss through the production of other livestock agricultural products is lost. Another implication of this greater number of acres utilized for the production of cash crops infers a greater ability on the part of these operators to obtain production capital. This is implied by the fact that production costs of cash crops are higher than production costs of non-cash crops.

Further analysis of the optimum solution provides an estimate of the total production of the six commodities. Using average yield information gathered in the sample area in conjunction with acreage predictions of the optimum solution, commodity production resulting from implementing the Joint Venture Project is estimated. This projection is presented in Table 4.6, which illustrates the magnitude of the primary effects of agricultural production to the immediate area upon completion of the project. Additional indications of this agricultural effect to the immediate area are developed in the following sections of the chapter.

Population Changes

The number of farms the project may include is available for the optimum solution of the linear programming model developed. Table 4.7 presents a possible 444 individual farm operations assuming the optimum

TABLE 4.6

COMMODITY PRODUCTION ON PROJECT

Commodity	Average Yield/Acre	Commodity Acreage	Projected Production
Alfalfa	5.4 tons	39,000 acres	210,000 tons
Silage corn	23.2 tons	3,600 acres	83,520 tons
Mixed grain	82.1 bus.	28,000 acres	2,298,800 bus.
Mint	80.2 lbs.	1,000 acres	80,200 lbs.
Potatoes	323.2 cwts.	35,427 acres	661,068 tons
Sugar beets	22.4 tons	10,500 acres	235,200 tons

solution of the linear programming model given in Table 3.8. This should not be construed as being any indication of the maximum number of farms possible or even the optimum combination of farm sizes of the project. Numerous possibilities exist as to the number of individual farms the project can include. By varying the size of the model farms included in the linear programming model, numerous and significant changes will occur in all aspects of the optimum solution. Rather than dwell on these resulting changes by varying the model farms, the analyses and conclusions drawn are based on the optimum solution of the linear programming model given in Table 3.8.

With the inclusion of a few assumptions, prediction of the actual population comprising these farms is possible. Assuming that regulations pertaining to the settlement of this project includes the limitation that each farm must initially be managed by a single household, independent of the other operations, aids in the determination of population

TABLE 4.7

POSSIBLE NUMBER OF FARMS

Model Farm Size	Total Acres	Model Farms
160	38,952	243
320	27,823	87
480	27,823	58
640	36,201	56
Total number of farms		444

numbers. As a result, this assumption specifies a minimum number of farms would exist on the project at least for the development stages of the project. Also, the assumption the average farm family is composed of four members is necessary. With these two assumptions the farm family population would initially be approximated at 1,776 persons for the linear programming model's solution.

Population changes other than farm families would also result from the off-farm labor supplies needed to assist the farm families in the production of the agricultural commodities. Total hours of labor required for the production of the commodity combination of the optimum solution is part of the linear programming solution. Table 4.8 shows a demand for as many as 2,825 workers during peak labor periods. Included in this total is operator and family labor, in addition to the off-farm labor numbers necessary for agricultural production.

TABLE 4.8

PROJECT AGRICULTURAL LABOR DEMAND

Month	Total Labor Requirement* (hrs.)	Average Hrs./Mo. Worked by All Labor**	Total Labor Numbers
March	140,133	177.32	790
April	190,987	187.91	1,016
May	560,598	198.44	2,825
June	293,718	193.93	1,515
July	449,471	203.28	2,212
August	376,822	202.40	1,862
September	284,782	173.29	1,643
October	380,266	172.92	2,199
November	175,161	149.21	1,174
Total accumulated workers			15,236
Average workers by month			1,692

*Source--The optimum solution, Table 4.1.
**Source Table B.4.

As an average, 28 percent of the total agricultural employment in Idaho during 1970 was composed of hired workers.[21] Family labor, comprising the other 72 percent, is defined as those operators contributing one hour and all other family members contributing fifteen hours or more of work each week to the farm but not receiving cash wages for their services. Then a maximum of 635 (2,825 x 28%) farm

[21] Agricultural Statistics, 1971, U.S. Department of Agriculture, Washington, D.C., 1971, Table 649, p. 453.

labor positions, or an average of 474 (1,692 x 28%) laborers per month, would be created as a result of the linear programming solution. These positions would be filled from off-farm labor supplies if the definition for family labor is applied.

Carrying further the assumption that the average family size of four members applies to all families, a possible maximum population increase of 2,540 persons would result from the labor demands for primary agricultural production on the project lands. This is assuming only one member of each family fills these farm labor positions. Applying this linear programming solution to population predictions, the project could sustain a livelihood for 4,316 persons, or 1,079 families. This would be an increase due to just the primary agricultural effect of opening, and settling, the project lands.

Agricultural Income

The $12,947,124.68 income of Table 4.1 refers to the net returns to fixed factors of production, water purchases, and management. This income does not reflect net income resulting from commodity production on the project lands. To reflect net returns to management and water purchases, the fixed costs associated with the specific commodity production must be subtracted from the income coefficient given in Table 4.1. This exclusion is accomplished in Table 4.9. The coefficients of the column listing per acre returns to the variable costs of production are the coefficients of the objective function of the linear programming model.

TABLE 4.9

MODEL FARM PLANS AND RETURNS TO MANAGEMENT AND WATER

Commodity	Total Acres of Commodity	% Crop Acreage is of Total	Commodity Acreage Per Farm	/Acre Return to Variable Costs	Total Returns/ Commodity
160 Acre Model Farm					
Alfalfa	15,000	38.51	62	$ 5.91	$ 366.42
Silage corn	3,600	9.24	15	16.60	249.00
Mixed grain	10,500	27.73	44	12.61	554.84
Mint	1,000	2.57	4	276.30	1,106.72
Potatoes				237.68	
Sugar beets	4,600	11.81	19	118.83	2,257.77
Idle	3,952	10.15	16	0.00	
Totals	38,952	100.01	160		$ 4,534.75
Total fixed costs of production					-6,814.58
Total net returns to management and water					$-2,279.83
Avg./acre net returns to management & water--160 acres					$- 14.25
320 Acre Model Farm					
Alfalfa	7,500	26.96	86	$ 14.59	$ 1,254.74
Silage corn				25.25	
Mixed grain	5,375	19.32	62	20.12	1,247.44
Mint				293.60	
Potatoes	6,225	22.37	72	258.83	18,635.76
Sugar beets	5,900	21.20	68	136.71	9,296.28
Idle	2,823	10.15	32	0.00	
Totals	27,823	100.00	320		$30,434.22
Total fixed costs of production					-15,148.30
Total net returns to management and water					~~$15,148.30~~ 15,285.91
Avg./acre net returns to management & water--320 acres					$ 47.77

TABLE 4.9--Continued

Commodity	Total Acres of Commodity	% Crop Acreage is of Total	Commodity Acreage Per Farm	/Acre Return to Variable Costs	Total Returns/ Commodity
		480 Acre Model Farm			
Alfalfa	7,500	26.96	130	$ 22.43	$ 2,915.90
Silage corn				33.70	
Mixed grain	5,375	19.32	93	26.91	2,502.63
Mint				299.74	
Potatoes	12,125	43.57	209	278.05	58,112.45
Sugar beets				152.89	
Idle	2,823	10.15	48	0.00	
Totals	27,823	100.00	480		$ 63,530.98
Total fixed costs of production					$-22,457.91
Total net returns to management and water					$ 41,073.07
Avg./acre net returns to management & water--480 acres					$ 85.57
		640 Acre Model Farm			
Alfalfa	9,000	24.86	160	$ 29.45	$ 4,712.00
Silage corn				40.97	
Mixed grain	6,450	17.82	114	32.99	3,760.86
Mint				309.70	
Potatoes	17,077	47.17	302	295.25	89,165.50
Sugar beets				167.36	
Idle	3,674	10.15	64	0.00	
Totals	36,201	100.00	640		$ 97,638.36
Total fixed costs of production					-29,754.38
Total net returns to management and water					$ 67,883.98
Avg./acre net returns to management & water--640 acres					$ 106.07

Table 4.9 lists total net returns to management and water purchases for the actual production acres of each model farm plus the average net returns per acre for the total acres of each of the four model farms. The 160 acre model farm shows a negative net return. An explanation for this conclusion is found in the large portion of the acres of this farm being utilized for the production of non-cash crops. The net returns are calculated using actual cash values for these non-cash commodities rather than the value these commodities would receive by using them on that farm for the production of other agricultural products such as milk or meat. An assumption that small farms, with excess on-farm labor supplies during some seasons, would be diversified into such secondary production practices appears to be logical.

The other model farms show positive net returns to management and water purchases. These net returns are shown to increase as acreage increases which conforms with the economic theory of the inverse relationship of production costs and farm size. This theory states that as farm size increases, the associated production costs decline to some minimum point.

Table 4.10 shows a total net return, as a result of primary agricultural production on the project, to be $6,959,617.29. From this figure deductions would be made for water expense. Labor expenses for both the manager and his hired labor have previously been included in the model through the coefficients of the objective function. Therefore, considerations of an appropriate amount as rewards to the management abilities of the operator should be adjusted accordingly.

TABLE 4.10

TOTAL NET RETURNS TO MANAGEMENT AND WATER DUE TO PRIMARY AGRICULTURAL PRODUCTION ON THE PROJECT

Model Farm	Net Returns Per Farm	Number of Farms	Project Net Returns
160 acres	$- 2,279.83	243	$- 553,998.69
320 acres	15,285.92	87	1,329,875.04
480 acres	41,073.07	58	2,382,238.06
640 acres	67,883.98	56	3,801,502.88
Total net returns to management and water			$ 6,959,617.29

As for the value of hired labor, secondary production data published for Elmore County, Idaho, is used.[22] By converting gross agricultural income and total hired labor expense data into individual farm averages, the incurred hired labor expense is developed as a percentage of the farm's gross agricultural income. This calculation is presented below:

Gross Ag. income ($24,570,000) ÷ number of farms reporting (187)
Total labor exp. ($ 1,867,640) ÷ number of farms reporting (125)
$14,941.12 ÷ $131,390.37 = 11.4%

Total expense for hired labor is 11 percent of the farm's gross income. The result of this procedure projects the total labor expense for all hired employees to be $3,557,122.12--Table 4.11.

The intention was to compare this labor value with the shadow prices of labor found in the solution of the linear programming model. The method of procedure to obtain these shadow prices was discussed

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[22] Op. cit. Census of Agriculture, Sec. 2, Tables 13 and 14, pp. 164, 165.

TABLE 4.11

VALUE OF LABOR EXPENDED FOR PRIMARY AGRICULTURAL PRODUCTION ON PROJECT

Commodity	Projected Production	Commodity Selling Price	Projected Gross Income
Alfalfa	210,000 tons	$19.00 / T	$ 3,990,000.00
Silage corn	83,520 tons	5.00 / T	417,600.00
Mixed grain	2,298,800 bus.	1.07 / bu.	2,459,716.00
Mint	80,200 lbs.	5.20 / lb.	417,040.00
Potatoes	661,068 tons	32.20 / T	21,286,389.60
Sugar beets	235,200 tons	15.40 / T	3,622,080.00
Gross agricultural income on project			$31,202,825.60
Percentage labor expense is of gross income			11.4%
Total hired labor expense			$ 3,557,122.12

on page 31. These shadow prices were not developed because of the linear programming model itself. Attempting to solve for these shadow prices without changing the optimum solution limited the resource range of the labor supplies to that of Table 4.3. These ranges still allowed numerous combinations of labor supplies to be available. Regardless of which month became restrictive first, the remaining eight months had surplus labor supplies. Only one month of labor was found to be restrictive at any one solution since that month determined total acres of production and this in turn limited the amount of labor necessary in the other eight months. By reducing supplies of the remaining eight months to the point where one of these months became restrictive, caused the first month to be non-restrictive. Thus the shadow prices were not available using the procedure described. Because of this, no comparison of these values of the labor supply and shadow prices of labor by month is available.

From the above calculations the net returns to the project for primary agricultural production and the associated labor requirements is estimated to be $10,516,739.41. The cost of the water still remains to be deducted from this value.

Value of Water

The optimum solution of the linear programming model valued an additional acre-inch of water for irrigation purposes at $6.15. This corresponds to $73.80 per acre-foot. A reminder of the instability of the optimum solution is given here. Besides the instability of the solution, this value retains the cost of the fixed factors of production. The average fixed costs of production per acre are calculated to be $50.90 as in Table 4.13. Reducing the water value of the linear programming model by this amount results in a value of $22.90 per acre-foot of irrigation water and management of the farm operations. This compares with $23.12 per acre-foot for the 320 acre farm in the Dry Lake area of southern Idaho.[23] This area was included in the sample area of this thesis. Assuming management to have a value of $20.00 per acre and an average of three acre-feet of water is used by the plant per acre, then the value of water could be ($22.90 - [$20.00 ÷ 3]) $16.24 per acre foot.

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[23] Karl H. Lindeborg, "Economic Values of Irrigation Water in Four Areas along the Snake River in Idaho," Idaho Ag. Exp. Sta. Bulletin 513, January 1970, p. 18.

TABLE 4.12

AVERAGE FIXED COSTS PER ACRE OF PRODUCTION

Commodity	Fixed Cost Per Acre	Commodity Acreage	Fixed Cost/ Commodity
Alfalfa	$43.35	39,000	$1,690,650.00
Silage corn	45.58	3,600	164,088.00
Mixed grain	45.98	28,000	1,287,440.00
Mint	57.95	1,000	57,950.00
Potatoes	60.03	35,427	2,126,682.81
Sugar beets	62.46	10,500	655,830.00
Total		117,427	$5,982,640.81*
Average fixed costs of production/acre			$ 50.90

*Total fixed costs plus projected net returns to management and water (Table 4.10) do not sum to equal the optimum solution income of Table 4.2 because farm numbers of Table 4.10 are rounded back to the nearest whole number.

Parametric Linear Programming Analysis

Figure 4.1 is the price map resulting from the solutions of the parametric linear programming procedures. The border solutions of the programming model followed the line segments "DB" and "DC." When the commodity mix changed as a result of the changing prices of the two commodities being studied, the borders of the various plans are determined. Within each of these plans the commodity mix remains constant even when the values of the variable priced commodities fluctuate within the

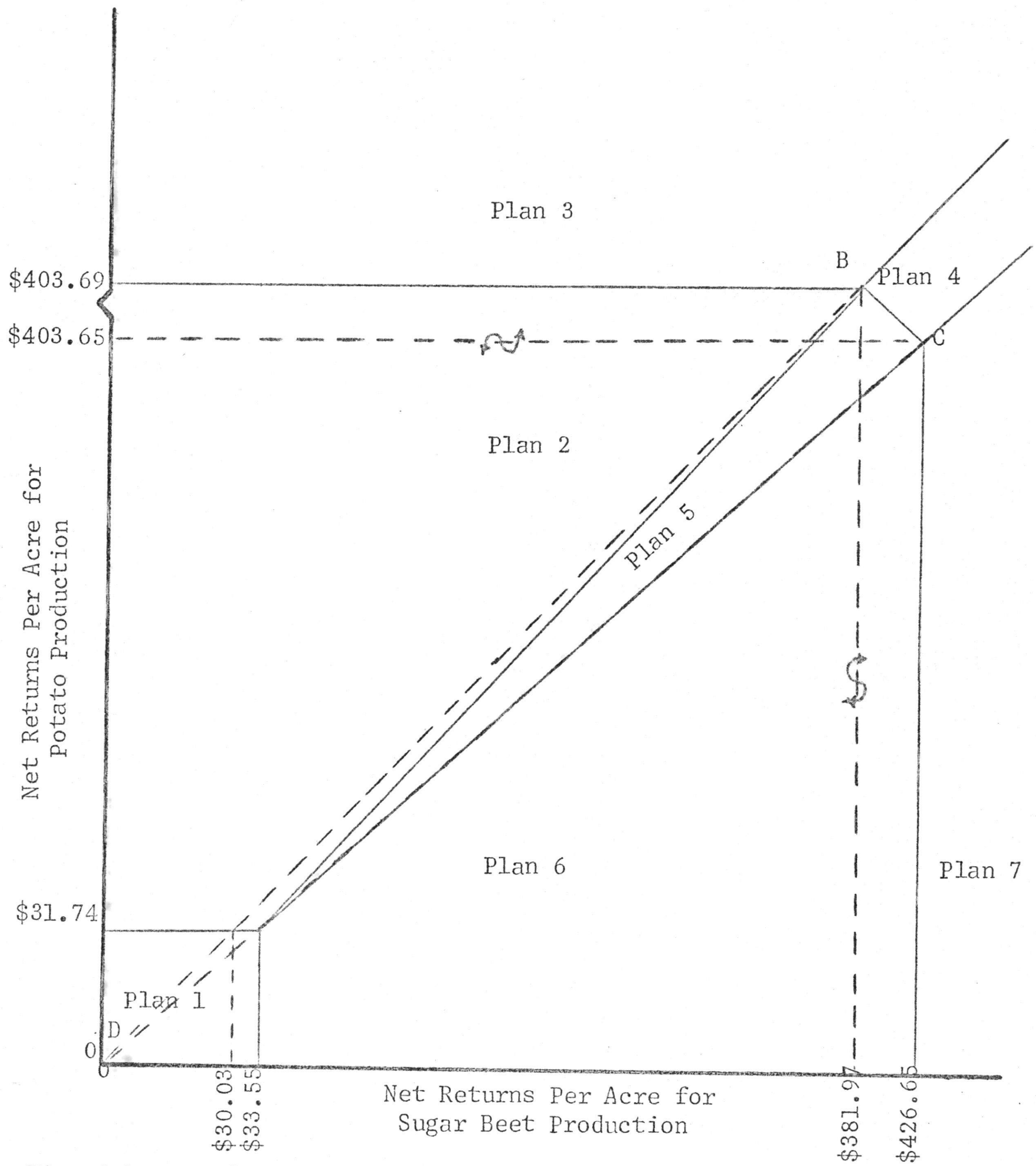

Fig. 4.1--Variable Price Map for Potato and Sugar Beet Production*

*Price refers to net returns to fixed factors of production, management, and water.

established price range as determined by the boundaries of the plans. These boundaries are the continuous line segments of Figure 4.1.

The coefficients used in this programming model are net returns to the fixed costs of production, management and water. The specific value of these coefficients for the various plans is presented in Table 4.13. In addition, the price ranges of potatoes and sugar beets are given. These price ranges are the boundaries of the various plans of Figure 4.1.

TABLE 4.13

NET RETURNS PER ACRE TO FIXED FACTORS, MANAGEMENT AND WATER

Plan	Alfalfa	Silage Corn	Mixed Grain	Mint	Price Range			
					Potatoes		Sugar Beets	
					Low	High	Low	High
1	$14.59	$25.25	$20.12	$293.60	$ 0	$ 31,74	$ 0	$ 33.55
2	14.59	25.25	20.12	293.60	31.74	403.69	33.55	381.97
3	14.59	25.25	20.12	293.60	403.69	+ ∞	381.97	+ ∞
4	14.59	25.25	20.12	293.60	403.65	+ ∞	381.97	+ ∞
5	14.59	25.25	20.12	293.60	31.74	403.69	33.55	426.65
6	14.59	25.25	20.12	293.60	31.74	403.65	33.55	426.65
7	14.59	25.25	20.12	293.60	403.65	+ ∞	426.65	+ ∞

Within the seven plans, the commodity mix remains constant, but the net returns for potato and sugar beet production vary, as is illustrated in Table 4.13. At each of the critical points (points A, B, and C) the commodity mix of the adjoining plans produces equal total net returns to the fixed factors of production, management, and water for the total production regardless of the plan. Table 4.14 presents the acreage combinations of the various plans. For plan 4 and 5 simultaneous equation formulation is used to determine the commodity mixes. From the price map the acreage and price coefficients of the four constant priced commodities are known. Also the price map gives the commodity prices for the two unknown acreages. By formulating equations for each critical point, two equations can be developed that have the same acreage combinations of potato and sugar beet production. The equations are:

Plan 4

point B \$403.69 potato + \$381.96 sugar beet = \$19,074,946.24
point C \$403.65 potato + \$426.65 sugar beet = \$19,074,946.24

Plan 5

point B \$403.69 potato + \$381.96 sugar beet = \$18,781,586.25
point C \$403.65 potato + \$426.65 sugar beet = \$18,781,586.25

The solutions are given in Table 4.14.

TABLE 4.14

TOTAL ACREAGES OF COMMODITY PRODUCTION

Plan	Alfalfa	Silage Corn	Mixed Grain	Mint	Potato	Sugar Beets
1	39,000	62,091	28,000	1,000	000	000
2	39,000	3,600	28,000	1,000	46,525	000
3	39,000	3,600	28,000	000	47,252	000
4	39,000	3,600	28,000	000	47,215	38
5	39,000	3,600	28,000	1,000	46,484	42
6	39,000	3,600	28,000	1,000	000	44,021
7	39,000	3,600	28,000	000	000	44,709

Although at each critical point the various plans yield equal total net returns to the fixed factors of production, management, and water, these same plans do not generate equal net returns to management and water. This is a result of the unequal fixed production costs of the various commodities. The consequence of this inequality of fixed production costs is that within each critical point, there is one plan that yields higher net returns to management and water than the other plans of that critical point. Plans 1, 3, and 7 are the most advantageous production plans for the three critical points established by the parametric linear programming model.

The information contained in Tables 4.13 and 4.14 results in stepped supply functions for potato (Figs. 4.2a, b) and sugar beet (Figs. 4.3a, b) production. The resulting supply functions are the amount of production of the two commodities producers are willing to supply at the specified prices. From these graphs, the conclusion is that the production of these two commodities is quite stable. Once the commodity enters the production plan, subsequent price increases do not significantly change the production acreages utilized for the commodities. A logical explanation of this conclusion is the relatively high production costs associated with each commodity. Once either commodity is included in the production plan, production factors warrant a large acreage of that commodity. And a large price increase must be realized before the production factors can be justifiably increased.

Comparing the two commodities with one another indicates that potatoes are the more advantageous commodity to produce. This is implied in plans 4 and 5 of Table 4.13. Even though prices of both commodities are such that (on the basis of net returns per acre) the two commodities are competitive for production acreage, potatoes are chosen. This can partially be explained through the higher fixed costs of sugar beet production and, more significantly, in the larger irrigation requirement of sugar beets. In terms of acre-feet of water, more income is realized from potato production.

The marginal value product of water verifies this conclusion. With irrigation supply being the most restrictive resource, the MVP per acre-inch of water for potato production is 1.10091. This translates into a $1.10091 increase in the net returns to the fixed factors of production, management, and water for every additional acre of potato production included in the production plan. The MVP of water per acre-inch for sugar beet production is 0.98561. In other words, the producer is gaining slightly more than eleven and one-half cents in net returns for each acre of potato production he substitutes for sugar beet production in his farm plans of production.

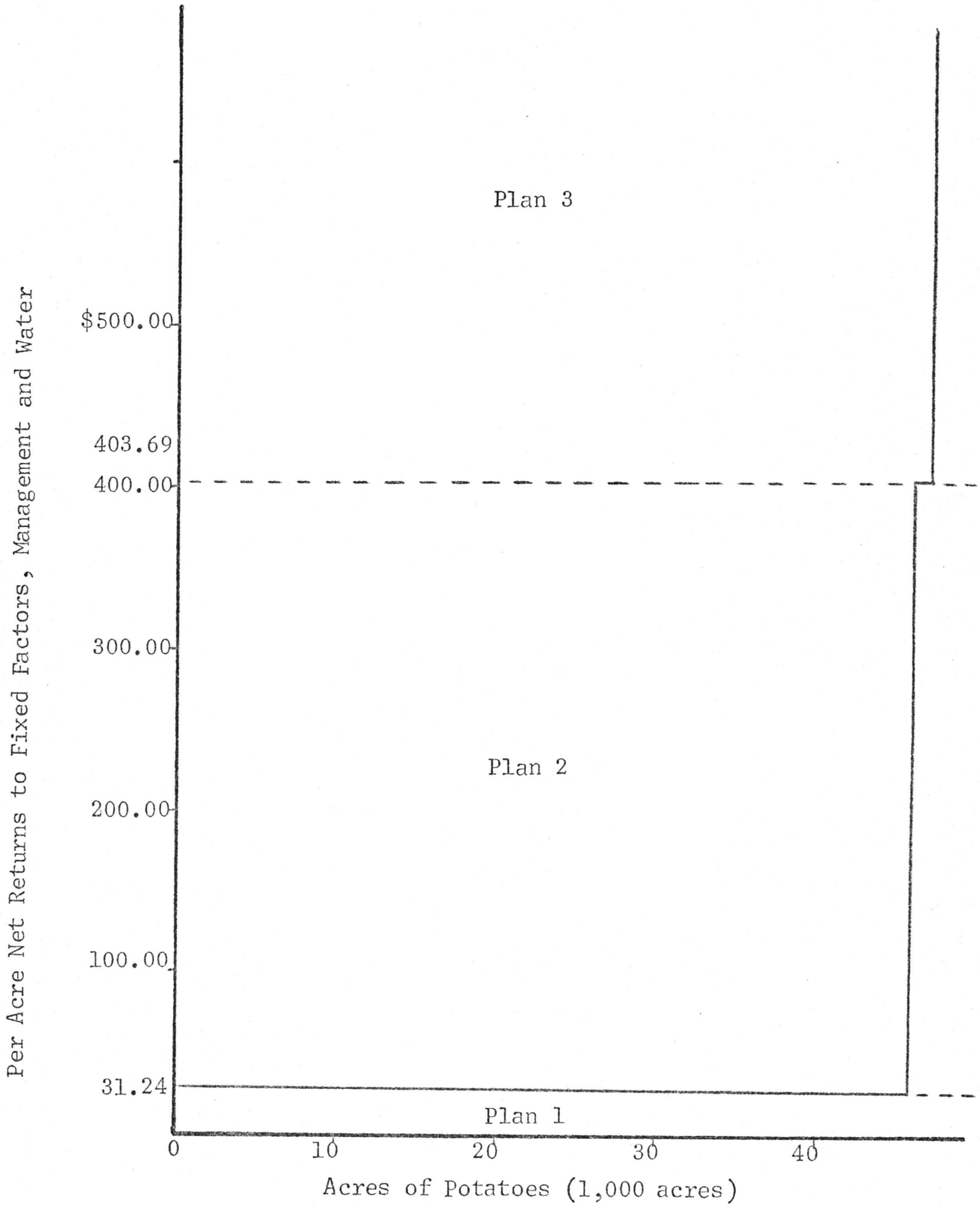

Fig. 4.2a--Potato Production Acreage

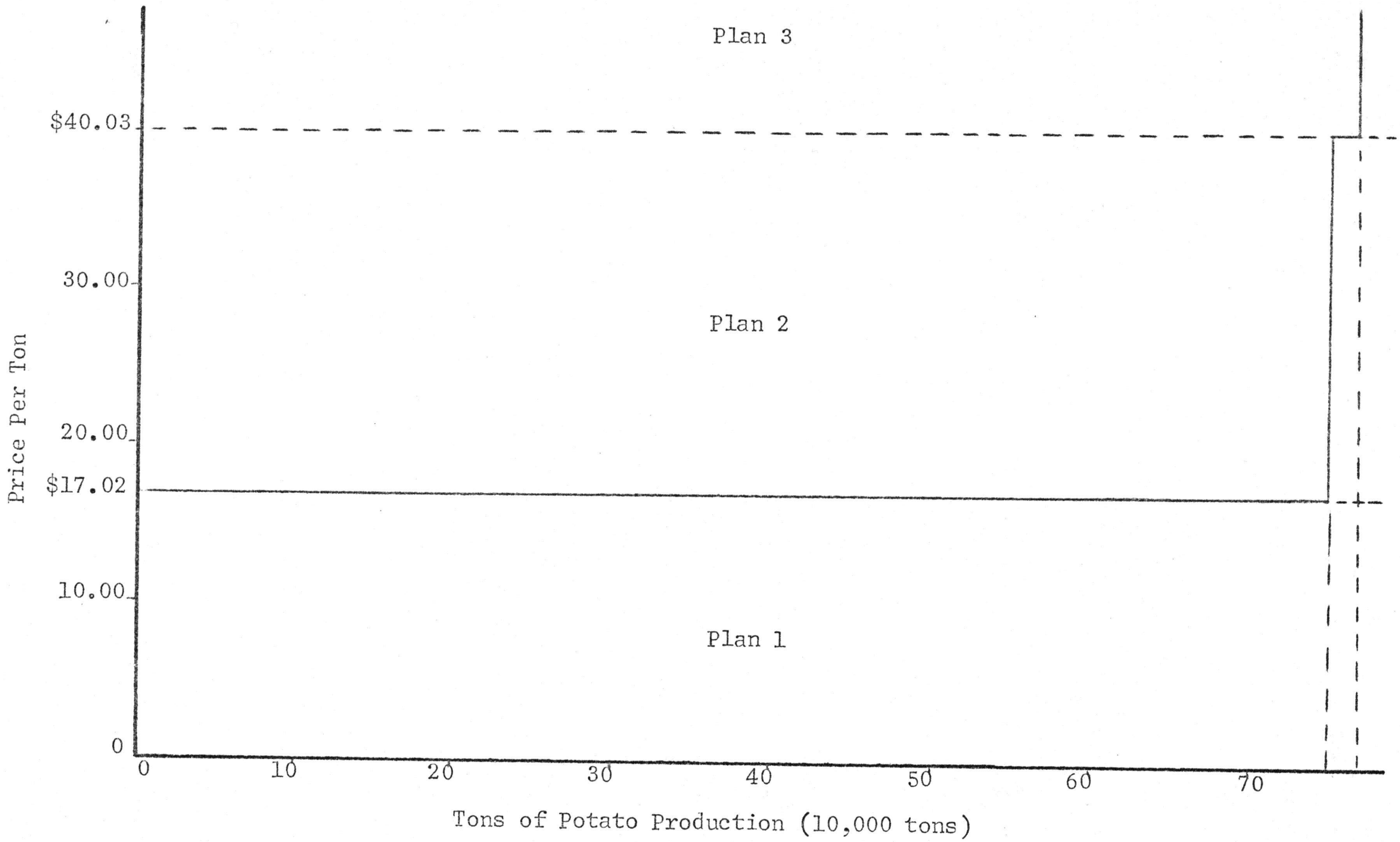

Fig. 4.2b--Stepped Potato Supply Function

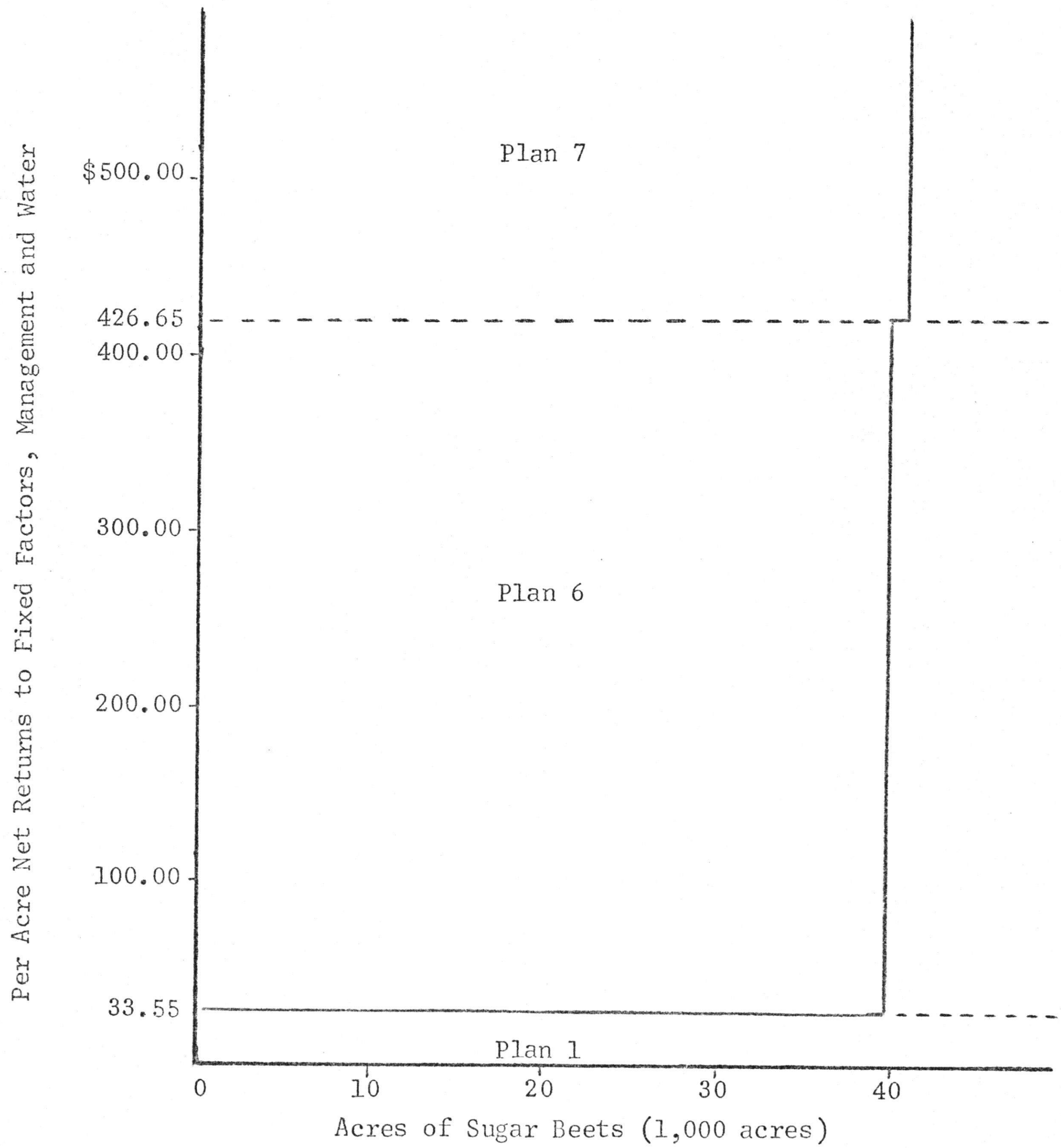

Fig. 4.3a--Sugar Beet Production Acreage

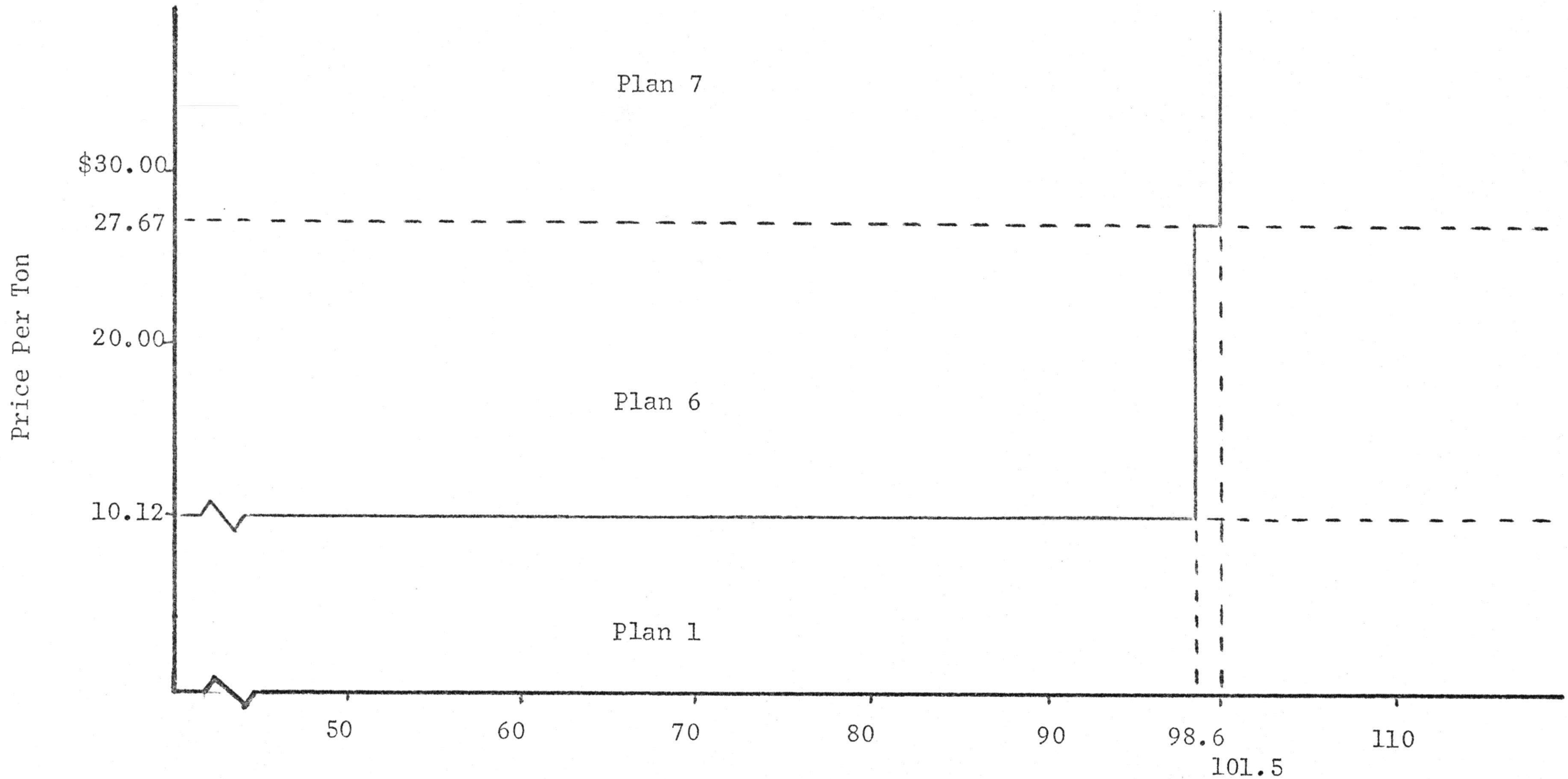

Fig. 4.3b--Stepped Sugar Beet Supply Function

CHAPTER V

SUMMARY

The method of procedure to develop the objectives of this study utilized regression, activity, and parametric linear programming analyses.

Primary data, collected from a personal interview-type survey, were organized into partial farm budgets for the purpose of completing a regression analysis of the primary data. The resulting unit cost curve ($Y' = \frac{1}{2.25616 + 0.00102X}$, where ($Y'$) is cost per dollar of farm income and (X) is the acres used for commodity production) was used to develop net returns to management practices and water purchases for the four model farms of the linear programming model. The four model farms developed were sizes of 160, 320, 480, and 640 acre sizes.

Secondary data were utilized to develop restraints for the agricultural production resources of land, labor, and water. These coefficients formed the linear programming model used to analyze development of the Joint Venture Project of the Southwest Idaho Water Development Project.

Conclusions drawn from this analysis were included in the discussion of the results within Chapter IV. Table 4.9, pages 49 and 50, contains the production plans of the four model farms developed from the allocation of the various resources studied. The population increase resulting from primary agricultural production, including both farm families and the hired farm laborers, is projected to be 4,316 persons. Total income generated from agricultural production and the associated labor requirements of primary production is projected to be $10,516,739. In addition the payment capacity by farm operators for irrigation supplies is projected to be $16.24 per acre-foot of water, which is comparable to other studies of irrigation water payment capacities in the general area of this study.

The data of the activity analysis were adapted to the analysis of parametric linear programming. The commodities, potatoes and sugar beets, were subjected to varying net returns to management, water and the fixed costs of production. The results of this procedure were presented in a price map with accompanying stepped supply functions of the commodities. The conclusion of this analysis was that a large price change in the selling price of the commodities is necessary to generate a moderate change in the production plans of either of the two commodities.

The above conclusions are effective only in conjunction with the specific optimum solutions of the programming models used in the study. Commodity and factor prices used in developing coefficients for the models were based on prices in effect during the 1969 and 1970 production periods, which was the latest available information at the commencement of this study. Since the beginning significant increases have been realized in commodity prices, changes have occurred in production practices, and factor prices have changed. As a consequence, the above conclusions may be somewhat affected.

APPENDIX A

CALCULATION OF PER ACRE NET RETURNS TO MANAGEMENT AND WATER PURCHASES

APPENDIX A

CALCULATION OF PER ACRE NET RETURNS TO MANAGEMENT AND WATER PURCHASES

Four major tables are used to present the procedure used in formulating net returns to management and water purchases. With a rigorous explanation of the first table, no need exists to discuss the other three major tables. These four tables are identical in procedure, the first column of each determining the configuration of the specific tables. Columns of Table A-1.1 are numbered as an aid to the orderly presentation of the procedure used.

The percentages in column 1 of Table A-1.1 are approximations of the percentages found in Table 3.2. These percentages are used to distribute the individual farm acres among the various commodities of this study in similar proportions to the actual commodity distribution on irrigated Southern Idaho crop lands. The variation of the percentage combinations in column 1 of the four tables is only a gradual diversification of the theoretical farm plans until all six commodities are included. This graduation is designed to include each commodity in at least two theoretical farm plans to facilitate the calculation of an average net return for each commodity.

Column 2 is the column 1 percentages converted to acres consistent with the appropriate farm size. This model farm size is denoted in the first column, entitled "Crop." Column 3 is a presentation of data found in Table 3.1. These are the products of yield per acre

TABLE A-1.1

PER ACRE MODEL FARM NET RETURNS TO MANAGEMENT AND WATER

Column	1	2	3	4	5	6	7	8	9	10
Crop	% Crop Dist.	% Dist. /Acres	Income Per Acre	Expense Per Acre	Gross Income	Gross Expense	Gross Exp.% Dist.	Adjusted Gross Expense	Adjusted /Acre Expense	Net Ret. Per Acre
Alfalfa 160	30	48.0	$102.60	$123.89	$ 4,924.80	$ 5,946.72	58.5	$ 6,719.33	$139.99	$-37.39
Silage corn	3	4.8	116.00	127.70	556.80	612.96	6.0	689.16	143.58	-27.58
Mixed grain	21	33.6	87.85	107.29	2,951.76	3,604.94	35.5	4,077.54	121.36	-33.51
Mint		86.4	417.04	179.16						
Potatoes			520.51	303.49						
Sugar beets			344.96	255.55						
					$ 8,433.36	$10,164.62		$11,486.03		
Alfalfa 320	30	96.0	$102.60	$123.89	$ 9,849.60	$11,893.44	58.5	$12,606.16	$131.31	$-28.71
Silage corn	3	9.6	116.00	127.70	1,113.60	1,225.92	6.0	1,292.94	134.68	-18.68
Mixed grain	21	67.2	87.85	107.29	5,903.52	7,209.89	35.5	7,649.90	113.84	-25.99
Mint			417.04	179.16						
Potatoes			520.51	303.49						
Sugar beets			344.96	255.55						
					$16,866.72	$20,329.25		$21,549.00		
Alfalfa 480	30	144.0	$102.60	$123.89	$14,774.40	$17,840.16	58.5	$17,779.46	$123.47	$-20.87
Silage corn	3	14.4	116.00	127.70	1,670.40	1,838.88	6.0	1,823.53	126.63	-10.63
Mixed grain	21	100.8	87.85	107.29	8,855.28	10,814.83	35.5	10,789.24	107.04	-19.19
Mint			417.04	179.16						
Potatoes			520.51	303.49						
Sugar beets			344.96	255.55						
					$25,300.08	$30,493.87		$30,392.23		
Alfalfa 640	30	192.0	$102.60	$123.89	$19,699.20	$23,786.88	58.5	$22,358.10	$116.45	$-13.85
Silage corn	3	19.2	116.00	127.70	2,227.20	2,451.84	6.0	2,293.14	119.43	- 3.43
Mixed grain	21	134.4	87.85	107.29	11,807.04	14,419.78	35.5	13,567.74	100.95	-13.10
Mint		445 6	417.04	179.16						
Potatoes			520.51	303.49						
Sugar beets			344.96	255.55						
					$33,733.44	$40,658.50		$38,218.98		

multiplied by commodity price per unit of production for that specific commodity. Column 4 is the reproduction of total cost data of Table 3.3. Column 5 is the product of columns 2 and 3, while column 6 is the product of columns 2 and 4. Column 7 is the amount each commodity that is produced contributes to the total cost of production for each model farm. These are expressed as percentages. Because constant cost coefficients are used to determine this total cost, these percentages remain constant for the commodity combination of each table regardless of the model farm size.

The method used to adjust these factor costs to reflect economies of size is the application of the unit cost curve of Chapter III. This adjustment is accomplished in Table A-1.2. The columns of Table A-1.2 are identified alphamerically to avoid any confusion with the discussion of Table A-1.1. Also a rigorous discussion of Table A-1.2 eliminates the necessity of presenting the procedurally identical tables for the remaining Tables A-2, A-3, and A-4.

TABLE A-1.2

CALCULATION OF ADJUSTED GROSS EXPENDITURES USING REGRESSION ANALYSIS

Col.	a	b	c	d	e	f
Model Farm Size	Regression Income Per Acre	Gross Income	Expenditures by Crop Per Dollar Income	% Expense by Crop of Total Income	Gross Expense	Adjusted Gross Expense
160	0.413	$ 8,433.36	$ 3,482.98	11.3%	$ 10,164.62	$ 11,486.03
320	0.387	16,866.72	6,527.42	21.2	20,329.25	21,549.00
480	0.364	25,300.08	9,209.23	29.9	30,493.87	30,392.23
640	0.344	33,733.44	11,604.30	37.6	40,658.50	38,218.98
			$30,823.93	100.0%	$101,646.24	$101,646.24

TABLE A-2

PER ACRE MODEL FARM NET RETURNS TO MANAGEMENT AND WATER

Crop	% Crop Dist.	% Dist. /Acres	Income Per Acre	Expense Per Acre	Gross Income	Gross Expense	Gross Exp.% Dist.	Adjusted Gross Expense	Adjusted /Acre Expense	Net Ret. Per Acre
Alfalfa 160	30	48.0	$102.60	$123.89	$ 4,924.80	$ 5,946.72	56.9	$ 6,719.86	$140.00	$-37.40
Silage corn	3	4.8	116.00	127.70	556.80	612.96	5.9	696.79	145.16	-29.16
Mixed grain	21	33.6	87.85	107.29	2,951.76	3,604.94	34.5	4,074.43	121.26	-33.41
Mint	1	1.6	417.04	179.16	667.26	286.66	2.7	318.87	199.29	217.75
Potatoes			520.51	303.49						
Sugar beets			344.96	255.55						
					$23,118.66	$19,135.29		$21,622.88		
Alfalfa 320	30	96.0	$102.60	$123.89	$ 9,849.60	$11,893.44	56.9	$12,607.17	$131.32	$-28.72
Silage corn	3	9.6	116.00	127.70	1,113.60	1,225.92	5.9	1,307.25	136.17	-20.17
Mixed grain	21	67.2	87.85	107.29	5,903.52	7,209.89	34.5	7,644.06	113.75	-25.90
Mint	1	3.2	417.04	179.16	1,334.53	573.31	2.7	598.23	186.95	230.09
Potatoes			520.51	303.49						
Sugar beets			344.96	255.55						
					$18,201.25	$20,902.56		$22,156.71		
Alfalfa 480	30	144.0	$102.60	$123.89	$14,774.40	$17,840.16	56.9	$17,780.87	$123.48	$-20.88
Silage corn	3	14.0	116.00	127.70	1,670.40	1,838.88	5.9	1,843.71	128.04	-12.04
Mixed grain	21	100.8	87.85	107.29	8,855.28	10,814.83	34.5	10,781.02	106.95	-19.10
Mint	1	4.8	417.04	179.16	2,001.79	859.97	2.7	843.73	175.78	241.26
Potatoes			520.51	303.49						
Sugar beets			344.96	255.55						
					$27,301.87	$31,353.84		$31,249.33		
Alfalfa 640	30	192.0	$102.60	$123.89	$19,699.20	$23,786.88	56.9	$22,359.88	$116.46	$-13.86
Silage corn	3	19.2	116.00	127.70	2,227.20	2,451.84	5.9	2,318.51	120.76	- 4.76
Mixed grain	21	134.4	87.85	107.29	11,807.04	14,419.78	34.5	13,557.40	100.87	-13.02
Mint	1	6.4	417.04	179.16	2,669.06	1,146.62	2.7	1,061.02	165.78	251.26
Potatoes			520.51	303.49						
Sugar beets			344.96	255.55						
					$36,402.50	$41,805.12		$39,296.81		

TABLE A-3

PER ACRE MODEL FARM NET RETURNS TO MANAGEMENT AND WATER

Crop	% Crop Dist.	% Dist. /Acres	Income Per Acre	Expense Per Acre	Gross Income	Gross Expense	Gross Exp.% Dist.	Adjusted Gross Expense	Adjusted /Acre Expense	Net Ret. Per Acre
Alfalfa 160	30	48.0	$102.60	$123.89	$ 4,924.80	$ 5,946.72	31.1	$ 6,724.72	$140.10	$-37.50
Silage corn			116.00	127.70						
Mixed grain	21	33.6	87.85	107.29	2,951.76	3,604.94	18.8	4,065.10	120.99	-33.14
Mint			417.04	179.16						
Potatoes	13	20.8	520.51	303.49	10.826.61	6,312.59	33.0	7,135.55	343.06	177.45
Sugar beets	8	12.8	344.96	255.55	4,415.49	3,271.04	17.1	3,697.51	288.87	56.09
					$23,118.66	$19,135.29		$21,622.88		
Alfalfa 320	30	96.0	$102.60	$123.89	$ 9,849.60	$11,893.44	31.1	$12,616.28	$131.42	$-28.82
Silage corn			116.00	127.70						
Mixed grain	21	67.2	87.85	107.29	5,903.52	7,209.89	18.8	7,626.57	113.49	-25.64
Mint			417.04	179.16						
Potatoes	13	41.6	520.51	303.49	21,653.22	12,625.18	33.0	13,387.05	321.80	198.71
Sugar beets	8	25.6	344.96	255.55	8,830.98	6,542.08	17.1	6,936.93	270.97	73.99
					$46,237.32	$38,270.59		$40,566.83		
Alfalfa 480	30	144.0	$102.60	$123.89	$14,774.40	$17,840.16	31.1	$17,793.72	$123.57	$-20.97
Silage corn			116.00	127.70						
Mixed grain	21	100.8	87.85	107.29	8,855.28	10,814.83	18.8	10,756.33	106.71	-18.86
Mint			417.04	179.16						
Potatoes	13	62.4	520.51	303.49	32,479.82	18,937.78	33.0	18,880.80	302.58	217.93
Sugar beets	8	51.2	344.96	255.55	13,246.46	9,813.12	17.1	9,783.69	254.78	90.18
					$69,355.96	$57,405.89		$57,214.54		
Alfalfa 640	30	192.0	$102.60	$123.89	$19,699.20	$23,786.88	31.1	$22,376.05	$116.54	$-13.94
Silage corn			116.00	127.70						
Mixed grain	21	134.4	87.85	107.29	11,807.04	14,419.78	18.8	13,526.36	100.64	-12.79
Mint			417.04	179.16						
Potatoes	13	83.2	520.51	303.49	43,306.43	25,250.37	33.0	23,743.07	285.37	235.14
Sugar beets	8	51.2	344.96	255.55	17,661.95	13,084.16	17.1	12,303.23	240.30	104.66
					$92,474.62	$76,541.19		$71,948.71		

TABLE A-4

PER ACRE MODEL FARM NET RETURNS TO MANAGEMENT AND WATER

Crop	% Crop Dist.	% Dist. /Acres	Income Per Acre	Expense Per Acre	Gross Income	Gross Expense	Gross Exp.% Dist.	Adjusted Gross Expense	Adjusted /Acre Expense	Net Ret. Per Acre
Alfalfa 160	30	48.0	$102.60	$123.89	$ 4,924.80	$ 5,946.72	29.7	$ 6,723.92	$140.08	$-37.48
Silage corn	3	4.8	116.00	127.70	556.80	612.96	3.1	701.82	146.21	-30.21
Mixed grain	21	33.6	87.85	107.29	2,951.76	3,604.94	18.0	4,075.10	121.28	-33.43
Mint	1	1.6	417.04	179.16	667.26	286.66	1.4	316.95	198.09	218.95
Potatoes	13	20.8	520.51	303.49	10,826.61	6,312.59	31.5	7,131.43	342.86	177.65
Sugar beets	8	12.8	344.96	255.55	4,415.49	3,271.04	16.3	3,690.23	288.30	56.66
		121.6			$24,342.72	$20,034.91		$22,639.45		
Alfalfa 320	30	96.0	$102.60	$123.89	$ 9,849.60	$11,893.44	29.7	$12,614.78	$131.40	$-28.80
Silage corn	3	9.6	116.00	127.70	1,113.60	1,225.92	3.1	1,316.69	137.15	-21.15
Mixed grain	21	67.2	87.85	107.29	5,903.52	7,209.89	18.0	7,645.32	113.77	-25.92
Mint	1	3.2	417.04	179.16	1,334.53	573.31	1.4	594.65	185.83	231.21
Potatoes	13	41.6	520.51	303.49	21,653.22	12,625.18	31.5	13,379.31	321.62	198.89
Sugar beets	8	25.6	344.96	255.55	8,830.98	6,542.08	16.3	6,923.26	270.44	74.52
		243.2			$48,685.45	$40,069.82		$42,474.01		
Alfalfa 480	30	144.0	$102.60	$123.89	$14,774.40	$17,840.16	29.7	$17,791.60	$123.55	$-20.95
Silage corn	3	14.4	116.00	127.70	1,670.40	1,838.88	3.1	1,857.04	128.96	-12.96
Mixed grain	21	100.8	87.85	107.29	8,855.28	10,814.83	18.0	10,782.79	106.97	-19.12
Mint	1	4.8	417.04	179.16	2,001.79	859.97	1.4	838.66	174.72	242.32
Potatoes	13	62.4	520.51	303.49	32,479.82	18,937.78	31.5	18,869.88	302.40	218.11
Sugar beets	8	38.4	344.96	255.55	13,246.46	9,813.12	16.3	9,764.42	254.28	90.68
					$73,028.15	$60,104.74		$59,904.39		
Alfalfa 640	30	192.0	$102.60	$123.89	$19,699.20	$23,786.88	29.7	$22,373.38	$116.53	$-13.93
Silage corn	3	19.2	116.00	127.70	2,227.20	2,451.84	3.1	2,335.27	121.63	- 5.63
Mixed grain	21	134.4	87.85	107.29	11,807.04	14,419.78	18.0	13,559.63	100.89	-13.04
Mint	1	6.4	417.04	179.16	2,669.06	1,146.62	1.4	1,054.64	164.79	252.25
Potatoes	13	83.2	520.51	303.49	43,306.43	25,250.37	31.5	23,729.35	285.21	235.30
Sugar beets	8	51.2	344.96	255.55	17,661.95	13,084.16	16.3	12,279.00	239.82	105.14
					$97,370.88	$80,139.65		$75,331.27		

Column "a" is the cost per dollar of farm income calculated by inserting the appropriate total acres (X) in the unit cost curve. Columns "b" and "e" are reproductions of the total of Table A-1.1, columns 5 and 6, respectively. Column "c" is the product of columns "a" and "b" while column "d" is the percentage each model farm's total production costs of column "c" is of the sum total expenditures. The respective coefficients of column "f" are the application of the column "d" percentages to the sum total of column "e." These coefficients are the totals found in column 8 of Table A-1.1.

Returning to Table A-1.1, the individual row coefficients of column 8 are the product of the respective percentages of column 7 applied to the totals of column 8. The division of the row coefficients of column 8 by the respective row coefficients of column 2 yield the column 9 values. The subtracting of column 9 coefficients from those of column 3 results in column 10 coefficients.

Table A-5 is the presentation of the per acre net returns to management and water found by computing averages of the respective coefficients of column 10 in Tables A-1.1, A-2, A-3, and A-4.

TABLE A-5

PER ACRE NET RETURNS TO MANAGEMENT AND WATER

Acres	Crop					
	Alfalfa	Silage Corn	Mixed Grain	Mint	Potatoes	Sugar Beets
160	-$37.44	-$28.98	-$33.37	$218.35	$177.65	$ 56.37
320	- 28.76	- 20.33	- 25.86	235.55	198.80	74.25
480	- 20.92	- 11.88	- 19.07	241.79	218.02	90.43
640	- 13.90	- 4.61	- 12.99	251.75	235.22	104.90

APPENDIX B

DERIVATION OF LABOR COEFFICIENTS

APPENDIX B

DERIVATION OF LABOR COEFFICIENTS

Secondary sources are used to derive the labor distribution since the information gathered through the interviews does not include a significant range in the farm sizes. Nor does the number of interviews warrant their use for the determination of these labor coefficients. The "Annual Farm Labor Report" is used as the source of the initial information.

Using this information, which is presented in Table B-1, requires the assumption that the total labor requirements are distributed among the various production activities of farm operations in a similar proportion to the reported distribution of seasonally hired laborers. Table B-1 is a listing of seasonally employed laborers involved in various identifiable production activities in the ES-223 Reporting District of Idaho. This enumeration is a bi-weekly count. Table B-1 gives only the larger of the two enumerations reported for each month from mid-March to mid-November.

The number of laborers, reported by activity in Table B-1 which deal with specific commodities are combined under the general heading of the commodity for each of the nine months. The number of laborers per month is transformed into percentages of the total number of laborers employed in the specific commodity production for the nine-month period. The results of this procedure are given in Table B-2.

TABLE B-1

PEAK BI-WEEKLY ES-223 DISTRICT SEASONAL LABOR NUMBERS

Activity	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Total
Soil preparation	1,330	2,090	2,097	570	--	--	305	670	495	7,557
Hop yard preparation	220	450	250	200	50	--	--	--	--	1,170
Orchard cleaning	160	425	475	830	450	450	385	250	200	3,625
Grain planting	50	125	--	--	--	--	--	--	--	175
Potato seed sorting	175	590	905	125	--	--	--	--	--	1,795
Irrigation cleaning	60	119	--	--	--	--	--	--	--	179
Row crop planting	100	175	--	--	--	--	--	--	--	275
Potato planting	--	350	423	--	--	--	--	--	--	773
Sugar beet planting	--	185	50	--	--	--	--	--	--	235
Gravity irrigation	--	250	780	885	900	900	685	90	--	4,490
Sprinkler irrigation	--	239	1,110	2,402	2,515	2,455	1,925	270	--	10,916
Row crop cultivation	--	--	650	1,045	1,080	385	85	--	--	3,245
Sugar beet culling	--	--	2,620	4,946	3,400	835	--	--	--	11,801
Onion hand labor	--	--	325	265	130	95	--	--	--	815
Corn planting	--	--	120	--	--	--	--	--	--	120
Miscellaneous weeding	--	--	125	250	390	465	230	--	--	1,460
Summer fallow	--	--	25	50	125	75	50	--	--	325
Bean planting	--	--	230	165	--	--	--	--	--	395
Hay harvesting	--	--	55	1,155	1,410	1,295	890	292	20	5,117
Fruit harvest	--	--	--	520	1,175	725	1,135	1,855	--	5,410
Corn detasseling	--	--	--	--	525	200	--	--	--	725
Grain harvest	--	--	--	--	20	690	460	--	--	1,170
Potato weeding	--	--	--	--	255	410	--	--	--	665
Bean weeding	--	--	--	--	485	395	--	--	--	880
Mint harvest	--	--	--	--	60	125	125	--	--	310
Pea harvest	--	--	--	--	65	75	--	--	--	140

TABLE B-1--Continued

Activity	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Total
Sweet corn harvest	--	--	--	--	--	300	340	75	--	715
Hop Harvest	--	--	--	--	--	25	400	--	--	425
Potato harvest	--	--	--	--	--	220	3,600	6,205	40	10,065
Onion harvest	--	--	--	--	--	315	1,025	225	--	1,565
Bean harvest	--	--	--	--	--	175	580	125	--	880
Silage corn harvest	--	--	--	--	--	--	630	170	145	945
Cabbage harvest	--	--	--	--	--	--	25	35	15	75
Sugar beet harvest	--	--	--	--	--	--	25	2,722	1,140	3,887
All other	770	1,094	1,091	958	955	925	930	890	885	8,498
Total	2,865	6,092	11,331	14,366	13,990	11,535	13,830	13,874	2,940	90,823

TABLE B-2

PERCENTAGE DISTRIBUTION OF ES-223
SEASONAL LABOR NUMBERS

Activity	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	% Activity is of Total
Common	73.3	52.3	29.2	12.4	9.6	12.0	10.6	11.2	46.9	19.3
Potatoes	6.1	15.4	11.7	0.9	1.8	5.5	26.0	44.7	1.4	14.7
Irrigation	2.1	10.0	16.7	22.9	24.4	29.1	18.9	2.5	--	17.1
Sugar Beets	--	3.0	23.5	34.4	24.3	7.2	0.2	19.6	38.8	17.6
Onions	--	--	2.9	1.8	0.9	3.5	7.4	1.6	--	2.6
Sweet corn	--	--	1.1	--	3.8	4.3	2.5	0.5	--	1.7
Silage corn	--	--	--	--	--	--	4.6	1.2	4.9	1.0
Beans	--	--	2.0	1.1	3.5	4.9	4.2	0.9	--	2.4
Alfalfa	--	--	0.5	8.0	10.0	11.2	6.4	2.1	0.7	5.6
Mixed grain	1.7	2.1	--	--	0.1	6.0	3.3	--	--	1.5
Mint	--	--	--	--	0.4	1.1	0.9	--	--	0.3
Peas	--	--	--	--	0.5	0.7	--	--	--	0.2

The two activities "Common" and "Irrigation" of Table B-2 should be distributed among the remaining activities. The distribution of "Common" is accomplished by increasing each of the ten commodity activities by 10 percent of the monthly coefficients of "Common." Because these commodities have differing irrigation requirements, the distribution of the "Irrigation" coefficients is based on the water requirements of Table 3.6. With this procedure the commodity requiring the largest amount of water also requires the largest amount of irrigation labor.

The result of these procedures is presented in Table B-3. This table has been further limited to only the six commodities of interest in this study. The column totals of this table do not equal 100 percent. An adjustment to reflect an exact 100 percent will be simultaneously accomplished when the percentages are converted into hours of labor per acre.

TABLE B-3

COMBINED ES-223 DISTRICT PERCENTAGE LABOR DISTRIBUTION

Month	Alfalfa	Silage Corn	Mixed Grain	Mint	Potato	Sugar Beets
March	7.33%	7.33%	9.03%	7.33%	13.43%	7.33%
April	5.23	5.23	7.33	6.07	20.70	11.59
May	8.98	4.79	11.44	10.51	16.79	29.27
June	24.00	8.29	19.81	20.50	13.10	44.61
July	33.96	21.31	24.62	21.51	30.37	47.48
August	30.50	19.95	15.31	3.73	30.31	29.98
September	17.18	11.06	4.36	1.96	30.31	13.30
October	5.82	2.32	1.12	1.12	45.82	23.92
November	5.39	9.59	4.69	4.69	5.09	43.49
Totals	138.39%	89.87%	97.71%	77.42%	205.92%	250.97%

This conversion of the percentage data of Table B-3 into hours of labor required per acre for each commodity begins by first finding the amount of labor, in hours, that is provided for agricultural production by all farm workers in the ES-223 District. This procedure is given in Table B-4. To distribute this total hours of labor among the various activities and commodities of interest to this study, a process presented in Table B-5 is followed. The percentages of Table B-2 are applied to this 73,566,481 hours and the product of this is divided by the commodity acreages of Table 3.2. The result is the total hours of labor required to produce one acre of the commodity excluding irrigation labor and the common labor. The coefficients of the activities of "Irrigation" and "Common" are distributed in the same manner as these same percentages were distributed among the six commodities of Table B-3.

TABLE B-4

ES-223 TOTAL AGRICULTURAL EMPLOYMENT IN HOURS

Month	Hours Worked /Week*	Weeks Per Month	Hours Worked /Month	Total ES-223 Ag. Workers**	Total Hours Per Month
March	40.3	4.4	177.32	32,824	5,820,352
April	43.7	4.3	187.91	35,484	6,667,798
May	45.1	4.4	198.44	40,655	8,067,578
June	45.3	4.3	193.93	45,936	8,908,368
July	46.2	4.4	203.28	46,150	9,381,372
August	46.0	4.4	202.40	43,941	8,893,658
September	40.3	4.3	173.29	42,715	7,402,082
October	39.3	4.4	172.92	46,673	8,070,695
November	34.7	4.3	149.21	34,698	5,177,289
					73,566,481

*"Farm Labor," Statistical Reporting Service, Boise, Idaho.

**"Annual Farm Labor Report," Department of Employment, Boise, Idaho, Table 5.

TABLE B-5

COMMODITY LABOR REQUIREMENTS

Activity	Labor Distri-bution	Total Hours Worked	Total Hours Per Commodity	Crop Acreages	Hours /Acre
Common	19.3%	73,566,481	14,198,331	2,119,383	6.699
Irrigation	17.1	73,566,481	12,579,868	2,119,383	5.935
Alfalfa	5.6	73,566,481	4,119,723	632,052	6.518
Silage corn	1.0	73,566,481	735,665	58,150	12.651
Mixed grain	1.5	73,566,481	1,103,497	452,532	2.438
Mint	0.3	73,566,481	220,699	7,132	30.944
Potatoes	14.7	73,566,481	10,814,273	268,748	40.239
Sugar beets	17.6	73,566,481	12,947,701	171,529	75.484

The result of this distribution increased the per acre total hourly labor coefficients of Table B-5 to those of the column summations of Table B-6. These column summations were each multiplied by the percentages of the last row of Table B-3. These products were then multiplied by the respective individual column labor coefficients of Table B-3 which produces the individual column coefficients of Table B-6. This table is the labor coefficient for the 320-acre model farm of the linear programming model.

TABLE B-6

PER ACRE LABOR REQUIREMENTS BY HOURS

Month	Alfalfa	Silage Corn	Mixed Grain	Mint	Potatoes	Sugar Beets
March	0.420	1.130	0.342	3.040	2.712	2.245
April	0.300	0.806	0.277	2.517	4.180	3.350
May	0.515	0.738	0.433	4.359	3.391	8.965
June	1.375	1.278	0.749	8.501	2.646	13.663
July	1.946	3.285	0.931	8.920	6.133	14.542
August	1.748	3.076	0.579	1.547	6.121	9.182
September	0.984	1.705	0.165	0.813	6.121	4.073
October	0.333	0.358	0.042	0.464	9.253	7.326
November	0.309	1.478	0.177	1.945	1.028	13.320
Totals	7.930	13.854	3.695	32.106	41.585	76.866

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