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AN ECONOMIC APPROACH TO THE AGRICULTURAL USE OF GROUND WATER IN THE OAKLEY FAN AREA OF CASSIA COUNTY, IDAHO

A Thesis
Presented in Partial Fulfillment of the Requirements for the
DEGREE OF MASTER OF SCIENCE
Major in Agricultural Economics

in the
UNIVERSITY OF IDAHO GRADUATE SCHOOL
by

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June, 1968

This thesis of Richard John Cheline for the Master of Science degree, "An Economic Approach to the Agricultural Use of Ground Water in the Oakley Fan Area of Cassia County, Idaho,"

A. has been reviewed in rough draft form and preparation of the final draft is recommended; permission is granted to proceed with the final examination upon submission of two final draft copies to the Graduate School:

Major Professor Russell V Withers Date 13 May 1968
Committee Members __________ Date 13 May 1968
Wm E Folz Date 5/13/68

B. is approved in final draft form:

Head of Department Wm E. Folz Date 5/13/68
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C. has been granted final acceptance after review by the Graduate Council and after successful completion of the oral examination:

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BIOGRAPHICAL SKETCH OF THE AUTHOR

Richard J. Cheline was born in 1939 in Buhl, Idaho. He attended Saint Edwards parochial grammar school until 1954. In the fall of 1954 he enrolled at Twin Falls High School. Four years later he graduated. Following graduation, he enrolled at the University of Idaho. After successfully completing two years of college, he interrupted his studies to travel throughout South America. Upon returning from his travels, he was called to active duty by the military. Three years later, he enrolled at the University of Idaho. In June, 1966, he received the degree of Bachelor of Science with a major in Agricultural Economics. The following fall he enrolled in the Graduate School of the University of Idaho and in June, 1968, completed the requirements for the Master of Science degree of which this thesis is a part.

ACKNOWLEDGMENTS

The author wished to acknowledge his appreciation to the producers in the Oakley Fan area of Cassia County, Idaho for the information and assistance they provided to this study. Gratitude is expressed to the following individuals: Doctor Karl Lindeborg, for his encouragement and kindness during the first year of graduate study; Doctor Gerald Marousek, for his help in getting this thesis started; Doctor Russell Withers, for his constructive criticism and suggestions concerning the principles and theory used in writing this thesis; Doctor Dale Everson, for his aid in coordinating various aspects of this study; and to all the members of the Department who aided in the completion of this study.

Special thanks go to the author's wife, Nancy, whose work and patience made the author's graduate study possible.

ABSTRACT

Establishing feasible amounts of revenue farmers do have and could have available for water costs was the object of this study. A definite area known commonly as the Oakley Fan was selected as the site for analysis.

The author interviewed many of the farmers in the area in order to collect physical input and output information. This information was gathered for the years 1965, 66, & 67.

The analytical tools applied to fulfill the objectives were a synthetic budget approach in conjunction with a linear programming model. Such analysis depicted the structure of three sizes of typical farms in the area in contrast to three theoretical optimum farms.

The results of this study indicate that the farmers in the area are now relatively close to the theoretical optimum structure. Also, economies of size were found to the extent that the smaller farmers received approximately 50% less than the larger farmers for their return to management and water.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

In the last few years a great deal has been heard about the affluence of our society. A noted economist has suggested that we are too preoccupied with increasing production of goods and services and that we are starving the public compared to the private sector of our economy.[1] Regardless of how one feels about the consequences of our affluence the fact remains that now, as always, governmental decisions are made within a system of constraints. Many resources are scarce; they must be allocated between public and private sectors within the government in such a way as to maximize human satisfaction.

A rational choice of the allocation of scarce resources is essential to mankind. The task of rational decision making has been defined by Hubert Marshall, associate professor of Political Science, Stanford University, to include:

1. the identification of the value or values to be maximized,
2. the listing of alternative courses of action,
3. the determination of the consequences that follow from each of the alternatives, and,
4. the comparative evaluation of these sets of consequences in terms of the value or values to be maximized.

Thus, following this definition the decision maker must have knowledge that is sufficiently accurate to permit the

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[1] John Gailbrith, The Affluent Society, (Boston: Houghton Mifflin Co., 1958).

correct choice among the alternatives.

It is to achieve these ends that this study was prepared. There is, of course, no single solution to the scarce resource problem, nor is there a limit on the amount of knowledge that is desired by decision makers.

I. THE PROBLEM

Within the last ten to fifteen years, several large areas of Idaho desert land have been developed for irrigation practices. The present rate of development of irrigated land by individuals using private capital is approximately 50,000 acres per year.

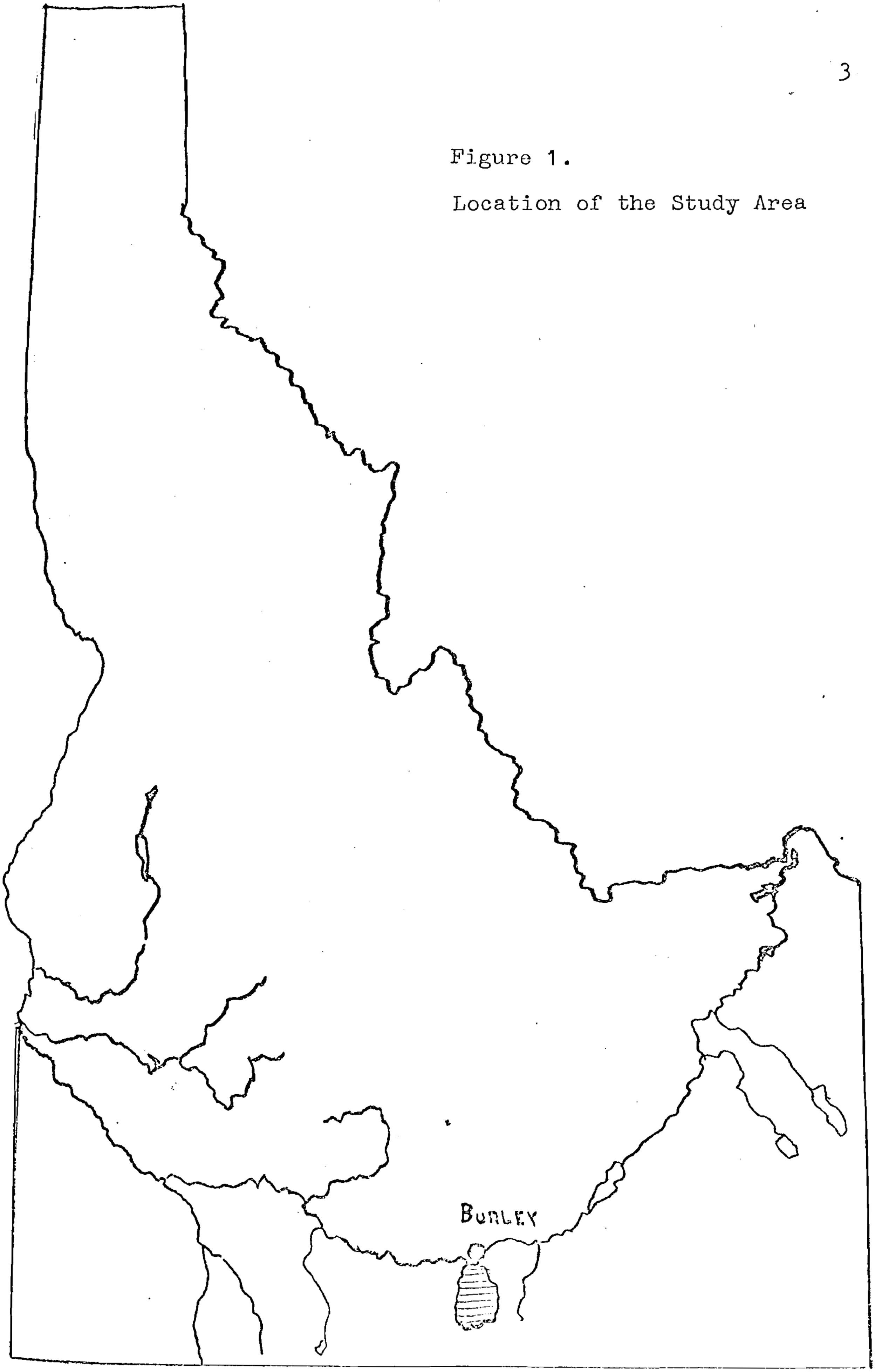
The principal tools in this development plan are the pump and the deep well. The importance and the problems associated with deep well pumping are illustrated throughout the Snake River Basin. The subject area chosen for this study lies in the Snake River Basin, south of Burley, Idaho, in Cassia County. This area is commonly referred to as the Oakley Fan area. The relative bounds are outlined in Figure 1 on the following page.

The Oakley Fan is a relatively new farming area. Some production units are less than ten years old, and most units have not been producing for more than fifteen years.

Because recharge of groundwater is so small relative to withdrawal, the groundwater supply in the Oakley Fan can be considered a stock resource. In conventional economic analysis

Figure 1.

Location of the Study Area



the present value of a stream of expected net revenues from a given stock resource is usually assumed as an objective. However, since groundwater in the Oakley Fan is a "community resource," individual farmers lack full control of the water under their land and are not able to maximize in the usual sense. Even if a farmer does not pump water on his land, his water table will decline, because pumping by his neighbors affects the water level of the whole area. Thus, attempts to conserve water, or to extend the length of time the stock resource can be utilized by an individual, will not be effective.

Because an individual farmer does not have full control of the stock of water under his land, he will maximize profits if he considers his groundwater as a "flow" resource. That is, the services from the resource are available during only one period of time. If the resource is not used during that period, it is lost forever. Water at any given depth, is available to the individual farmer at only one period of time regardless of whether he pumps or not. In this situation, the farmer would maximize profits by applying the economic principles of traditional firm analysis, which are to produce at the point where marginal cost equals marginal revenue. For purposes of this study, however, the farmer will attempt to produce as much as possible at the low point on his long run average cost curve.

The existing farmers approach to the problem of a stock water supply is further complicated by the fact that additional development has been occurring in the area. The existing producers would rather have land development cease than to jeopardize their available water supply. Thus, it becomes our public officials' duty to make rational decisions with respect to the scarce resource, water. Under the existing law, the State of Idaho is in a position to expand the number of additional wells that will go into the area; under the condition that previously existing water rights are not violated. It may well be that water from the deeper more involved pumping systems is being put to a better economic use that water pumped from wells of lesser depth. In such a case, there exists a possibility that wells of lesser depths allow economic profits for the individual to the detriment of the public. If the law were to limit the pumping of the shallow well the water would not be being used to maximize total human satisfaction.

Particularly, the answer to the specific problem will have a direct bearing on the economy of Idaho and the future development of the state. Water is one of our state's most valuable resources, and it must be beneficially and economically utilized. Thus one of the primary purposes of this study was to provide public officials with farm cost analyses that can be used to judge the feasibility of future farm development projects. It is an economic fact that the more a farmer can pay for water, the deeper and more elaborate pumping system he may develop. But should a man be allowed to develop such a pumping system at the expense of his neighbors who may well have prior water rights? If economies of size are shown to exist should the larger farmer be allowed to expand at the expense of the smaller farmer?

The answer to these questions will be decided by the state courts with the aid of state officials. In order to aid them in making their decisions, this study has analyzed the problems of defining a reasonable pumping level in the Oakley Fan area for crop producers. This study also sought to determine if the size of the farming operation altered the amount of revenue producers could pay for water. These problems and their implications are important to the field of agricultural economics to the extent that they demonstrate the return to factor inputs. An attempt has been made to isolate the return available to the factor input, water.

Also the principal of economies of size is described and supported by empirical evidence. It is not expected that this study will show conclusive evidence of how the courts and State Engineer will make their decisions, but it will attempt to make valuable contributions to what is already known about this problem area. The study will also supply future research with a basic model with which to work.

II. OBJECTIVES

The main objective of this study was to determine the amount of revenue producers could feasibly have available to pay for water. From an economic standpoint the objective was to establish the maximum amount of revenue available for water with respect to area limitations. In conjunction with this objective the study sought to show how much revenue the "typical producer" in the area presently had available for water expenditures, after allowing a fair return to all other factors of production.

Another major objective was to determine if the size of the farm operation altered the amount of revenue producers could pay for water on a unit basis. The available revenue was measured by the capability of the farms to produce high value crops at low costs.

Four minor or subobjectives were chosen: (1) to suggest more efficient methods of combining the available resources. That is, to reorganize the cropping patterns in such a manner as to obtain an optimum rotation, given the local restrictions, (2) to assess the magnitude of the technical economies associated with the size of production units, (3) to demonstrate the use of linear programming in determining optimum farm patterns, (4) to establish positive coefficients that could be used together with concurrent research to establish a reasonable pumping depth for the area.[2]

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[2] University of Idaho, "Agricultural Engineering Dept. Study on Pumping Systems and Costs", Restricted Current Project Number 7135, Moscow, Idaho, 1968.

CHAPTER II

METHODOLOGY

I. HYPOTHESIS STATEMENT

The initial hypothesis of this study was:

Under present conditions the producers in the Oakley Fan are producing in the most optimum manner. Such a hypothesis implies that the revenue available to pay for water is presently at a maximum.

The alternative hypothesis states that the producers are not producing in the most optimum manner, thus suggesting that additional revenue could be made available to water.

A second hypothesis formulated was: That technical economies of size exist in the subject area irrespective of superior management.

With respect to the first hypothesis a comparison was made between what the collected data showed was being accomplished to what a linear programming model showed could be accomplished.

The use of empirical data within a minimum cost analysis was utilized to solve the second hypothesis. A downward sloping long run average cost curve for the average farm will indicate that with a long run rotation, economies of size are attainable. If the long run average cost curve does not slope down the indication will be that size economies are not attainable with the given long run rotation.

II. SOURCES OF DATA

Personal interviews with a sample of farm operators during the summers of 1966 and 1967 provided the basic data for the empirical analysis in this study. These data, based on the 1965, 1966, and 1967 crop years were supplemented with cost data from secondary sources, primarily publications of the Idaho Agriculture Extension Service and from Idaho Experiment Station personnel. Cassia county's county agent also provided additional information for the analysis.

Initially a list of fifty commercial farming operations were compiled subject to the following requirements:

1. Location: The farm had to be located within the relative boundaries set as the subject area.
2. Commercial farming: The farm had to be a "commercial" operation. That is, the farm had to be operated primarily for profit, which excludes "hobby" or "show" farms, experimental farms, and other similar operations. Part-time operations were also eliminated.
3. Type of Farming: To qualify as a field crop farm, all of the farm gross revenue had to come from field crops.

From the list of fifty, thirty-eight were initially contacted. Twenty-one interviews were set up from this initial contact.

Information was obtained from each farm on crop acreages, yield, machinery, investment, labor use, farm expenses, and on the various enterprises. The enterprise information indicated the operations performed, the sequence of the operation's occurrence, and the performance rates on all equipment and labor.

Farm records and income tax summaries were the main source of data for 18 of the 21 producers interviewed. Thus a three year collection of data from 18 producers is the basis of the empirical data in this study. The size and enterprise breakdown is given in Table I.

III. ANALYTICAL PROCEDURE

The synthetic firm approach was used in this study.[3] This approach involves developing budgets for hypothetical firms, using the best available estimates of the technical coefficients and charging market prices or opportunity costs for all resources. The term technical coefficient is defined as including all resource requirements and expected yields.

The reasonable division lines for the model farms appeared to be at the 200, 400, and 600 acre range. It was felt that this distribution would most reasonably approach the situation in land size as it exists in the area. Three sizes of machinery varied directly with the three different land sizes. The costs and factor inputs were found to be different for the various land sizes. A separate budget was prepared for each of the land sizes. Then each of the budgets was presented in a linear programming tableau. Conventional linear

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[3] R. G. Bressler, "Research Determination of Economics of Scale," Journal of Farm Economics, Vol. XXVII, No. 3, August, 1945.

programming methods were used, and will be discussed in a following section.[4]

The synthetic or "average firm" is represented by a given level of fixed resources--land, labor, and capital. Thus it is possible in a profit maximizing linear programming problem to compute the optimum combination of products and variable resources for a specific farm size.

Linear Programming Logic. Linear programming is very similar in purpose to the analytical technique of comparative budgeting which was introducted into economics some 75 years ago. The actual linear programming method utilizes a system of linear inequalities and matrix algebra to select the optimal combination of a given set of resources under a given set of conditions. That is, several variables can be considered simultaneously with other fixed variables. Since linear programming reduces the problem-solving to a routine, many more variables may be included in the analysis than would be feasible using conventional procedures.[5]

An explanation of the programming technique can be made by the use of mathematical terms. A matrix, made up of columns

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[4] E. O. Heady and W. Candler, "Linear Programming Methods," Iowa State College Press, Ames, Iowa, (1958), Chap. 3.

[5] Robert Dorfman, "Application of Linear Programming to the Theory of the Firm," University Microfilms, Inc., Ann Arbor, Michigan (1961), Chap. 1-3.

TABLE I

NUMBER OF SAMPLE FARMS REPORTING IRRIGATED CROPLAND HARVESTED BY SIZE OF FARMS AND FARMS REPORTING SELECTED CROPS, SUBJECT AREA IN CASSIA COUNTY, 1965-67

Size of Farm	No. of Farms Reporting	No. of Farms Reporting Crops Grown				
		Grain	Potatoes	Alfalfa	Beans	Sugar Beets
200-249	5	5	4	4	4	4
250-299	3	3	2	3	2	2
300-349	2	2	1	2	2	2
350-399	0	-	-	-	-	-
400-449	3	3	3	1	1	1
450-499	1	1	1	1	0	1
500-549	1	1	0	0	0	0
550 or more acres	3	3	2	2	1	1

and rows is utilized in this technique.

The matrix is a collection of production function points for the various activities included in the problem. Each row in the matrix represents a production function point for a specific product. This can be represented diagramatically as:

$$\begin{array}{llllll}
A_{11}X_1 & + A_{12}X_2 & + A_{13}X_3 & \cdots & A_{1m}X_m \underline{\hspace{8em}} & 1Y_1 \\
\vdots & \vdots & \vdots & & & \\
\vdots & \vdots & \vdots & & & \\
A_{1m}X_1 & + A_{2m}X_2 & + A_{3m}X_m & \cdots & A_{nm}X_m \underline{\hspace{8em}} & 1Y_m
\end{array}$$

The subscripts following the letters indicate the row and column in which the item appears.

A = input-output ratio

X = the quantity of factor input

Y = the quantity of output

$A_{nm}X_m$ ______________ $1Y_m$, indicates the specific amount of each input factor necessary to produce one unit of Y_1.

The existence of restrictions on the availability of initial inputs limits the total amount of output that can be produced. When these restricted resources can be used in the production of more than one product, the problem of deciding which product to produce arises.

Figure 2 represents a theoretical example of restricting resources. Section a-b of restriction line LABOR II, section b-c of restriction line land and section c-d of restriction line LABOR III make up the production possibility curve for the production of Y_1 and Y_2 is possible at any point along this curve, ranging from producing only Y_1 at point "a" to producing only Y_2 at point "d". Between these two points production of both products is possible. The point at which production is most profitable will be determined by the price received for products Y_1 and Y_2.

Such a price point is graphically presented in Figure 3. The RR_1 line denotes all the possible combinations of the two products which will yield the same total revenue. This line is called an iso-revenue curve. The slope of the iso-revenue curve is determined by the ratio of the price of Y_1 to the price of Y_2. Thus with given prices, the point of maximum profit or least cost is established by the tangency of the iso-revenue curve to the production possibility curve. In Figure 3 the iso-revenue line RR_1 assumes an equal price for Y_1 and Y_2. If the price of Y_1 exceeds the price of Y_2 the iso-revenue curve will be RR_2. On the other hand, if the price of Y_2 exceeds Y_1 the iso-revenue curve will be RR_3.

This study delt with five different production crops associated with three fixed restrictions, for each of three different land sizes. Therefore, the involvement became much greater than the figures show. However, the procedure was identical.

Limiting Resources:

Land	XX Acres
Labor 1	XX Hours
Labor 2	XX Hours
Labor 3	XX Hours

Per Acre Requirements:

	Y_1	Y_2
Land	X	X
Labor 1	X	X
Labor 2	X	X
Labor 3	X	X

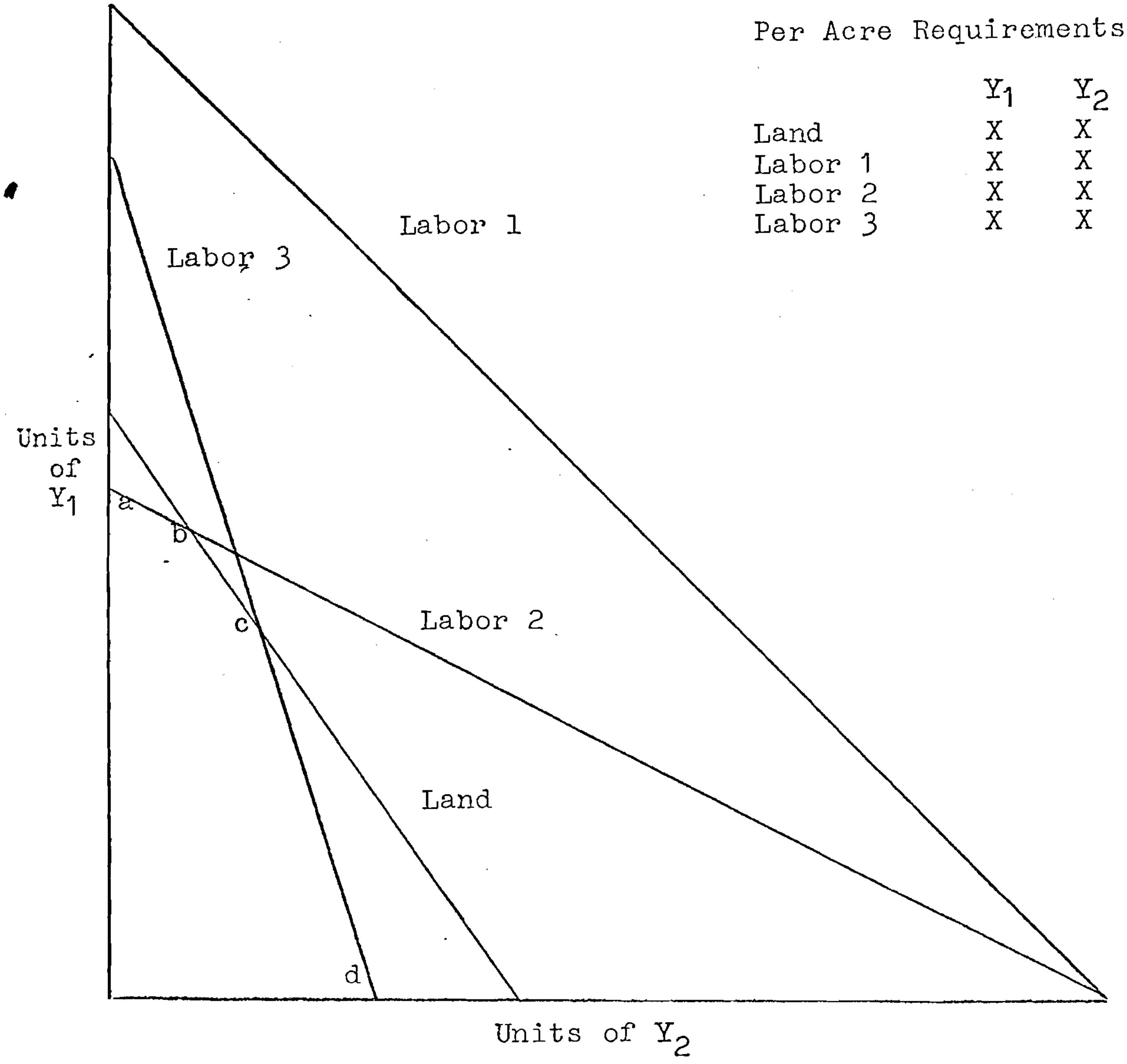

Figure 2. Hypothetical production possibility for four limiting resources.

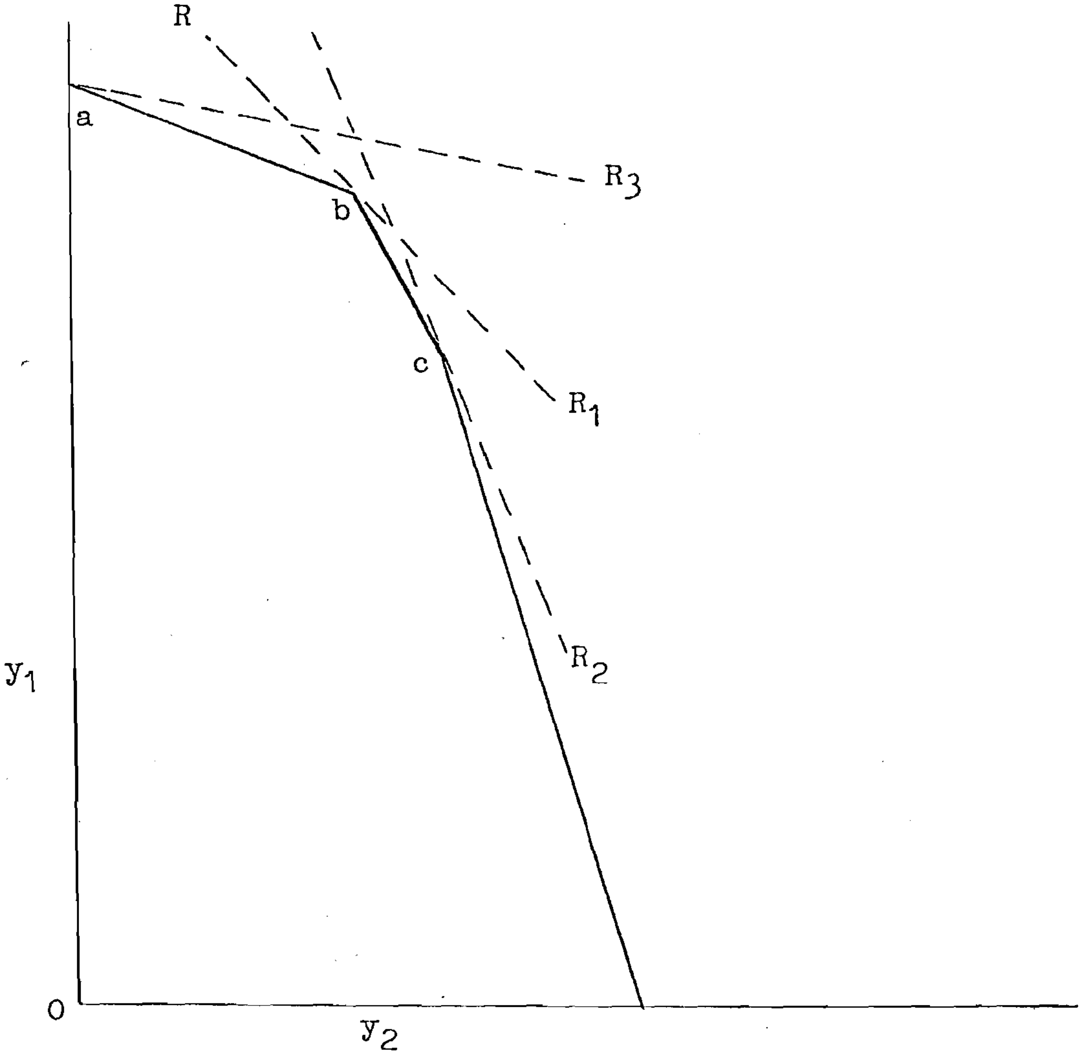

Figure 3. Production possibility curve and iso-revenue lines.

IV. NATURE AND CAUSES OF ECONOMIES OF SIZE

The relationship between the level of output and the unit cost of production are major factors of consideration concerning economies of size. Treatments of the traditional theory of economies of size under perfect competition are found many places in economic literature.[6] The theoretical framework used in this study departs from the traditional one in that this analysis assumes a constant level of output per acre for the various sizes involved.

Our interest is focused on possible reductions in the average total cost of the different farm sizes. Force leading to such reductions may be classed as either internal or external economies. An external economy is defined by Samuelson as:

> "A favorable effect on one or more persons that emanates from the action of a different person or firm; it shifts the cost curve of each person it helps, and such an externally caused shift should be distinguished from any internal movement along the affected individual's own cost curve."[7]

These economies are not in any way related to the output of an individual firm. Hence, external economies were excluded from consideration in the present study. Internal economies result from changes occurring within the firm. These include discounts to firms using a large volume of particular resources. Such

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[6] Jacob Viner, "Cost Curves and Supply Curves" <u>AEA Readings in Price Theory</u> (ed.) G. S. Stigler, and Boulding, VI, 198-232. Chicago: Richard Irwin, 1952.

discounts are called pecuniary economies.

Pecuniary economies were found to be nonexistent in the study area. Attention was therefore concentrated on technical economies--those arising from changes in the input combinations at successively higher levels of output. Because of the assumption of constant output per acre, increased output can only be achieved by increasing the number of acres of the particular crop.

Divisibility and Economies of Size. Discrete (nondivisible) resources are available to the firm only in whole number quantities of specific size units. The discrete unit may be a single item, such as a tractor, or a certain sized increment of land. Divisible resources are available in measured quantities, including such items as bulk fertilizer, gasoline, feed, and seasonal hired labor.

E. H. Chamberlin has pointed out that nondivisible resources may sometimes become available to the firm in divisible quantities.[8] This can occur when the firm obtains the use of a discrete resource factor for a fraction of the production period. For example, a potato cultivator may be owned and operated jointly by two or more farmers. Custom hiring and leasing are also possible in many cases. However,

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[8] E. H. Chamberlin, "Proportionality, Divisibility, and Economies of Scale." Quarterly Journal of Economics, Vol. LXII, No. 2 (February, 1948).

consideration of all of these factors is beyond the scope of this study. Implements and tractors were assumed to be owned by the farm operator, subject to capital involvements which will be discussed later. Harvesting equipment was treated as a custom operation, as it was found to be readily available in the area.

If all resources were divisible, any under utilized resource could be replaced by the rational manager for a slightly smaller and cheaper resource; achieving full utilization of all resources. Thus, average costs would be less than or equal to those costs experienced under nondivisible resources. However, resources which may be divisible such as land, labor, and capital may also be limited by exogenous factors. Also, the operator may decide to allow excess machine capacity as a safeguard against losses resulting from unfavorable weather conditions.

Basis for Analysis of Cost Economies. The economic theory underlying an analysis of cost economies is illustrated in Figure 4, using the average-unit-cost curves of the firm.[9] The short run average cost curves (SRAC) assume one or more resources to be fixed, while the other resources are variable. In this study, land, labor, and "capital" are designated as fixed resources, at the least cost position on the curve. At all other positions land would vary while "capital" and

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[9] George J Stigler, The Theory of Price, rev. ed., New York, Macmillian Company (1952), pp. 134-147.

labor remained relatively fixed. This study formulated the low point on the assumed SRAC--the average of what was actually being done. From this point extensions were made to arrive at a relative SRAC for the three different sizes involved.

Curve $SRAC_2$ is a similar average cost curve based on different "capital," labor and land restrictions. Curve $SRAC_3$ has the same interpretations for still larger fixed combinations. The short run average cost curves have the typical "u" shape Average costs decline with an initial expansion of output as fixed costs are spread over more units; eventually, however, average costs per unit of output level off and then rise as other inputs must be added in increasing proportions to the fixed resources, in order to reach greater output levels. It is emphasized that the empirical data in this study depicts only the low point on the relative short run cost curves. It was not within the range of this study to derive the complete short run average cost curves.

From the standpoint of trends in farm size and survival of the firm, the long run average cost curve (LRAC) is probably most relevant. The LRAC curve is an "envelope" formed as a tangency to the short-run cost curves. The LRAC curve can be considered as a planning curve in the sense that a farmer planning for the long-run with all resources variable could decide to operate at any point on the curve. If the U shape is appropriate for the LRAC curve, producers would tend to limit expansion so as not to go beyond the minimum point Q

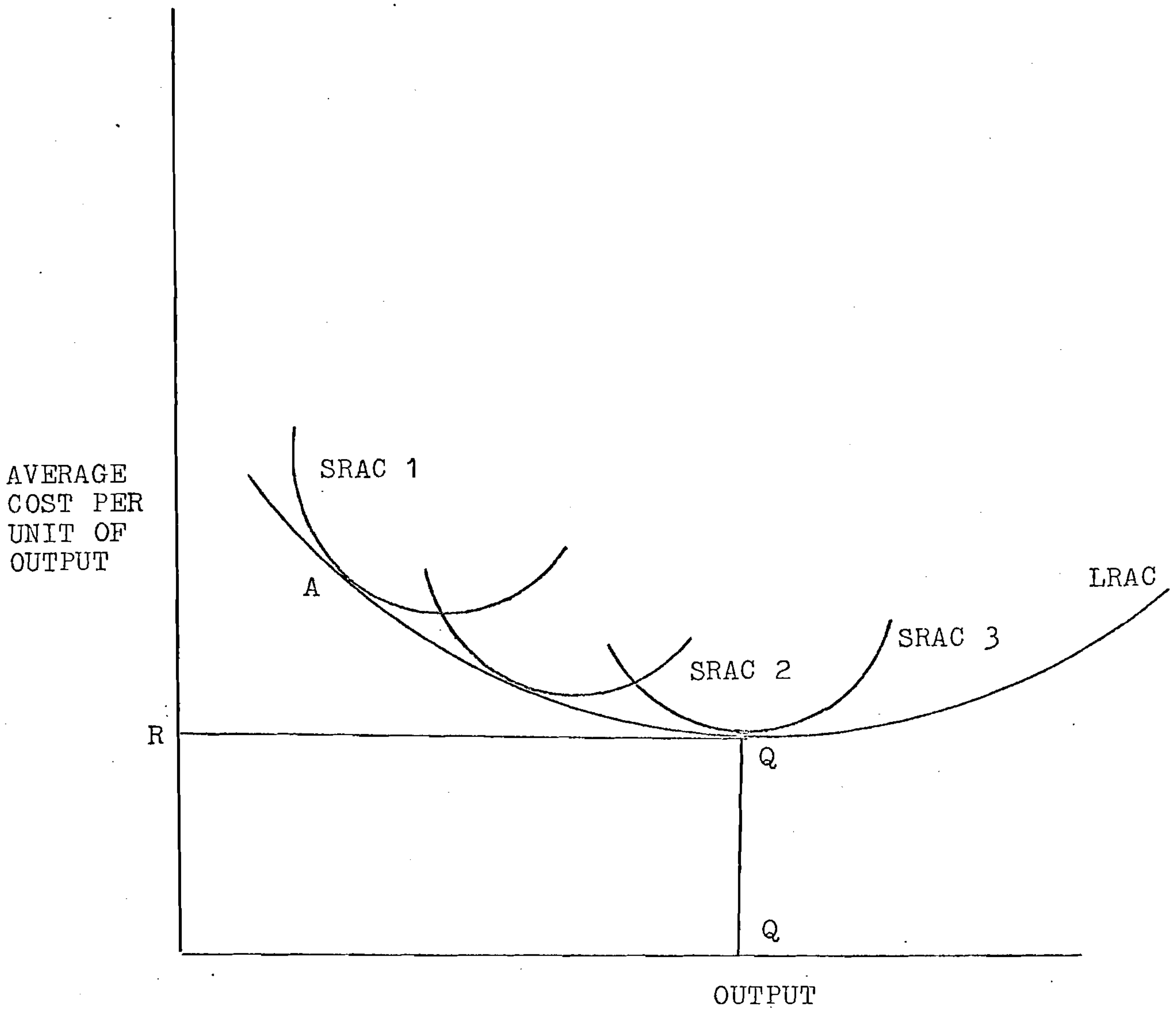

Figure 4. Hypothetical short run and long run average unit cost curves for farms of different sizes.

unless returns were high enough above R, to make a larger output more profitable. However, if the LRAC declines throughout or becomes constant beyond some point, there would be no cost disadvantage in expanding size indefinitely.

A long run cost curve, LAC, can be constructed for any family of short-run cost curves, as in Figure 4. The empirical evidence gathered for this study restricts the analysis to the area between points A and Q.

For purposes of this study it is assumed that this range is the low range of the long run cost curve. This assumption is justified by the producers already in the area. However, it must be pointed out that the size of the unit in agriculture is partly a historical phenomenon, where-in a beginning operator acquires a size determined by the limited resources he possesses. The average size farm in this area on which the model and the linear programming coefficients are based could have been determined by exogenous factors. If this is true, the extent to which these exogenous factors change over time must vary the results of this study.

Probably the most important single factors limiting farm size are the risk and uncertainity inherent in farming. Expansion in size ordinarily requires borrowed capital; as more borrowed capital is employed the risk of losing equity or burdening the family with a large debt increases. Thus, farmers who have achieved an efficient sized unit and satisfactory incomes may tend to "play it safe" in order to protect their current position.

The area study reveals that as the farm size increases beyond the 600 to 700 acre range, the producers felt they must diversify widely. Most of the producers of this size are in the live animal market primarily, while raising some cash crops. Since this study was designed to analyze crop production farms, the upper limit acreage range was 600 to 700 acres.

Minimum Costs. In any empirical study it is important to specify what costs are being minimized and the conditions under which costs are minimized. One of the first steps in this specification process is to determine the sources of possible economies or diseconomies associated with farm size. In this study as has been presented, the source of economies or diseconomies rests with technical or physical economies or diseconomies arising from input combinations. An attempt was made to determine the minimum cost points for three levels of output (three sizes) taking into account only technical economies.

The conditions under which the minimum cost points were selected are (1) that prices paid for similar inputs do not vary by size of farm, (2) the input-output relationships used are currently available in the Oakley Fan area, and (3) the input-output relationships used are also those which could be attained subject to the area restrictions.

Fixed and Variable Resources and Costs. In order to adequately establish minimum costs, it is necessary to distinguish between fixed costs and variable costs. Such a distinction has meaning only in the short run context, where the resources defining plant size are fixed; that is, the resources are available to the firm only in specified quantities. In the long run all resources and costs are variable.

Before specifically distinguishing between fixed and variable costs a few common warnings should be pointed out:

1. the dividing line between what is a fixed cost and what is a variable cost is not the same for all decisions;
2. an expense may be a mixture of both fixed and variable elements;
3. the term variable does not refer to variations in prices over time, but rather to cost-output relationships at given moments in time; and
4. the expression "completely fixed expense" is open to diverse interpretations, depending on the classification of the cost involved.[10]

These warnings will become more significant in the following sections of this study.

Fixed costs. Fixed costs go on regardless of the volume of the output provided and are, therefore, lower per unit of output at higher volumes of output. Generally, major fixed costs include such items as depreciation, interest, insurance and taxes on buildings and equipment. A decrease in fixed

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[10] Haynes, W. W., Managerial Economies, (Homewood, Illinois: Darsey Press Co., 1963), pp. 214-220.

cost per unit of output can result by increasing volume through an expanding crop production so that the same or only slightly increased total fixed cost can be divided over a larger volume. In general declining average fixed costs open the possibility of economies of size.

Variable Costs. Variable costs include all those costs which increase in total as the volume of output increases. Some variable cost items increase proportionately, or nearly so, with output. Some may even increase more than proportionately. Others increase only slightly with increases in output. The greatest opportunities for reductions in variable costs lie in reducing them in total rather than on a per unit of volume basis. Particularly in the subject area where no pecuniary economies were found to exist. However, for purposes of this study directly proportional average variable costs were assumed. On the average such an assumption is justified. For example, consider the divisable input product, seed. As a producer plants more seed his output increases up to a given point; beyond such a point decreasing returns may set in causing his output to decrease. In actual practice there are usually some men who are below this optimum seed application rate and some who are over it. This study utilized the actual data gathered along with suggested optimum rates by the previously mentioned agencies. In this way, directly proportional variable costs to output were established.

VI. ASSUMPTIONS

The basic assumption underlying the analysis of this study is that the Oakley Fan farmer will attempt to maximize profits in the long run by considering both fixed and variable production costs in deciding what, how and how much to produce.

Two further assumptions were made in direct connection with this study. It was assumed that all farmers had sufficient water to grow any of the crops in the plan. Second, it was assumed that the farmers production possibilities were limited to five main crops.

The "sufficient water" assumption was necessary in order to provide a net return available for water.

The crop limitation assumption was made because a statistical average showed that the five crops, potatoes, grain, alfalfa, beans, and sugar beets made up 89.01 per cent of the total acreage. The remaining 11 per cent consists of idle land, pasture, homestead, ditches and roads, and other crops.

In addition to the above assumptions there are four basic assumptions that must be made when dealing with linear programming. They are:

1. Linearity - each additional unit of output requires the identical amount of inputs.
2. Divisibility - any process can be used to any positive extent so long as sufficient resources are available.

3. Additivity - two or more processes can be used simultaneously, and if this is done the values of the outputs and inputs will be the sums of the values which would have resulted if the process were used individually.

4. Finiteness - the number of processes available are finite.[11]

Other assumptions concerning specific aspects of this study will be made explicit and will be explained as they arise.

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[11] Robert Dorfman, "Application of Linear Programming to the theory of the Firm", University Microfilms, Inc., Ann Arbor, Michigan (1961), p. 81.

TABLE II

THREE-YEAR AVERAGE PERCENTAGE OF CROP DISTRIBUTION

Crop	Per Cent Average
Grain	39.01
Potatoes	15.16
Alfalfa	11.58
Beans	10.36
Sugar Beets	12.81
Peas	2.75
Corn	2.13
Clover	1.12
TOTAL	94.92*

* The total is not 100% and this difference is attributed to rounding, homesite, roads, ditches, pasture, etc.

CHAPTER III

PRESENTATION OF DATA AND ANALYSIS

The analysis was conducted using constraints imposed by the farm programs that were in effect at the time of the analysis, namely the 1965-67 programs.

Crops Produced and Cropping Programs and Soils

Crops Produced and Cropping Programs. Five principal field crops were produced in the Oakley Fan area during the survey. These were: (1) grain, (2) potatoes, (3) sugar beets, (4) beans, and (5) alfalfa. Three other crops were grown in the area during the 1965-67 time span. However, when combined, these three crops amount to only 6 percent of the total acreage interviewed and were not found to be of over all significance. Table II gives the percentage breakdown.

Grain is the most important crop produced in the Oakley Fan area in terms of total acres. On conferring with the county agent it was discovered that a ready market existed for the grain crop. There are several large cattle operations in the near vicinity which create a ready demand for the grain crop. Potatoes were the most important crop in terms of value of the crop assuming average prices. However, few farmers would consider putting more than 25 percent of their farm into potatoes because of the high risk factor. The price fluctuation is wider for potatoes than for any of the other crops.

Because contracts were available, sugar beets and beans were raised as a hedge against market fluctuations. There was no apparent concern by the producers over the number, or amount of acres that were available to be let on contract by the companies. After an initial investment had been made for the equipment necessary to raise sugar beets the producers implied that they felt they must raise at least 7 to 10 per cent sugar beets to utilize their equipment. Economically stated, the producers were attempting to at least cover their fixed costs, with a contract crop.

Generally the producers interviewed, tended to grow about the same acreage of beans as they did sugar beets. This occurred because the farmers generally maintained that at about 10 to 15 per cent of their crop acreage should be covered by contract crops. By so doing, the farmers were able to stabilize a given amount of their income.

More than half of the producers in the area insisted on growing alfalfa. They were cognizant of the fact that it was costing them money to raise it. Several reasons were given for raising alfalfa. A few gave historical background and desire to have feed available as a reason. Others pointed out that there was a readily available market in the area, and there were soil building advantages. A few farmers stated that alfalfa was necessary to control possible disease on their potato ground. Most of the farmers assumed that full utilization of their land was necessary, therefore, alfalfa became a cost minimizing crop. When the farmers were limited by some factor such as capital, labor, or water, they would neglect their alfalfa in order to have additional factors available for cash crops.

A basic cropping program using the above crops and restrictions was selected for investigation by the linear programming method.

Soils. The majority of the soils in the Goose Creek area of cassia County are classified as sandy loam. For this investigation it was assumed that no appreciable difference occurred in farming operations because of soil differences. An interview with the S.C.S. office substantiated the above assumption. No farmers in the area gave soil as one of their restricting factors.

II. SIZE AND TYPE OF FARM IN AREA

The twenty-three farms surveyed consisted of 10,076 acres, which is a major portion of the area which was selected as the subject area. There were no explicit boundaries on the subject area.

The distribution of farms by size for the producers interviewed is presented in Table III. The smaller farms predominate presently, because of relatively new entry of farmers into the area. All of the farmers in the 349 acre and under range planned to increase acreage in the future. Those producers with more than 550 acres generally had livestock investments in addition to their farming. Farmers in the 350 to 549 range appeared to be relatively content with their farm size. Therefore, restrictions of water and labor was their main concern.

The sizes of the farms selected for the synthetic models as previously stated were 200, 400, and 600 acre farming operations. Land in roads, ditches, farmstead, etc. are not considered within the above farm sizes. The amount of land not actually used for farming purposes was found to average between 6 and 7 per cent. For example, to farm 200 acres the producer must have at least 212 acres at his disposal. The stated acreage for the models are mid-points of a range assumed to extend 100 acres on either side.

Since the cropping patterns were predetermined, they varied with the size of the farming unit. The average careage of the farms interviewed fell into the 350-399 range. There were approximately 50 per cent above this range and 50 per cent below.

III. CLIMATE AND AVAILABLE WORK DAYS

The climate is characterized by hot summers and relatively mild winters. Rainfall averages approximately eight inches per year. Most of the rain falls in the winter months of November through March. Very little rain falls from May to September. The amount of rainfall and the frequency were used to estimate the number of workdays lost due to rain; this was adjusted to the average of the farmers own estimate of lost time due to family sickness or other unforseen factors. Holidays and Sundays were excluded as work days. Table III shows the monthly breakdown of average available work days, and the total work hours.

Based upon this information, the hours of work time available to the farm operator are specified as follows:

Time period 1: January 1 to March 31 -- 510 hours
Time period 2: April 1 to June 30 -- 864 hours
Time period 3: July 1 to September 30 -- 900 hours
Time period 4: October 1 to December 31 - 610 hours.

The hours shown in Table III are the hours for the farm operator. Additional hired labor and seasonal labor will be discussed in the optimum farm restriction section.

Water

It was difficult to generalize about the water resource in the Oakley Fan. However, all of the farmers interviewed obtained their irrigation water from wells. The total life of the water from the wells varied from less than 490 feet to more than 1,300 feet. For purposes of this study, however, water was assumed to be present at the head gate in a sufficient amount to irrigate any of the five crops to be grown. Water, as such, was not to be assumed a restrictive factor. By assuming it to be unrestrictive the study was able to arrive at a relative maximum amount to be spent on water.

Yields

Average crop yields in the area are somewhat above the

TABLE III

NORMAL WORK HOURS AVAILABLE AND TIME PERIODS

Time Period	Total Workdays	Total Work Hours	Hours Per Day
1			
January	13	130	10
February	18	180	10
March	20	200	10
sub total	51	510	--
2			
April	22	264	12
May	25	300	12
June	25	300	12
sub total	72	864	--
3			
July	25	300	12
August	26	312	12
September	24	288	12
sub total	75	900	--
4			
October	23	230	10
November	20	200	10
December	18	180	10
sub total	61	610	--
Grand Total	259	2,884	--

averages for the state or for the county. This implies a degree of management above average, since the growing and soil conditions were not found to be above average. The specific method of arriving at crop yield will be discussed in the next section.

IV. STANDARDIZED MODEL FARM BUDGET ENTRIES

Data for the model budgets were developed in three major steps. First the empirical data were tabulated into a per acre basis, second the physical requirements to raise one acre of a crop were established, and third the computed costs were applied to the resource requirements.

Management

As previously stated, the basic assumption is that the farm managers are profit maximizers; in conjunction with this idea the farmers are assumed not be ingenious, because such an assumption would nullify the differences due to farm size. This would cause this study to be an analysis of managerial ability instead of a measure of the exogenous factors and economies of size. The level of education, degree of planning, higher yields, and the willingness to adopt new technology suggests that these farm managers are above average, but not exceptional.

Application Rates for Seed, Fertilizer, and Irrigations

Standard rates for seed, fertilizer and number of irrigations were set up for the models. Standardizing these factors acts to remove any managerial differences between farms. The data in Table IV and V represents the typical input coefficients on the three sample farms.

The range in grain seeding rates was 70 to 130 pounds. The product, grain, includes wheat, barley and mixed grain, the majority of acres being mixed grain. The variation in potato seed was from 1,300 to 1,700 pounds. For alfalfa the range was 8 to 16 pounds. Because the producers reseed alfalfa about every four years, the estimated seed rate was divided by four. Bean seeding rates ranged from 85 to 110 pounds depending on the contract restrictions. The seeding rate for sugar beets varied from 5 to 9 pounds of monogerm seed.

The range in fertilization rates for grain ran from 50 to 100 pounds of actual nitrogen per acre and 15 to 25 pounds of actual phosphate. For potatoes, the range was 150 to 250 pounds of nitrogen and 80 to 180 pounds of phosphate per acre. The alfalfa hay fertilization varied from 0 to 50 pounds of phosphate per acre. The fertilization rate of the beans would vary depending on the advice of the field man for the contracting company. Generally, however, the range fell between 0 and 20 pounds of phosphate and 0 to 30 pounds of nitrogen. Sugar beet application rate ranged from 100 to 325 pounds of nitrogen units and 60 to 300 pounds of phosphate units.

The frequency of irrigations, of course, varies with the weather conditions. However, the three years this study covered involved a so called "wet year" 1965, a "dry year" 1966, and a "normal" year in 1967. These are "area terms" and simply imply a relative degree of moisture. Even in a "wet year" irrigation is necessary. Actually there is never sufficient rainfall to exclude a significant amount of irrigation. Therefore, on the average the number of irrigations are quite reliable. The variation in the number of irrigations depends on the crop involved but in no case did the range differ by more than three irrigations. Since this study is not dealing with amount of water applied, the number of irrigations is significant only from the standpoint of labor involvement.

Yields, Seed Prices, and Product Prices

Since very little information is available for small areas from secondary sources, the yields and seed prices presented in Table IV are what were actually reported or estimated by the interviewed farmers.

Grain. New varieties of grain have greatly increased the yields. The reported range went from 70 bushels to 130 bushels. Many of the farmers were very near the 100 bushel per acre mark.

The grain seed price was developed by compiling the information from the producers with the local seed merchants. There is, of course, quite a variation in seed prices but most farmers in the subject area were not willing to spend over $5.00 per 100 pounds. The distribution in the seed price was

TABLE IV

PER ACRE SEEDING RATES, FERTILIZATION RATES, AND NUMBER OF IRRIGATIONS PER SEASON FOR THE MAJOR ENTERPRISES FOUND ON THE SAMPLE FARMS

Enterprise	Seeding Rate Per Acre	Fertilization Rates Per Acre		Number of Irrigations
		Nitrogen Available	Phosphate Available	
Grain	100 lbs.	72 lbs.	18 lbs.	5
Potatoes	1,500 lbs.	192 lbs.	103 lbs.	11
Alfalfa	3 lbs.*	0	90 lbs.	5
Beans	100 lbs.	30 lbs.	20 lbs.	8
Sugar Beets	7 lbs.	150 lbs.	150 lbs.	11

* 12 pounds per seeding once every four years.

divided evenly between barley and wheat prices. Most of the grain grown in the area found a ready market as livestock feed. Because of this some producers grew a high quality barley and received a comparable price to that of a wheat-barley mixture.

The actual product price was somewhat unique for the area, which created a high demand for grain products. For this reason the price the producers received for their product was associated with livestock market prices. Most of the farmers did not limit their grain crop because of government restrictions, but chose instead to sell on the local market. The price in Table V is an average of the actual price received for the three year period, 1965-67.

Potatoes. Because the subject area was relatively new to farm production, the initial potato yields were higher than those now received. Virgin land productivity is higher than previously worked land because of more stable soil structure. However, after two to four years a fairly constant productivity due to soil conditions, is established. But most farmers agree that in the long run they will average no less than 250 CWT.

The relatively high seed cost is what was reported to have been paid in the 1966 crop year. Although this cost may,[12]

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[12] Kurt Moller, "Cost Economics Associated With an Increase in Size of the Potato Enterprise on Pump Irrigated Farms in South Central Idaho," (Master's Thesis, The University of Idaho, Moscow, Idaho, 1963), p. 79.

seem high compared to the long-term average cost that was extablished by a 1962 cost study, it includes cutting, treating, shrinkage, rot loss, etc. None of the producers thought this price was out of line, even though some producers cut and treat the seed themselves. They would do so as a means of quality control rather than as an economic saving venture.

A 1959-66 adjusted average price was used to determine the product price.[13] Since few producers had storage facilities, great consideration was given to the October price of potatoes. There were no potatoes sold on contract in the area, therefore, wide price fluctuations were possible.

Alfalfa. The reported ranges in the yields of alfalfa were from 3.5 tons to 7 tons. However, the one producer who reported 7 tons was a highly unusual operator with family advantages many operators did not have.

The seed prices were calculated directly from the dealer prices in the area. According to the dealers there has been very little fluctuation in alfalfa seed price for at least the last five years.

The price of hay varies inversely with the previous year's supply. It has been known to change from $15.00 per ton to $30.00 in a single year. However, the growth of the ready market has shown a tendency to reduce the wide variation.

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[13] United States Department of Agriculture, Agricultural Statistics 1967, (Washington D.C.: Government Printing Office), 1967, p. 240.

The value in Table V is a weighted average for the years 1959-67.[14]

Beans. Beans are a relatively new crop to the area, but each year they grow in popularity. All of the beans grown in the area were subject to various contract restrictions. The range in yields were from 11 CWT to 22 CWT. The low yield was reported by a producer who had had his crop damaged by frost.

Seed is readily available throughout the county which results in a price slightly lower than the state average price. The price used in the models was arrived at from interviews with the local dealers.

The price of beans has been sharply increasing over the last five years. The 1966 price was more than a dollar above the figure used in Table V. The value in the table is a 1959-66 weighted average.[15] It was felt that the last three years showed an unusually abnormal price advantage to beans, therefore, the long run estimate was made. The price range computed by the linear program, however, provides sufficient flexibility to include the 1966 price.

Sugar Beets. All sugar beets in the subject area were grown on contract. Therefore, contract negotiations may alter the acres of sugar beets grown. The producers in this area

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[14] Ibid. p. 274.

[15] Ibid. p. 289.

get a lower tonnage per acre than some other areas in the state. However, the sugar content in the beets is higher in the Oakley Fan than in several other areas. It is possible that as the sugar content premium becomes more recognized, the producers will grow more sugar beets.

The yield in sugar beets ranged from 12 tons to 18.5 tons per acre. Again the fluctuations are mainly due to weather conditions.

The seed price of sugar beets is that reported by the local sugar companies. The product price was computed as the previous price by weighting the 1959-66 prices.[16] However, the price does not include the sugar content adjustment. At the time of this study there was no reliable set price for this premium. The selling price in Table V includes both the payment from the factory and government subsidy.

Irrigation Systems. To further standardize the farms, a common means of irrigation was selected. This posed no problem since all but one producer flood irrigated. However, the variation in the labor time involved was a difficult and important factor to isolate. The problem became quite involved because of the variations in length of runs, labor desire, and various irrigation aids such as concrete ditches. However, with the aid of an agricultural engineering student, irrigation labor requirements for the various crops were devised.

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[16] Ibid. p. 81.

TABLE V

ASSUMED SEED PRICES, PRODUCT PRICES, AND PER ACRE YIELDS FOR THE ENTERPRISES FOUND ON THE SAMPLE FARMS

Enterprise	Seed Price	Yield Per Acre		Product Price*
Grain	$4.88/bu.	95	bu.	$ 1.47
Potatoes	$5.50/cwt	250	CWT	$ 1.47*
Alfalfa	$ .50/lb.	4.5	tons	$20.75*
Beans	$8.97/cwt	17.5	CWT	$ 7.47*
Sugar Beets**	$ .55/lb	17	tons	$14.30*

* 1959-66 weighted prices from U. S. Agricultural Statistics

**Sugar Beet price includes government payment

Opportunity Costs.

> "The reflection of opportunity costs in the accounts if far from simple; in fact, it probably is impossible to devise a programmed system of accounts that will routinely provide accurate estimates of opportunity costs."[17]

In this study implicit opportunity costs are recognized. There are the costs which are not ordinarily recognized in the accounts, such as the interest on the producer's own investment. The definition applied to the opportunity cost principle by W. W. Haynes is "The cost involved in any decision consists of the sacrifices of alternatives required by that decision. If there are no sacrifices, there is no cost."[18]

The implicit opportunity costs were assumed to be 5 per cent for land and building capital, 5 per cent for machinery capital, and 8 per cent for operation capital. The three different rates reflect the varying time involved in the use of the capital in conjunction with the risk element. The interest payment on land and buildings is stated explicitely in the budgets. The machinery capital is imputed in the tractor and implement designations. These values were taken from a recent study of machinery costs.[19] The interest on the operating capital is paid back primarily through the interest on capital entry in the budgets.

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[17] W. W. Haynes, Managerial Economics, (Homewood, Ill.: Darsey Press Co., 1963), pp. 30-31.

[18] Ibid. p. 32.

[19] Karl H. Lindeborg, Cost of Operating Farm Machinery (University of Idaho; Moscow, Idaho, 1962), pp. 2-8. (Mimeographed).

Machinery Costs.

In a farm production unit machinery costs are one of the main areas where economies of size may be found. However, because of the vast number, types, styles and varying ages, a comparison of machinery between farms is extremely difficult and would be of questionable value. Therefore, a standard family of machinery was settled upon based on the empirical evidence. The machinery was then assumed to have standard new costs and standard depreciation and salvage value rates. The new cost values were computed from a ten year average retail selling price.[20] Such values were then related to the above mentioned cost study. A standard 10 per cent salvage value was assumed. The remaining 90 per cent of the new cost was depreciated out on a straight line basis for a 10 year period.

Truck and Pick Ups.

The trucks and pick up costs were computed in the same general manner as for all machinery following the general procedure outlined in the cost study by Lindeborg. The salvage value was assumed at 40 percent. The remaining 60 percent of the cost was depreciated out on a straight line basis for six years.[21]

Repair Costs.

All repair costs for both general machinery and trucks

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[20] *Official Tractor and Farm Equipment Guide*, National Farm and Power Equipment Dealers Asso., (St. Louis, Mo.: NRFEA Publishing, Inc., 1966).

[21] Lindeborg, op. cit. pp. 2-8.

and pick ups are included in the budgeted per acre value.

Tractor

The cost per hour for the various size tractors involved also was taken from the previously mentioned cost study. The number of hours of use was an empirical estimate based on the collected information.

Custom Work

Because many of the farmers interviewed, hired custom operators to perform some of their operations, it was assumed that this possibility also existed for the models. The major custom work was harvesting and spraying. Rates that include hauling were assumed to have a standard distance of 14 miles round trip.

Farm Supplies

The entry farm supplies includes such items as small hand tools, nails, bailing twine, rope, etc. Also the traveling, accounting fees, and legal fees that the farmers may have would come under this entry. An estimate of such expenses was derived from the empirical data. The estimate was then checked with other budget analysis to arrive at the figure in the budgets.[22]

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[22] Arthur Lee Coffing, "The Relationship of Farm Size to Ability to Pay for Irrigation Water in the Dry Lake Area of Canyon County, Idaho" (Unpublished Master's Thesis, The University of Idaho, Moscow, Idaho, 1965), p. 49.

Building Costs

The methodology employed for the machinery and trucks was also used for determining building costs. Typically the sample farms had few buildings other than the manager's home and the machine shed. Straight-line depreciation was used for a twenty year period. The manager's home was not included in this entry. The initial cost includes shop and equipment for the shop. The rate of depreciation was 4½ percent per year. This resulted in a 20 percent salvage value for buildings and equipment after twenty years.

Direct Labor

Direct labor includes the farm manager's own labor along with his family and or hired labor. The rate was figured at $1.50 per hour regardless of who performed the operation. However, it was assumed that the farm manager would be willing to work the hours listed in Table III before hiring any additional labor. This return to labor is the opportunity cost for the farmer's labor. There is no provision made within this value for the return to the manager's ability beyond that of labor.

Taxes

The tax rate was based upon county clerk records, of land tax valuation. The irrigation system was excluded from this taxation value as much as possible, to isolate charges concerned with water. All water costs are assumed to be paid from the net return budget entry. The value of the land was reported to be $400 per acre excluding the irrigation development expenditures. Machinery taxes and truck and pick up taxes are included in this entry. A standardized license rate was also included for trucks and pick ups.

Insurance

There appears to be a relatively standard insurance rate throughout the state of Idaho. This is $0.65 per $100 valuation for machinery and $0.55 per $100 value of buildings. This value was charged against the buildings and larger machinery items.

Effects of the Assumptions in the Model

The various standardizing assumptions were made in an attempt to segregate out differences due to size and available water supplies. These assumptions are prone to bring about fixed averages which may require adjusting if the models are compared to specific real farms. Because the assumptions are based on long run averages, they should have little or no effect on the outcome of the relative advantages of the different sizes. To the extent that the models use averages and are not exact representations of specific farms the solutions will be in error.

V. EMPIRICAL MODEL FARM BUDGET ENTREES

From the basic data gathered during the interviews and from the standard coefficients explained in section IV, of this chapter, a standardized cost budget was prepared for each of three different farm sizes. By using either direct or weighted formula allocations, or sometimes both measures, it was possible to allocate each budgetary cost to the individual enterprise on which it was expended. Such items as contract harvesting labor, could be allocated directly, while fuel, repairs, and similar items had to be allocated according to a system of weights. The system of weights varied with the item and the enterprise. For example, the amount of repairs allocated to the grain crop was the percentage of the grain acres multiplied by the total investment in specialized grain equipment and the hours of labor involved.

The enterprise budgets are presented in Tables XV through XXIX in the appendix. Because the farmers had kept only records for the entire farm and not for each individual enterprise, it was necessary to establish fine systems for allocating the cost of each item in the budget.

Cost Allocation Systems

Direct Cost Allocation. Direct allocation of costs can be achieved with such things as seed, fertilizer and spraying. A given amount is used per acre and it costs a certain price; multiplying the two together yields a per acre cost. Adding the respective per acre cost together will give the total cost for the given enterprise on the farm.

Allocation of Tractor Hours. From the interviews of the sample farms, tractor hours per acre were established for each operation that takes place in raising a particular crop. For example, the question was asked, "How many acres can you plow in an hour?" By correlating their plowing to a specific field, and remembering days or half days involved, most farmers were able to arrive at a figure which they believed to be fairly reliable. A model average of the individual reports was then computed to determine the total tractor hours for the individual enterprises and for entire farms. They totals do not include the custom tractor work involved in some spraying and harvesting. The tractor hours represent only work performed by the operator's tractors and hired men.

Allocation of Labor Hours: The allocation of labor costs was constructed in a manner similar to that used for tractor hours. The method is concerned with the man hours spent doing the field work, this includes machine and tractor operators' time. Such contract jobs as hoeing sugar beets, custom machine work, or custom hauling are not included in the labor cost allocation. Man hours for each operation of a given enterprise was determined by finding the machine time for the operation and multiplying it by the crew size to get the man hours for the operation. Man hours for each operation and for irrigational purposes were totaled to get the total number of man hours for the enterprise and for the farms.

Entries in the Budgets. The previously explained budget items were all assigned a value or cost per acre. The value of the output was arrived at by multiplying the yield by the price per unit. From this value the sum of the costs was subtracted. The net result was a net return to water and management. This coefficient of return to water and management was found to vary with the size of the farm involved.

Empirical Economies of Size. The initial analysis of the empirical data did not show any significant economies of size. However, a more rigorous analysis with additional data gathered from the farmers did show definite technical economies of size. Such economies were most easily discovered by an analysis of the tractor, implement and labor entries. For example, it was found that on the average when a producer increased his farm size from 200 acres to 400 acres he also increased his tractor size from 400 horsepower to 50 horsepower. Such a 25 percent increase in power does not represent a 25 percent increase in cost. A similar relation was found with 2 row, 4 row, and 6 row implements. Since the methodology used to compute the labor hours was directly related to the implement and tractor time, any saving or dissaving in the use of the implements and tractors was readily and directly shown in the labor coefficient. Making such adjustments, it was easily seen that economies of size did exist. Because of economies of size, three sets of the family of per acre enterprises were constructed. Once such entries in the per acre enterprise budgets had been derived, it was a simple method to construct input-output coefficients for the linear program model. Deriving the average real farms was a simple multiplication maneuver.

TABLE VI

COST AND COST DIFFERENCE PER ACRE PER CROP FOR THREE SIZES OF FARMS

Crop	Per Acre Cost, 200 Ac. Farm	Per Acre Cost, 400 Ag. Farm	Differ. in Cost 200-400	Per Acre Cost, 600 Ac. Farm	Differ. in Cost 400-600	Differ. in Cost 200-600
Grain	$ 96.52	$ 87.55	$ 8.97	$ 81.56	$ 5.99	$ 14.96
Potatoes	287.52	268.46	19.06	260.64	7.82	26.88
Alfalfa	100.40	91.10	9.30	87.12	3.98	13.28
Beans	112.82	101.32	11.50	94.99	6.33	17.83
Sugar Beets	226.18	212.37	13.81	204.08	8.29	22.10
TOTAL	$823.44	$760.80	$ 62.64	$728.39	$ 32.41	$ 95.05

CHAPTER IV

THE OPTIMUM FARM AND THE AVERAGE REAL FARM

In this section the two models will be presented along with their various assumptions and restrictions. A comparison of the two models will then be presented.

I. OPTIMUM FARMS

Initially, three different rotations with five different acreage sizes were associated with three different price levels in the linear program. However, such a program would develop more than 2,000 variables. Therefore, it was generally conceeded that one representative rotation with three farm sizes associated with adjusted average prices would be consistent with the objectives of this study.

The input data for the linear program is that data which has been presented in the per acre budgets, Tables XV - XXIX in the appendix. The restrictions placed on the optimum solutions are real restrictions which were derived from interviews with the farmers, financial institutions, and the Burley Department of Employment.

The land restriction was chosen as previously explained because the area suggested such division lines as 200 acres, 400 acres and 600 acres. Accordingly, the divisions are midpoints for the input coefficients. That is, the given 200 acre farm could vary from 100 to 300 acres without appreciably altering the input coefficients. This is true for the 400 and 600 acre farms.

The captial restriction was a figure arrived at by evaluating various amounts that were postulated by the financial institutions in the area. The capital coefficient does not represent an amount in ready cash. Included in the capital figure are such items as depreciation, return to investment and opportunity costs. The value was arrived at by utilizing two methods. First, farm loan officers in some financial institutions were asked to estimate the amount of funds they could reasonably make available under the following assumptions.

1. The farmer has a solid reputation and a reputable co-signer for his note.
2. The farmer has nothing as security except his co-signer.
3. The farmer will need to make a total investment for the farm. That is, he will have to acquire the land, machinery, labor, etc., with the exception of all irrigation costs and his home.
4. The farmer will make all payments when due out of his return.

These assumptions notably remove the element of risk. However, this was necessary in order to arrive at a given figure for capital. There is no empirical figure that can be applied to the risk factor.

The second method used to determine the capital restriction was to include risk as a factor to the farmer. The same general assumptions were made with the exception of the assumed reputable co-signer. In place of this, it was assumed and empirically supported that the farmer seeking the capital had

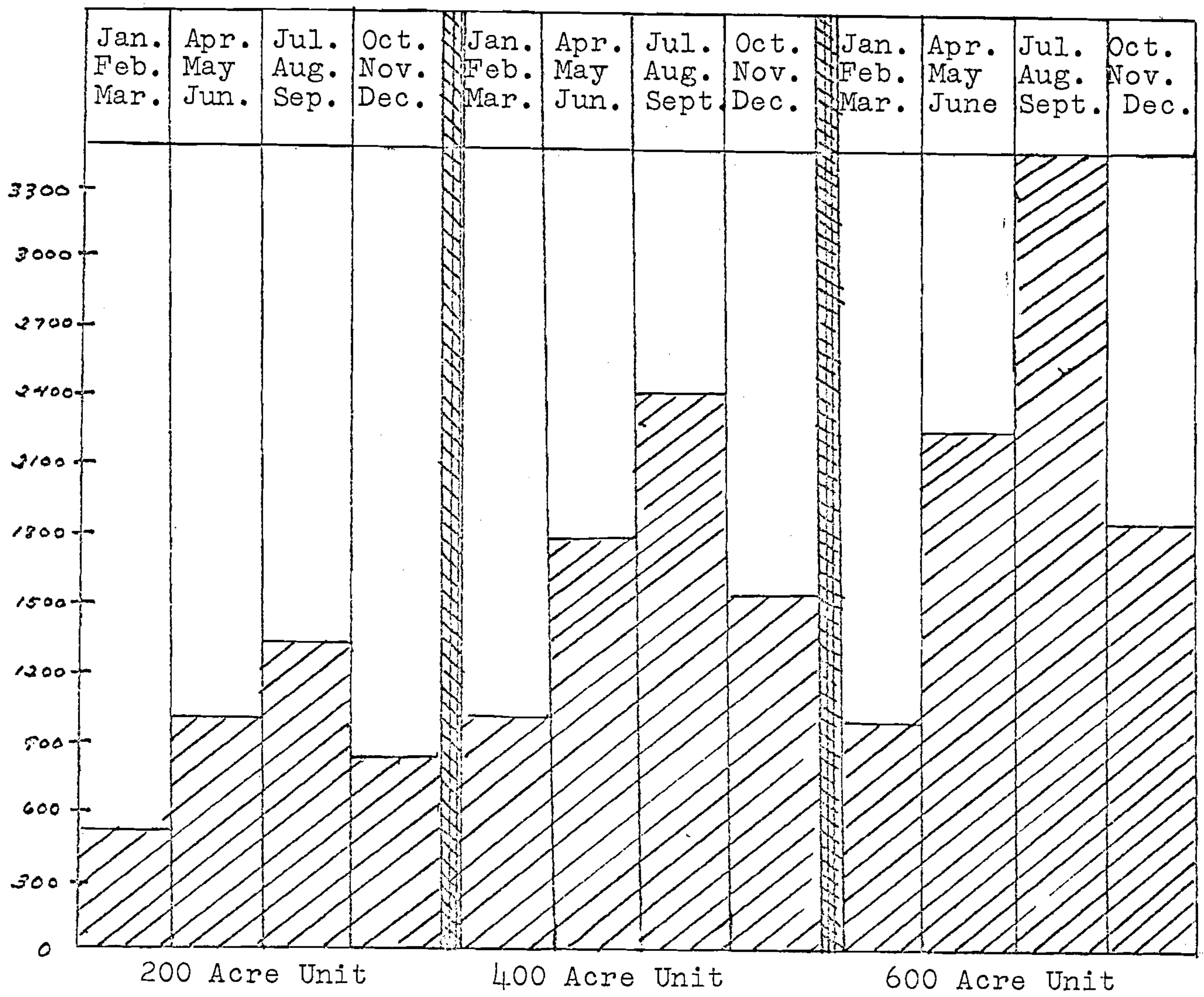

Figure 5. Labor hours available per farm unit.

an equity in his land that amounted to fifty percent ownership. This could then be held by the financial institutions as security.

The labor restriction was divided into four periods as quarterly divisions in the year as shown in Table III. In addition to the farm manager's own labor, full time and part time labor were included in the labor restrictions. Labor requirements, as did capital, varied with the size of the farm. The labor figures are a composite of the farmer's actual labor force in use, the farmer's own estimate of labor available to him, and information from the Department of Employment.

The smaller farmers faced a more restrictive labor supply than the larger producers because they required more highly skilled labor, but were not in a position to pay high wages. The larger producers, on the other hand, could efficiently utilize unskilled labor. A bar chart of the hours available per farm unit is presented in Figure 5. The various rotational restrictions on each of the three optimum farms were derived from the emperical information and the county agent. Many farmers suggested that they could reorganize their farm plan within limits. It is assumed that these limits have been discovered by the linear program optimization farm plan.

Farm Models

200 Acre Model. In the long run the grain crop is the high acreage crop. This is due to a combination of factors, many of them already mentioned, such as ready markets, good

TABLE VII

OPTIMUM FARM

200 ACRES

Enterprise	Per Cent of Total Acres	Net Return Per Acre	Acres	Net Return Per Enterprise
Grain	40	40.22	80	$3,217.60
Potatoes	15	73.58	30	2,207.40
Alfalfa	10	-4.94	20	-98.80
Beans	17.67	12.90	35.34	455.89
Sugar Beets	15.00	10.52	30	315.60
TOTAL	*97.67	--	195.34	$6,097.69

* Deviates from 100% due to "fallow" land practices.

TABLE VIII

OPTIMUM FARM

400 ACRES

Enterprise	Per Cent of Total Acres	Net Return Per Acre	Acres	Net Return Per Enterprise
Grain	4‸6.1	49.19	184.40	$ 9,070.63
Potatoes	23.9	92.64	95.60	8,856.38
Alfalfa	10.00	4.36	40.00	174.40
Beans	10.00	24.76	40.00	990.40
Sugar Beets	10.00	24.33	40.00	973.20
TOTAL	100.00	--	400.00	$20,013.82

prices, relatively low capital involvement, custom work available, good yields and so forth. But even with these advantages, producers felt that they could not put greater than 40 percent of their land in grain. Therefore, a limit of 80 acres was established.

Thirty acres of potatoes was set as the upper limit because of the high risk involved. Many farmers of this size would off-set their potato acreage with an equal acreage of sugar beets.

Ten percent or 20 acres was the lower limit restriction placed on alfalfa. Such a restriction was found to be consistent with the emperical evidence even though the producers lost money on the crop.

There was essentially no restriction placed on the bean enterprise. That is, the assumed producer could raise zero acres of beans or he could raise as many as the land, capital, and labor restrictions would allow.

The lower limit of sugar beets was placed consistent with the potato acreage as mentioned above. Also, farmers believed it necessary to grow a given amount of contract crops.

<u>400 Acre Model</u>. On the 400 acre model, the upper limit for grain is considerably higher than it was for the 200 acre model. The rise in the assumed production possibility curve of grain was because of a real increase in production factors associated with a desire to raise a labor saving crop. The

TABLE IX

OPTIMUM FARM

600 ACRES

Enterprise	Per Cent of Total Acres	Net Return To Mgnt. & Water Per Acre	Acres	Net Return Per Enterprise
Grain	46.67	55.18	280.00	$15,450.40
Potatoes	23.33	100.46	140.00	14,064.40
Alfalfa	10.00	8.34	60.00	500.40
Beans	10.00	31.09	60.00	1,865.40
Sugar Beets	10.00	31.34	60.00	1,880.40
TOTAL	100.00	--	600.00	$33,761.00

upper boundary of 280 acres was placed because of the feeling of necessity to raise both contract crops and alfalfa.

The upper limit on potatoes reflects the risk, plus the land, "capital", and labor involvement. None of the producers in the area felt that they could put more than 20 to 25 percent of their farm in potatoes.

The alfalfa, beans, and sugar beets have lower limits. Such lower limits are standardized at 10 percent of the total available crop acreage. Reasons for the alfalfa production have previously been discussed. The beans and sugar beets are a hedge against the potato crop and an income stabilizing factor.

600 Acre Model, Table IX. Production possibility restrictions for the 600 acre model are quite similar to the 400 acre model. Slight modifications were made on the upper limits of the grain and potato enterprises. As the size increased above 400 acres, empirical evidence showed that the producers were not willing to risk the same proportion of their acreage on grain and potatoes. However, the decrease was only slight, being a 3 percent proportional decrease in the grain upper limit and a 2 percent decrease in the potato upper limit.

Alfalfa, beans, and sugar beets maintain the standardized lower limit restriction.

II. AVERAGE REAL FARM

The average real farm coefficients were derived from selected farms and farm sizes in the area. Those farmers who

TABLE X

AVERAGE REAL FARM

200 ACRES

Enterprise	Average Percent of Total Acres	Net Return Per Acre	Acres	Net Return Per Enterprise
Grain	27.22	40.22	54.44	$2,189.58
Potatoes	15.00	73.58	30.00	2,207.40
Alfalfa	12.53	4.94	25.06	- 123,80
Beans	12,09	12.90	24.18	311.92
Sugar Beets	24.77	10.52	49.54	521.16
TOTAL	*96.15	--	183.22	$5,106.26

* Deviation from 100% is due to excessive land loss from ditches, etc. and from "fallow" land practices.

deviated greatly from what was typical of the area, were not considered. Farms of nearly the same size as the standard were most closely analyzed. A weighted average of such farms resulted in the percentage coefficients shown in Tables X through XII. The percentage was then multiplied by the set standard number of acres to arrive at the number of acres for the given enterprise. For example, on the 200 acre model the percent of grain 27.22, was multiplied by 200 in order to obtain the number of acres of grain. The acres were then multiplied by the net return per acre to present the net return per enterprise as shown in the following tables. The total of these coefficients thus yields the net return to management and water. The net return per acre coefficient is taken from the constructed per acre enterprise budgets.

III. COMPARISON OF OPTIMUM AND AVERAGE REAL FARMS

The difference between what could feasibly be accomplished (the optimum) and what, in fact, was being accomplished is presented in Figure 6 - Figure 9. As Figure 6 shows, the optimum farm plans are slightly higher than the average real farms. The difference in net revenue between the two constructed model farms increases as the size of the farm units increases, up to the 400 acre farm. The difference in net revenue decreases as size increases above 400 acres. That is, as the farm size increases above the 400 acre point, the average real farm's net returns approach the net returns of the optimum farms. Figures 7 - 9 show the very close correlation of the enterprise structure between the

TABLE XI

AVERAGE REAL FARM

400 ACRES

Enterprise	Average Percent of Total Acres	Net Return Per Acre	Acres	Net Return Per Enterprise
Grain	20.92	49.19	83.68	$ 4,116.22
Potatoes	24.91	92.64	99.64	9,230.65
Alfalfa	15.98	+4.36	63.92	278.69
Beans	24.30	24.76	97.2	2,406.67
Sugar Beets	13.80	24.33	55.2	1,343.02
TOTAL	*99.91	--	399.64	$17,375.25

* Deviates from 100% due to lack of full utilization of land.

TABLE XII

AVERAGE REAL FARM

600 ACRES

Enterprise	Average Percent of Total Acres	Net Return Per Acre	Acres	Net Return Per Enterprise
Grain	52.52	55.18	315.12	$17,388.32
Potatoes	15.80	100.46	94.80	9,523.61
Alfalfa	11.60	8.34	69.60	580.46
Beans	10.06	31.09	60.36	1,876.59
Sugar Beets	10.02	31.34	60.12	1,884.16
TOTAL	100.00	--	600.00	$31,203.14

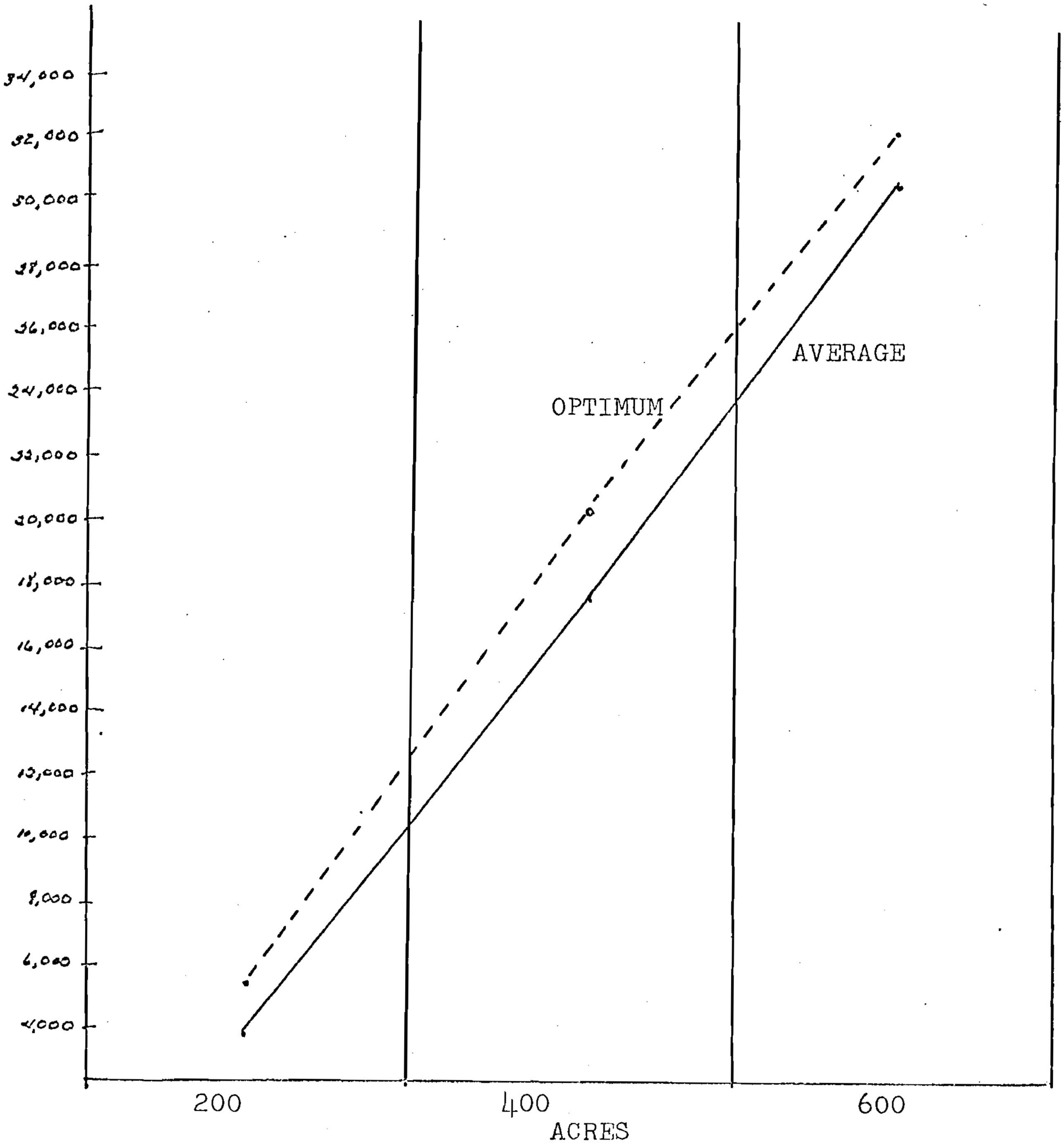

Figure 6. Total net return for optimum and average farms.

optimum and average real farms. In reference to the 200 acre sector (Figure 7) more sugar beets are grown than the optimum suggests because of the harmonious relations that have generally developed over the years between the sugar beet company and the producers. Although this harmonious relationship is subject to vary in any given year, in the long run it will remain relatively stable. The difference of the two farms in the grain enterprise may be explained by historical influence and possibly by the lack of sufficient data to establish an accurate average long run production schedule.

In the 400 acre sector (Figure 8) differences are noted between two specific enterprises, grain and beans. The strongest reason for this difference appears to lie in the historical background of the area and the producers in the 400 acre sector. The sugar beet crop helped many farmers in the area get started. Therefore, many producers had established habits that were not and will not be easily broken. Obviously, with more acres going into sugar beets, fewer acres would be available for the grain enterprise. In addition, however, many farmers felt that they could not risk placing a high proportion of their farm in only two crops. This feeling of risk avoidence is apparently built on intangible evidence, rather than physical data. Other producers, because of their conservative nature, were willing to make the investment in their own grain combine and would, therefore, raise only a

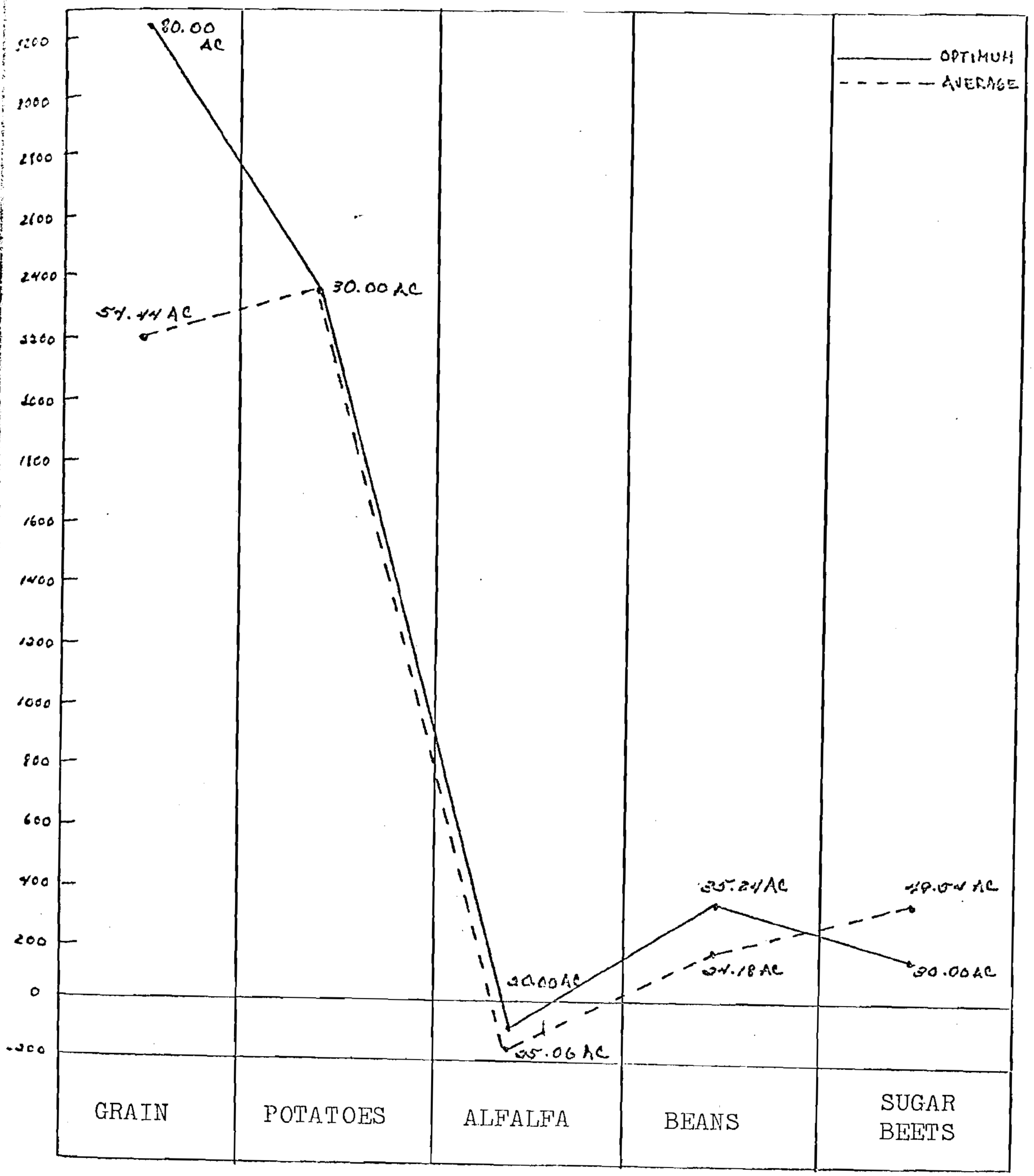

Figure 7. Net return per enterprise for the 200 acre average and optimum farms.

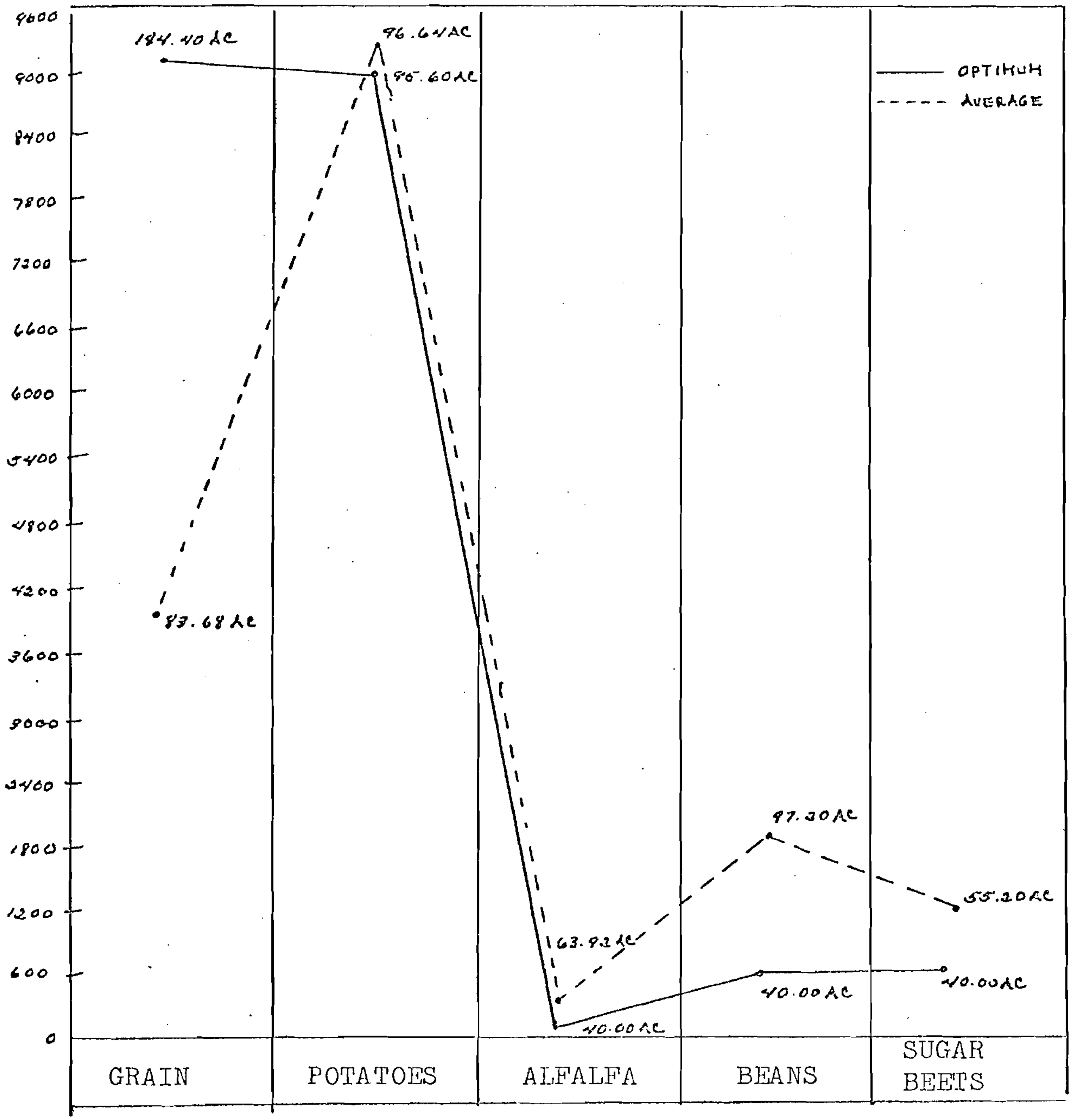

Figure 8. Net return per enterprise for the 400 acre average and optimum farms.

limited amount of grain. Such reasoning was not supported by producers in the 200 and 600 acre sectors, who suggested that custom work was readily available.

The 600 acre sector (Figure 9) depicts a lower production of potatoes on the average real farm than on the optimum farm because of the alleged mental anguish that is involved in producing potatoes. The difference in potato production is mainly taken up by the higher grain production. The total level of the net return for the average real farm is somewhat lower than the optimum, not only because of rotational differences but also because some of the land on the average real farms is inefficiently utilized.

Table X illustrates the relative importance of the total net income change. The greatest relative difference in total net income between the optimum and the average farms, occurs in the 200 acre sector. The larger average farms are closer to the optimum because the larger farms are less inhibited by the intangible, lack of knowledge, and personal favorites. Very few farmers in the 400 and 600 acre range are highly interested in the intrinsic values of farming.

It is perhaps wise to recall, at this point, a basic assumption of this study: that of profit maximization. Although all farmers in the area do seek to make a profit, the relative importance of this desire varies with the individual. This study is not designed or equipped to analyze any correlation between profit maximization and size. However, it does appear

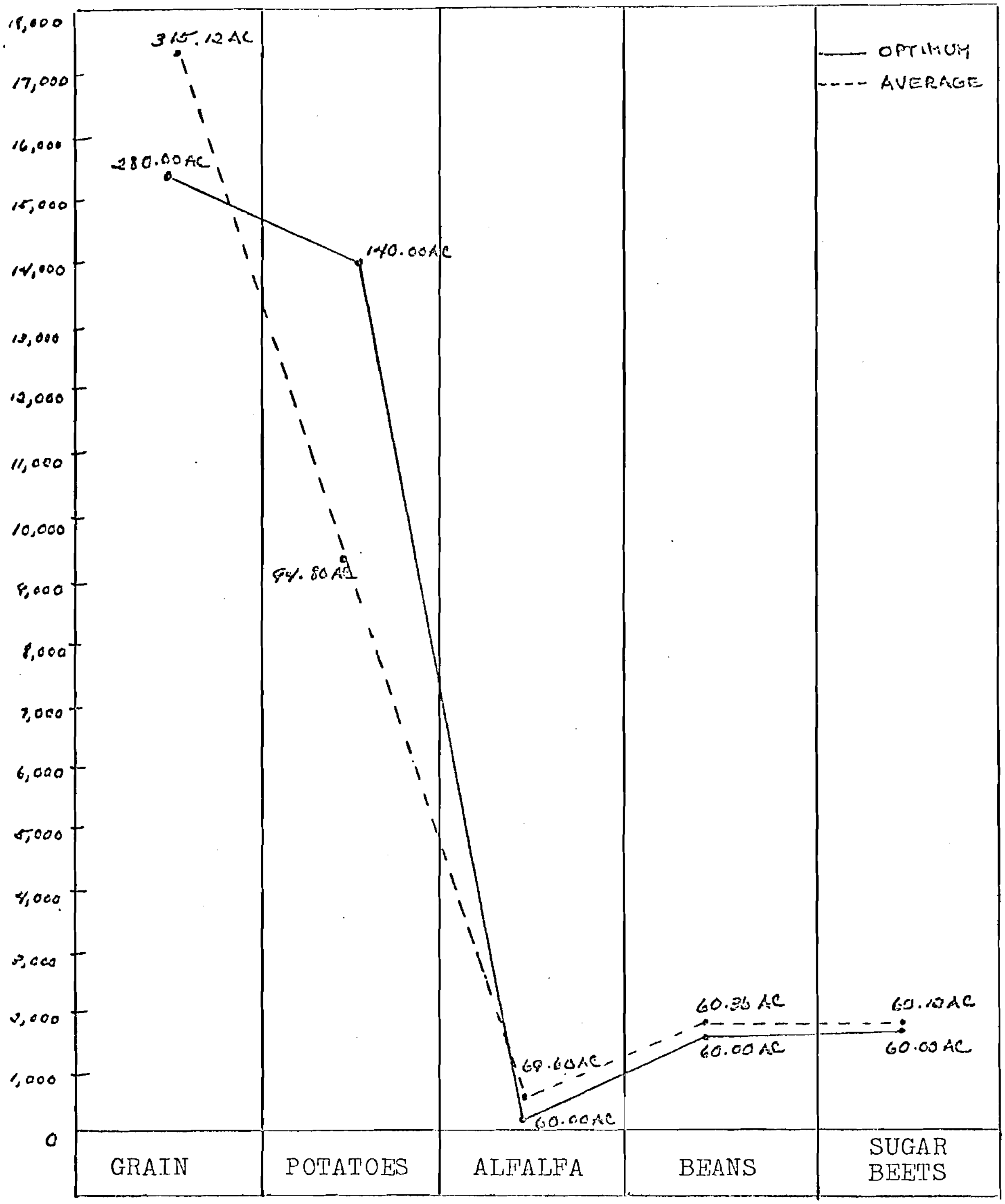

Figure 9. Net return per enterprise for the 600 acre average and optimum farms.

TABLE XIII

NET RETURN TO WATER AND MANAGEMENT FOR THE AVERAGE REAL FARMS AND NET DIFFERENCES AND PERCENTAGE DIFFERENCES BETWEEN OPTIMUM AND AVERAGE REAL FARMS

Acres	Optimum Farm Net Return to Water and Management	Average Real Farm Net Return to Water & Management	Net Difference Between A & B	Percentage Difference Between A & B
200	$6,097.69	$5,106.26	$ 991.43	16.25
400	20,013.82	17,375.25	2,638.57	13.18
600	33,761.00	31,203.14	2,557.86	7.58

as though the larger farm sizes have more economic advantages available to the producer. Therefore, they are more keenly aware of the optimum structure that could be obtained.

IV. RESULTS OF THE OPTIMUM ANALYSIS

The net revenue derived from the optimum analysis has been shown to be greater than the net revenue from the average typical farms. The explanation of this net income difference was presented in the previous section. However, in interpreting these results the assumptions both explicit and implied must be kept in mind. Government programs, technology, and prices are all assumed to remain constant. All of these factors are likely to change.

It is within the framework of the linear program to allow for a price range. That is, the price may vary from the constant average injected into the program, without altering the optimum rotational plan. Therefore, though the net revenue may change for the different enterprises the plan will retain its optimum structure. Because of the rotational restrictions and requirements most of the enterprises have an open end on their price range. For example, the price range for grain on the 200 acre plan goes from a low of $1.18 to an infinitely high price. Regardless of how high the price goes, the plan will not change. Refer to table XIV. The maximum amount of grain production acres allowed by the rotational restriction was used in the optimum plan at the $1.47 price. Therefore, no increase in price will effect the number of acres of grain produced.

TABLE XIV

ALLOWABLE PRICE VARIATION
IN
LINEAR PROGRAMMING MODEL

Enterprise	200 Acre Plan		400 Acre Plan		600 Acre Plan	
	High	Low	High	Low	High	Low
Grain	*	1.18	1.97	1.27	1.95	1.22
Potatoes	*	1.22	1.70	1.30	*	1.29
Alfalfa	24.14	*	30.63	*	31.16	*
Beans	9.06	7.22	10.06	*	8.85	*
Sugar Beets	14.62	*	17.53	*	15.70	*

Evaluation of the potato price range yields similar results. A low price of $1.22 with an infinitely high price was found to fit within the restrictions. The maximum acreage allowed was raised for the potato enterprise also. While the alfalfa crop was produced at the minimum level. Alfalfa, as Table XI shows, realized a minus net revenue. Thus, production of this crop at the minimum restriction level allowed the highest net return. Because of the rotational requirement, a given amount of alfalfa must be produced regardless of how great a loss is involved. Therefore, the low price range can extend infinitely without a change in the optimum plan. If the price of alfalfa exceeds $24.14, the plan will change slightly to include more alfalfa.

Because neither the maximum requirement not the minimum restriction was applied to the bean enterprise, an explicit price range developed. As long as the price falls between a high of $9.06 and a low of $7.22 the plan will not change.

If the sugar beet price exceeds $14.62, the optimum 200 acre rotational plan will be altered. However, as with the alfalfa, the price can drop infinitely low and still a fixed amount of sugar beets will be produced in the plan. This is due to previous machinery investment and the strong feeling for raising a "contract crop."

The 400 and 600 acre price ranges vary from the 200 acre price range to the extent that the restrictions and requirements vary on the different size plans. Since rational producers were assumed, an infinitely low price for any product would eventually force the producers out of business. The prices at which this would occur would vary with the individual situation. However, since a nine year weighted price average was initially used in the program, a relatively small price reduction probably would not effect the balance of the reality of the program.

Description of Data.

The data presented in Tables XXX through XXXII can be readily described by plowing coefficients into the general matrix form presented on page 13.

The input-output ratio "A" is equal to 1 because the common standard used for all crops is a per 1 acre basis. The quantity of factor input "X" is that quantity which has been derived from empirical evidence. The quantity of output "Y" is 1 acre of output.

Thus:

$$A_{11}X_1 + A_{12}X_2 + A_{13}X_3 \;.\;.\;.\;.\; A_{11m}X_m \underline{\qquad\qquad\qquad} 1Y_1$$

becomes:

$$(1)(1) + (1)(96.52) + (1)(1.5) + 1(3.63) + (1)(4.02) + (1)(2.05) = 1 \text{ Acre of grain or 95 bushels}$$

Five such equations can be written for each size plan, one equation for each enterprise in the plan.

The components of the body of the matrix are input-output coefficients. Their value is the amount of the restricted resource that it takes to produce an acre of output. An example of a restriction equation is: $\$30,000 - 96.52\ Y_1 + 287.52\ Y_2 + 95.40\ Y_3 + 112.82\ Y_4 + 226.18\ Y_5$.

With the inclusion of disposal activities the restriction equations become equality equations. Once the equations have all been formulated, and the prices and yields are established, the solution becomes one of finding the combination of input-output coefficients that will yield a maximum net return to water and management. Tables XXX through XXXII present the three matrices which were used in solving the linear program in this study.

CHAPTER V

THE SUMMARY

The personal interview-type survey technique was used to gather data from eighteen farmer cooperators of "above average" managerial ability. The survey schedule was designed to obtain resource requirements, input-output relationships, production practices, and costs and returns data for the major enterprises on 200, 400, and 600 acre farms.

Data obtained from the farm surveys and other sources were used to synthesize typical farm models stratified by size. Typical distribution of crops, the physical requirements for producing these crops, and their associated yields were established for each farm size. Cost and return data were then computed for these physical input-output relationships. From these data, enterprise budgets for the five major crops were developed for each farm size. Typical whole farm budgets, including all five crop enterprises, were then constructed.

The typical farm was compared to an optimum farm plan. The optimum farm plan was derived from the same physical input-output relationships as the typical farm. Using minimum and maximum restrictions and requirements the optimum plan showed what could feasibly be expected with respect to area limitations and requirements.

Production Practices.

Production practices followed in producing the five crops; grain, potatoes, alfalfa, beans, and sugar beets were determined from the crop enterprise records of the survey schedules. The typical operations performed and approximate date of performance were gathered in the order of their performance along with labor and equipment used in performing these operations.

Production practices followed in producing these specific crops varied little in relation to farm size. Most of the differences could be accounted for in type or size of equipment used. Therefore, only these technical economies were analyzed in this study. The production practices utilized in deriving the typical whole farm and the optimum farm were both determined from the survey information.

II. THE CONCLUSION

The total farm returns to water and management have been presented on tables VII through XII. On the average real farms the net return to management and water ranged from $25.53 on the 200 acre farm to 52.01 on the 600 acre farm. The comparable optimum farm return ranged from 30.49 on the 200 acre farm to 56.27 on the 600 acre farm. An analysis of the tables shows that the farmers in the subject area are actually very close to producing at the optimum level.

It was found that the amount of revenue producers could feasibly have available to pay for "water" on a per acre basis varied with the size of the operation for both the average real farms and the optimum farms.

The more efficient cropping patterns are presented in figures 6 through 8. The 400 acre plan shows the greatest variation of the optimum from the average. This probably occurs because the 400 acre stage appears to be a transitional stage between the 200 and 600 acre plans. That is few farmers tend to remain in the 400 acre range for long periods of time.

The magnitude of the technical economies of size has been presented on Table IV. A definite pattern of decreasing costs with increasing size has been established.

The nature and degree to which the economic tool, linear programming, has been demonstrated is effectively portrayed in the optimum farm plans. This method simultaneously analyzed all the possible farm plans that could exist given the restrictions and requirements, and chose the plan which would maximize the net return to management and water.

At the present time the net return to management and water coefficients are being used by the Department of Agricultural Engineering to establish a reasonable pumping depth for the area.

SUGGESTIONS.

This study and the linear program model which has been developed can be greatly expanded by an in-depth price yield study. A study of the design to alter the prices of the two main cash crops, grain and potatoes, would be very useful.

Two new crops are possibly being developed in the Oakley Fan. They are peas, and corn; the possible reason for their production is that a new processing plant is being built in the area.

Continued data gathering and updating will greatly enhance the usefulness of this study.

BIBLIOGRAPHY

Bressler, R. G. "Research Determination of Economics of Scale," Journal of Farm Economics, Vol. XXVII, No. 3, August 1945, 526-539.

Chamberlin, E. H. "Proportionality, Divisibility, and Economies of Scale," Quarterly Journal of Economics, Vol. LXII, No. 2, 1948, 235-246.

Coffing, A. L. "The Relationship of Farm Size to Ability to Pay for Irrigation Water in the Dry Lake Area of Canyon County, Idaho" (Unpublished Master's Thesis, The University of Idaho, Moscow, Idaho, 1965).

Dorfman, Robert, Application of Linear Programming to the Theory of the Firm, University Microfilms, Inc., Ann Arbor, Michigan (1961).

Heady, E. O. and W. Candler, Linear Programming Methods, (Iowa State College Press, Ames, Iowa, 1958), 53-108.

Haynes, W. W. Managerial Economics: Analysis and Cases. (Homewood, Illinois: The Dorsey Press, Inc.), 1963.

Lindeborg, Karl H. "Cost of Operating Farm Machinery," University of Idaho: Moscow, Idaho, 1962. (Mimeographed).

Moller, Kurt, "Cost Economics Associated With an Increase in Size of the Potato Enterprise on Pump Irrigated Farms in South Central Idaho," (Unpublished Master's Thesis, The University of Idaho, Moscow, Idaho, 1963).

National Farm and Power Equipment Dealers Assoc., Official Tractor and Farm Equipment Guide, (St. Louis, Mo.: NRFEA Publications, Inc., 1966).

Samuelson, Paul A. Economics: An Introductory Analysis, McGraw-Hill Book Co., Inc., New York, (1961).

Stigler, George J. The Theory of Price, rev. ed., New York, Macmillian Co., (1952).

United States Department of Agriculture, Agricultural Statistics, Washington D.C.: Government Printing Office (1967).

Viner, Jacob "Cost Curves and Supply Curves" AEA Readings in Price Theory (ed.) Stigler, G. S. and Boulding, K. E., VI, 198-232. Chicago: Richard Irwin, 1952.

TABLE XV

CROP BUDGET FOR A 200 ACRE FARM
GRAIN
PRODUCTION COSTS AND RETURNS PER ACRE

		Unit	Quantity	Price/ Acre	Value or Cost
Production (output)		bu.	95	1.47	139.65
Inputs:	Tractor	hrs.	4.04	1.81	7.31
	Implements	hrs.	4.04	2.68	10.83
	Labor	hrs.	11.20	1.50	16.80
	Spray (custom)	acre			1.75
	Combining (custom)	acre			8.00
	Hauling (custom)				4.00
	Seed	lbs.	100	4.88/ 100	4.88
	Fertilizer	lbs.	75	.106	7.95
	Truck & Pickup				2.45
	Farm Supplies				2.50
	Building Depreciation				2.40
	Interest on Land				20.00
	Interest on Investment				4.00
	Insurance				1.05
	Land Taxes				2.60
	Irr. Costs				2.91
	TOTAL COST				$ 99.43
	Net Return to Water and Management				$ 40.22

TABLE XVI

CROP BUDGET FOR A 200 ACRE FARM
POTATOES
PRODUCTION COSTS AND RETURNS PER ACRE

		Unit	Quantity	Price/ Unit	Value or Cost
Production (output)		cwt.	250	1.47	367.50
Inputs:	Tractor	hrs.	7.20	1.81	13.03
	Implements	hrs.	7.20	4.04	29.09
	Labor	hrs.	16.58	1.50	24.87
	Spray (custom)	acre			2.75
	Harvesting (custom)	cwt.	250	.25	62.50
	Hauling	cwt.	250	.07	17.50
	Seed	cwt.	14.5	5.00	72.50
	Fertilizer	lbs.	294	.103	30.28
	Truck & Pickup				2.45
	Farm Supplies				2.50
	Building Depreciation				2.40
	Interest on Land				20.00
	Interest on Investment				4.00
	Insurance				1.05
	Land Taxes				2.60
	Irr. Costs				6.40
	TOTAL COST				$ 293.92
	Net Return to Water and Management				$ 73.58

TABLE XVII

CROP BUDGET FOR A 200 ACRE FARM
ALFALFA
PRODUCTION COSTS AND RETURNS PER ACRE

		Unit	Quantity	Price/ Unit	Value or Cost
Production (output)		ton	4.5	20.75	93.37
Inputs:	Tractor	hrs.	2.89	1.81	5.23
	Implements	hrs.	2.89	.45	.85
	Harvesting (custom)				15.11
	Stacking and Hauling	bales	165	.10	16.50
	Labor	hrs.	6.43	1.50	9.65
	Seed	lbs.	13	.5	1.50
	Fertilizer (0-45-0)	lbs.	50	.0425	2.13
	Insecticide (custom)	acre			1.50
	Truck and Pickup				2.45
	Farm Supplies				2.50
	Building Depreciation				2.40
	Interest on Land				20.00
	Interest on Investment				4.00
	Insurance				1.05
	Land Taxes				2.60
	Irr. Costs				2.91
	TOTAL COST				$ 98.31
	Net Return to Management and Water				$ -4.94

TABLE XVIII

CROP BUDGET FOR A 200 ACRE FARM
BEANS
PRODUCTION COSTS AND RETURNS PER ACRE

		Unit	Quantity	Price/ Unit	Value or Cost
Production (output)		cwt.	175	7.47	130.73
Inputs:	Tractor	hrs.	7.11	1.81	12.87
	Implements	hrs.			
	Labor	hrs.	15.55	1.50	23.32
	Combining (custom)	acre	1	8.00	8.00
	Hauling				.83
	Hoeing and hand labor	hrs.	1.5	1.50	2.25
	Seed	lbs.	100	8.97	8.97
	Fertilizer	lbs.	100	.425	4.25
	Truck and Pickup				2.45
	Farm Supplies				2.50
	Building Depreciation				2.40
	Interest on Land				20.00
	Interest on Investment				4.00
	Insurance				1.05
	Land Taxes				2.60
	Irr. Costs				4.65
	TOTAL COST				$ 117.47
	Net Return to Management and Water				$ 12.90

TABLE XIX

CROP BUDGET FOR A 200 ACRE FARM
SUGAR BEETS
PRODUCTION COSTS AND RETURNS PER ACRE

		Unit	Quantity	Price/ Unit	Value or Cost
Production (output)		tons	17	14.30	243.10
Inputs:	Tractor	hrs.	8.31	1.81	15.04
	Implements	hrs.	8.31	2.91	24.18
	Labor	hrs.	18.89	1.50	28.33
	Hoeing and Thinning	acre	1.0	29.00	29.00
	Harvesting (custom)	tons	17.0	2.50	42.50
	Hauling (custom)	tons	17.0	1.0	17.00
	Seed	lbs.	7	.55	3.85
	Fertilizer	lbs.	300	.10	30.00
	Truck and Pickup				2.45
	Farm Supplies				2.50
	Building Depreciation				2.40
	Interest on Land				20.00
	Interest on Investment				4.00
	Insurance				1.05
	Land Taxes				2.60
	Irr. Costs				6.40
	TOTAL COST				$ 232.58
	Net Return to Management and Water				$ 10.52

TABLE XX

CROP BUDGET FOR A 400 ACRE FARM
GRAIN
PRODUCTION COSTS AND RETURNS PER ACRE

		Unit	Quantity	Price/ Unit	Value or Cost
Production (output)		bu.	95	1.47	139.65
Inputs:	Tractor	hrs.	3.04	2.17	6.60
	Implements	hrs.	3.04	1.34	4.07
	Labor	hrs.	10.2	1.50	15.30
	Spray (custom)	acre			1.75
	Combining (custom)	acre			8.00
	Hauling (custom)				4.00
	Seed	lbs.	100	4.88 per 100	4.88
	Fertilizer	lbs.	75	.106	7.95
	Truck & Pickup				2.45
	Farm Supplies				2.50
	Building Depreciation				2.40
	Interest on Land				20.00
	Interest on Investment				4.00
	Insurance				1.05
	Land Taxes				2.06
	Irr. Costs				2.91
	TOTAL COST				$ 90.46
	Net Return to Water and Management				$ 49.19

TABLE XXI

CROP BUDGETS FOR A 400 ACRE FARM
POTATOES
PRODUCTION COST AND RETURNS PER ACRE

		Unit	Quantity	Price/ Unit	Value or Cost
Production (output)		cwt.	250	1.47	367.50
Inputs:	Tractor	hrs.	5.95	2.17	12.91
	Implements	hrs.	5.95	2.02	12.02
	Labor	hrs.	15.33	1.50	23.00
	Spraying (custom)	acre			2.75
	Harvesting (custom)	cwt.	250	.25	62.50
	Hauling	cwt.	250	.07	17.50
	Seed	cwt.	14.5	5.00	72.50
	Fertilizer	lbs.	294	.103	30.28
	Truck & Pickup				2.45
	Farm Supplies				2.50
	Building Depreciation				2.40
	Interest on Land				20.00
	Interest on Investment				4.00
	Insurance				1.05
	Land Taxes				2.60
	Irr. Costs				6.40
	TOTAL COST				$ 274.86
	Net Return to Water and Management				$ 92.64

TABLE XXII

CROP BUDGET FOR A 400 ACRE FARM
ALFALFA
PRODUCTION COST AND RETURNS PER ACRE

		Unit	Quantity	Price/ Unit	Value or Cost
Production (output)		ton	4.5	20.75	93.37
Inputs:	Tractor	hrs.	1.89	2.17	4.10
	Implements	hrs.	1.89	.45	.85
	Harvesting				15.11
	Stacking & Hauling	bales	165	.10	16.50
	Labor	hrs.	6.43	1.50	9.65
	Seed	lbs.	13	.5	1.50
	Fertilizer (o-45.0)	lbs.	50	.0425	2.13
	Insecticide (custom)	acre			1.50
	Truck & Pickup				2.45
	Farm Supplies				2.50
	Building Depreciation				2.40
	Interest on Land				20.00
	Interest on Investment				4.00
	Insurance				1.05
	Land Taxes				2.60
	Irr. Costs				2.91
	TOTAL COST				$ 89.01
	Net Return to Water and Management				$ 4.36

TABLE XXIII

CROP BUDGET FOR A 400 ACRE FARM
BEANS
PRODUCTION COSTS AND RETURNS PER ACRE

		Unit	Quantity	Price/ Unit	Value or Cost
Production (output)		cwt.	17.5	7.47	130.73
Inputs:	Tractor	hrs.	5.84	2.17	12.67
	Implements	hrs.	5.84	1.29	7.53
	Labor	hrs.	14.55	1.50	21.82
	Combining	acre	1	8.00	8.00
	Hauling				.83
	Hoeing & hand labor	hrs.	1.5	150	2.25
	Seed	lbs.	100	8.97	8.97
	Fertilizer	lbs.	100	.425	4.25
	Truck and Pickup				2.45
	Farm Supplies				2.50
	Building Depreciation				2.40
	Interest on Land				20.00
	Interest on Investment				4.00
	Insurance				1.05
	Land Taxes				2.60
	Irr. Costs				4.65
	TOTAL COST				$ 105.97
	Net Return to Water and Management				$ 24.76

TABLE XXIV

CROP BUDGET FOR A 400 ACRE FARM
SUGAR BEETS
PRODUCTION COSTS AND RETURNS PER ACRE

		Unit	Quantity	Price/ Unit	Value or Cost
Production (output)		tons	17	14.30	243.10
Inputs:	Tractor	hrs.	7.31	2.17	15.86
	Implements	hrs.	7.31	1.46	10.67
	Labor	hrs.	18.14	1.50	27.21
	Hoeing & Thinning	acre	1.0	29.00	29.00
	Harvesting	tons	17.0	2.50	42.50
	Hauling	tons	17.0	1.00	17.00
	Seed	lbs.	7	.55	3.85
	Fertilizer	lbs.	300	.10	30.00
	Insecticide				1.28
	Truck & Pickup				2.45
	Farm Supplies				2.50
	Building Depreciation				2.40
	Interest on Land				20.00
	Interest on Investment				4.00
	Insurance				1.05
	Land Taxes				2.60
	Irr. Costs				6.40
	TOTAL COST				$ 218.77
	Net Return to Water and Management				$ 24.33

TABLE XXV

CROP BUDGET FOR A 600 ACRE FARM
GRAIN
PRODUCTION COSTS AND RETURNS PER ACRE

		Unit	Quantity	Price/ Unit	Value or Cost
Production (output)		bu.	95	1.47	139.65
Inputs:	Tractor	hrs.	2.04	2.54	5.18
	Implements	hrs.	2.04	.67	1.37
	Labor	hrs.	8.95	1.50	13.43
	Spray (custom)	acre			1.75
	Combining (custom)	acre			8.00
	Hauling (custom)				4.00
	Seed	lbs.	100	4.88/ 100	4.88
	Fertilizer	lbs.	75	.106	7.95
	Truck & Pickup				2.45
	Farm Supplies				2.50
	Building Depreciation				2.40
	Interest on Land				20.00
	Interest on Investment				4.00
	Insurance				1.05
	Land Taxes				2.60
	Irr. Costs				2.91
	TOTAL COST				$ 84.47
	Net Return to Water and Management				$ 55.18

TABLE XXVI

CROP BUDGET FOR A 600 ACRE FARM
POTATOES
PRODUCTION COSTS AND RETURNS PER ACRE

		Unit	Quantity	Price/ Unit	Value or Cost
Production (output)		cwt.	250	1.47	367.50
Inputs:	Tractor	hrs.	5.20	2.54	13.21
	Implements	hrs.	4.98	1.01	5.03
	Labor	hrs.	14.58	1.50	21.87
	Spraying (custom)	acre			2.75
	Harvesting (custom)	cwt.	250	.25	62.50
	Hauling	cwt.	250	.07	17.50
	Seed	cwt.	14.5	5.00	72.50
	Fertilizer	lbs.	294	.103	30.28
	Truck & Pickup				2.45
	Farm Supplies				2.50
	Building Depreciation				2.40
	Interest on Land				2.00
	Interest on Investment				4.00
	Insurance				1.05
	Land Taxes				2.60
	Irr. Costs				6.40
	TOTAL COST			$	267.04
	Net Return to Water and Management			$	100.46

TABLE XXVII

CROP BUDGET FOR A 600 ACRE FARM
ALFALFA
PRODUCTION COSTS AND RETURNS PER ACRE

		Unit	Quantity	Price/ Unit	Value or Cost
Production (output)		ton	4.5	20.75	93.37
Inputs:	Tractor	hrs.	.89	2.54	2.26
	Implements	hrs.	.89	.23	.21
	Labor	hrs.	5.43	1.50	8.15
	Harvesting (custom)				15.11
	Stacking & Hauling	bales	165	.10	16.50
	Seed	lbs.	13	.5	1.50
	Fertilizer (0-45-0)	lbs.	50	.0425	2.13
	Insecticide (custom)	acre			1.50
	Truck & Pickup				2.45
	Farm Supplies				2.50
	Building Depreciation				2.40
	Interest on Land				20.00
	Interest on Investment				4.00
	Insurance				1.05
	Land Taxes				2.60
	Irr. Costs				2.91
	TOTAL COST				$ 85.03
	Net Return to Water and Management				$ 8.34

TABLE XXVIII

CROP BUDGET FOR A 600 ACRE FARM
BEANS
PRODUCTION COSTS AND RETURNS PER ACRE

		Unit	Quantity	Price/ Unit	Value or Cost
Production (output)		cwt.	17.5	7.47	130.73
Inputs:	Tractor	hrs.	5.11	2.54	12.98
	Implements	hrs.	5.11	.65	3.32
	Labor	hrs.	13.55	1.50	20.33
	Combining (custom)	acre	1	8.00	8.00
	Hauling				.83
	Hoeing and Hand Labor	hrs.	1.5	1.50	2.25
	Seed	lbs.	100	8.97	8.97
	Fertilizer	lbs.	100	.425	4.25
	Truck & Pickup				2.45
	Farm Supplies				2.50
	Building Depreciation				2.40
	Interest on Land				20.00
	Interest on Investment				4.00
	Insurance				1.05
	Land Taxes				2.60
	Irr. Costs				4.65
	TOTAL COST				$ 99.64
	Net Return to Management and Water				$ 31.09

TABLE XXIX

CROP BUDGET FOR A 600 ACRE FARM
SUGAR BEETS
PRODUCTION COSTS AND RETURNS PER ACRE

		Unit	Quantity	Price/ Unit	Value or Cost
Production (output)		tons	17	14.30	243.10
Inputs:	Tractor	hrs.	6.31	2.54	16.03
	Implements	hrs.	6.31	.73	4.61
	Labor	hrs.	17.39	1.50	26.09
	Hoeing and Thinning	acre	1.0	29.00	29.00
	Harvesting (custom)	ton	17.0	2.50	42.50
	Hauling (custom	ton	17.0	1.00	17.00
	Seed	lbs.	7	.55	3.85
	Fertilizer	lbs.	300	.10	30.00
	Truck and Pickup				2.45
	Farm Supplies				2.50
	Building Depreciation				2.40
	Interest on Investment				4.00
	Insurance				1.05
	Land Taxes				2.60
	Irr. Costs				6.40
	Interest on Land				20.00
	TOTAL COST				$ 210.48
	Net Return to Water and Management				$ 31.34

APPENDIX B

PROGRAMMING CODES

TABLE XXX

LINEAR PROGRAMMING CODE
FOR A 200 ACRE MODEL

Per Acre Requirements

200 Acres

Yield	Grain 95 bu.	Potatoes 250 cwt.	Alfalfa 4.5 tons	Beans 17.5 cwt.	Sugar Beets 17 tons
Land	1	1	1	1	1
Expenses	96.52	287.52	95.40	112.82	226.18
Period I	1.50	1.98	.55	1.33	1.84
Period II	3.63	4.03	3.35	4.30	5.33
Period III	4.02	4.80	2.58	5.20	5.17
Period IV	2.05	5.77	.95	4.72	6.55
Irri. Cost	2.91	6.40	2.91	4.65	6.40
Prices	139.65	367.50	93.37	130.73	243.10
Net Revenue	43.13	79.98	-7.03	17.55	16.92

Restrictions:	Land	200 Acres	
	Capital	$30,000	
	Labor:	Period 1	510 hr.
		Period 2	920 hr.
		Period 3	1300 hr.
		Period 4	690 hr.

Determined with:

≤ 80 Acres of Grain

≤ 30 Acres of Potatoes

≥ 20 Acres of Alfalfa

≥ 0 Acres of Beans

≥ 30 Acres of Sugar Beets

TABLE XXXI

LINEAR PROGRAMMING CODE FOR A 400 ACRE MODEL

Per Acre Requirements

400 Acres

Yield	Grain 95 bu.	Potatoes 250 cwt.	Alfalfa 4.5 tons	Beans 17.5 cwt.	Sugar Beets 17 tons
Land	1	1	1	1	1
Expenses	87.55	268.46	86.10	101.32	212.37
Period I	1.47	1.49	.50	1.13	1.79
Period II	3.38	2.87	3.15	4.05	5.23
Period III	3.55	4.99	2.15	4.75	4.92
Period IV	1.80	5.68	.63	4.62	6.20
Irri. Cost	2.91	6.40	2.91	4.65	6.40
Price (Av.)	139.65	367.50	93.37	130.73	243.10
Net Revenue	52.10	99.04	2.27	29.41	30.73

Restrictions: Land 400 Acres

Capital $58,000

Labor:
Period 1 1010 hr.
Period 2 1740 hr.
Period 3 2395 hr.
Period 4 1530 hr.

Determined with:

$\leq$ 280 Acres of Grain

$\leq$ 100 Acres of Potatoes

$\geq$ 40 Acres of Alfalfa

$\geq$ 40 Acres of Beans

$\geq$ 40 Acres of Sugar Beets

TABLE XXXII

LINEAR PROGRAMMING CODE
FOR A 600 ACRE MODEL

Per Acre Requirements

600 Acres

Yield	Grain 95 bu.	Potatoes 250 cwt.	Alfalfa 4.5 tons	Beans 17.5 cwt.	Sugar Beets 17 tons
Land	1	1	1	1	1
Expenses	81.56	260.64	82.12	94.99	205.36
Period I	1.40	1.85	.48	1.00	1.73
Period II	2.88	2.78	2.65	4.00	5.13
Period III	3.06	4.47	1.85	4.60	4.62
Period IV	1.61	5.48	.45	3.95	5.91
Irri. Cost	2.91	6.40	2.91	4.65	6.40
Prices (Av.)	139.65	367.50	93.37	130.73	243.10
Net Revenue	58.09	106.86	6.25	35.74	37.74

Restrictions:	Land	600 Acres	
	Capital	$84,000	
	Labor:	Period 1	1010 hr.
		Period 2	2570 hr.
		Period 3	3345 hr.
		Period 4	1850 hr.

Determined with: $\leq$ 400 Acres of Grain

$\leq$ 140 Acres of Potatoes

$\geq$ 60 Acres of Alfalfa

$\geq$ 60 Acres of Beans

$\geq$ 60 Acres of Sugar Beets