# THE VALUE OF IRRIGATION WATER IN THE WASHITA RIVER BASIN OF ROGER MILLS COUNTY, OKLAHOMA

By

DALE O. ANDERSON

Bachelor of Science
North Dakota State University
Fargo, North Dakota
1959

Master of Science
North Dakota State University
Fargo, North Dakota
1960

Submitted to the Faculty of the Graduate School of
the Oklahoma State University
in partial fulfillment of the requirements
for the degree of
DOCTOR OF PHILOSOPHY
May, 1965

THE VALUE OF IRRIGATION WATER IN THE

WASHITA RIVER BASIN OF ROGER MILLS

COUNTY, OKLAHOMA

Thesis Approved:

James S. Plaxico
Thesis Adviser

Daniel D. Badger

Richard W. Poole

Odell L. Walker

J. H. Boggs
Dean of the Graduate School

## ACKNOWLEDGMENTS

I wish to express appreciation to Dr. W. B. Back, former Professor of Agricultural Economics at Oklahoma State University, for his guidance and encouragement throughout the major portion of my graduate program. Appreciation is extended to Dr. James S. Plaxico for his assistance and constructive criticisms during the final preparation of this dissertation. I am indebted to Dr. Odell L. Walker and Dr. Daniel D. Badger for reading preliminary drafts of this dissertation and offering valuable comments and suggestions for its improvement.

Special recognition is extended to Mr. M. L. Weinberger of the Economic Research Service for his counsel and advise during my graduate program. The cooperation received from personnel of the Soil Conservation Service is appreciated.

The author is indebted to Dr. Neil R. Cook, Head, Washita Economics Research Laboratory, for his assistance during my graduate program and for carrying out many of the details during the final phases of this research. A note of appreciation is extended to Mrs. Barbara Oberlander for her assistance in making computations and preparing data for processing.

Recognition is given to my parents, Mr. and Mrs. Odin Anderson, for the many sacrifices they have made to make my formal education possible.

Finally, a special note of appreciation is extended to my wife, Claudia, who has been a constant source of encouragement and support throughout my graduate program. Her patience in typing the several drafts of this dissertation is worthy of special recognition.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF TABLES

| Table | | Page |
|---|---|---|

## LIST OF TABLES (continued)

## LIST OF FIGURES

Figure | Page

# CHAPTER I

## INTRODUCTION

Nature often is bountiful, but it is not always dependable. The agricultural sector of the economy is directly affected by forces of nature such as precipitation, temperature, and other weather related factors. Because these factors are not predictable for any given production planning period, resource allocation in agricultural production is, by nature, formulated in a framework of uncertainty. That is, decisions regarding resource use must be made under conditions of imperfect knowledge about future occurrences of the many physical factors affecting the production of a given farm or area. The financial success of a farmer depends, to a large degree, upon the realized accuracy of his expectations of yields, prices, and other production related factors.

Technological advance in agriculture has been rapid in recent years. Superior varieties of crops have been developed, machinery has been devised to better till the soil and control weeds, mineral and organic fertilizers have been produced to supplement soil resources, and insects and diseases are being brought under control. Many such advances help reduce instability of production and help stabilize incomes from farming. Yet agricultural production and incomes in the Great Plains States remain highly variable, whereas cost commitments are relatively fixed.[1] A substantial amount of this income variability is generated by highly variable yields arising from extreme seasonal and annual fluctuations in quantity and distribution of rainfall.

This condition is characteristic of Roger Mills County in Western Oklahoma. Figure 1 summarizes the average annual yield per acre for wheat, oats, and grain sorghum for the period 1947-61. These yield data indicate the wide annual fluctuations in yields and, consequently, the technical uncertainty a farmer in the County faces when planning the allocation of his resources.

Irrigated agriculture, in general, permits greater control of physical factors in production than dryland systems of farming. Moisture is a very crucial variable in agricultural production. Consequently, irrigation could be expected to add substantially to the stabilization of production and income in this Great Plains County.

A recent study conducted at North Dakota State University indicates that yields were considerably more stable under irrigation than with dryland farming.[2] For example, yield variability of wheat was reduced by 44 per cent. Also, irrigation reduced the variability of gross income by 14 per cent and net income by 18 per cent. In addition to reducing variability, irrigation increased the returns per $100 of all production costs,

---

[1]Wallace G. Aanderud, "Income Variability of Alternative Plans, Selected Farm and Ranch Situations, Rolling Plains of Northwest Oklahoma" (unpub. Ph.D. dissertation, Oklahoma State University, 1964), p. 1.

[2]LeRoy W. Schaffner, Laurel D. Loftsgard, and Duane C. Vochrodt, Production and Income Variability for Farm Enterprises on Irrigation and Dryland, North Dakota Agricultural Experiment Station, Technical Bulletin 445 (Fargo, 1963).

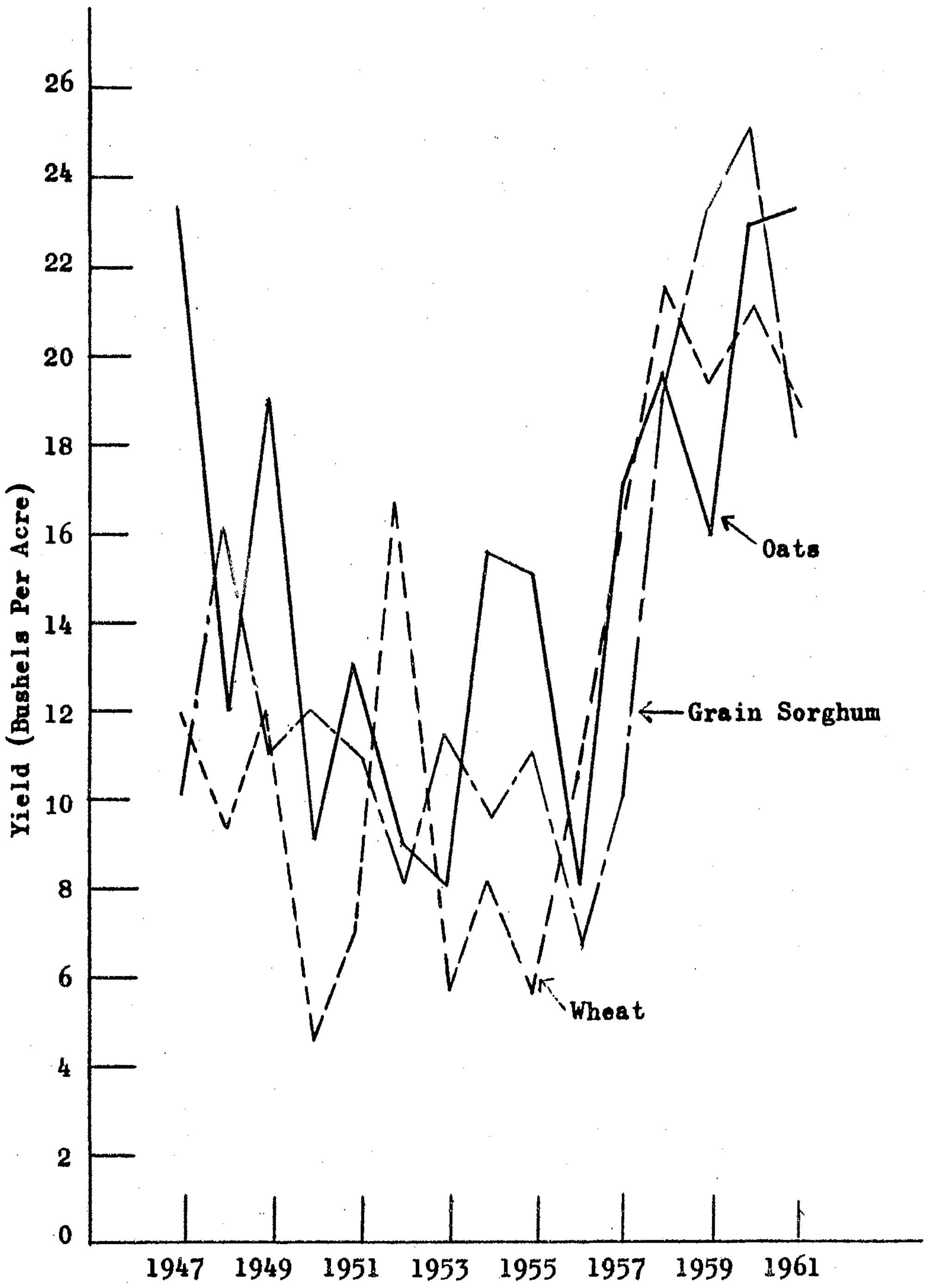


Figure 1. Average Annual Yields for Wheat, Oats, and Grain Sorghum, 1947-1961, Roger Mills County, Oklahoma.

excluding land and labor, by 24 per cent. A substantial amount of income variability in the Great Plains area is due to highly variable yields resulting from often inadequate and frequently untimely precipitation. In this respect, Roger Mills County of Oklahoma does not differ significantly from crop farming areas of North Dakota.

Upstream watershed development provides an alternative means of developing or increasing the supply of water for irrigation. The amount of water potentially available for irrigation is a function of design of the watershed development project. Structures built for flood protection only provide some irrigation potential. However, irrigation can be included as a project purpose. The appropriate emphasis to give to irrigation as a purpose in project design will depend partly on the value of water for irrigation in the watershed area. The major purpose of this study is to estimate values of water used in irrigation on bottomland soils of Roger Mills County. Estimates of the values of water for irrigation purposes are not presently available for Western Oklahoma. The results of this study should be useful to project planners in estimating the feasibility of a structure to serve the purpose of flood control along with irrigation water storage.

## Watershed Development Program

The watershed development program on the Washita River Basin evolved from the Flood Control Act of 1944.[3] This Act authorized the United States Department of Agriculture to install works of improvement on 11

[3]United States Statutes at Large, 78th Congress, 2d Session, 1944, Public Law 534, Volume 58, Part One, pp. 887-907.

rather large watersheds in the United States.[4] The Washita River drainage area was one of the original areas selected as pilot watersheds. The works of improvement include run-off and water-flow retardation as well as erosion prevention. These watershed improvements create a potential to increase agricultural production by providing the farmer with a more stable physical environment within which to plan the allocation of resources.

Through a reduction in flooding hazard and an increased potential for irrigation, opportunities exist for affected farmers to increase their production efficiency by making adjustments in land use, capital investments, and general farm organization. The limited amount of irrigation data and experience available in this area makes irrigation decision making difficult and uncertain. This lack of information is one possible reason for reluctance on the part of farmers to develop the irrigation potential available from watershed development projects.

A memorandum of agreement between the Soil Conservation Service and the Economic Research Service of the United States Department of Agriculture of January, 1955, contained provisions for developing a comprehensive research program emphasizing an economic evaluation of a watershed development program such as that authorized by the Flood Control Act of 1944. The Washita Economics Research Laboratory was organized to implement this memorandum. The research of this laboratory, a cooperative venture between the Economic Research Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station, is to evaluate works of improvement installed on the tributaries of the Washita River. The research reported in this manuscript is a part of that evaluation.

---

[4]Stanley W. Voelker and John Muehlbeier, "Institutional Arrangements for Watershed Programs", Journal of Farm Economics, XXXVI (December, 1954), pp. 1184-1185.

## Area of Study

This study is concerned with that portion of Roger Mills County encompassed by the Washita River Basin in general, and farms within the basin having bottomland soil in particular. Soil units classified as having potential for irrigation are emphasized in this study. The total land area of the County is approximately 726,000 acres; about 75 per cent of this land is situated in the Washita River Basin.[5] Less than three per cent of the land in the Washita River Basin is irrigable.

The economy of Roger Mills County is predominantly rural. Farming, ranching, and associated agricultural enterprises are the principal sources of income. Wheat and cotton are the major crop enterprises, and a beef cow-calf system is the leading livestock enterprise. The total income from all crops and livestock for 1959 amounted to $7,400,000.[6] All crops represented about 34 per cent and livestock and livestock products represented the remaining 66 per cent of this total income.

The average annual precipitation in the County is approximately 24 inches.[7] Rainfall distribution is highly erratic with the annual amounts varying from 13 to 46 inches in the County. Droughts of from three to eight weeks occur during nearly all growing seasons. These droughts are usually accompanied by hot, dry, evaporative winds, which

---

[5]United States Department of Agriculture, Soil Conservation Service (unpub. data, Stillwater).

[6]United States Department of Commerce, Bureau of Census, United States Census of Agriculture for Oklahoma, 1959 (Washington, 1961).

[7]United States Department of Commerce, Weather Bureau, Climatological Data, Oklahoma, 1914-1960, Volumes 23-69 (Washington, 1960).

quickly dissipate the soil moisture supplies. Interspersed with such droughts are storm periods, very frequently violent and of short duration, which produce intense rainfall and possible flooding over small areas.

The watershed program has been developed quite intensively in Roger Mills County. The program is nearing completion on all sub-watersheds in the County. A recent progress report of the Soil Conservation Service indicates that about 76 per cent of the floodwater retarding structures were completed or contracted for as of January, 1963.[8]

## The Objectives and Content of the Study

The continued planning and construction of watershed projects provides additional potential for farmers to increase their production efficiency through irrigation and/or other adjustments in resource use. The general objective of this research is to appraise and evaluate the potential value of water for irrigation in Roger Mills County. The specific objectives are: (1) to determine the amount of farm land in the area of study with physical and economic potential for irrigation; (2) to determine the value of water used to irrigate crops and pastures for (a) alternative crop systems and varying levels of water availability, (b) alternative farm resource situations, and (c) alternative systems of farming within a given resource situation; (3) to estimate the optimum allocation of alternative levels of available water among crops and farms in the area; and (4) to appraise the availability of water for irrigation relative to programmed demands for water.

---

[8]United States Department of Agriculture, Soil Conservation Service, Progress Report. Presentation at annual meeting of Washita Council, Stillwater, Oklahoma, January 13, 1963 (mimeo), p. 4.

The remainder of this thesis is divided into four chapters. The second chapter presents the theoretical concepts appropriate to this resource allocation problem and discusses the methods used in developing the analysis. Chapter three presents and discusses the results of the programming analysis. An interpretation and application of these results are presented in chapter four. The fifth chapter summarizes the study and presents conclusions relevant to Roger Mills County.

## CHAPTER II

## THEORETICAL CONCEPTS AND METHODS OF ANALYSIS

The purposes of this chapter are: (1) to present the basic economic theory relevant for determining the optimum allocation of supplemental irrigation water among alternative uses, (2) to describe the empirical methods used in making the theory operational, and (3) to describe sources and development of the data used in the study.

### The Value of Water

When the supply of water is plentiful in relation to the demand for it, it is treated as a free commodity. Benjamin Franklin once observed, "When the well is dry we know the worth of water."[1] When water is plentiful, there is little or no concern for its utility to man's existence and the laws that govern its use. However, when a sharp increase in demand relative to supply is experienced, water becomes a scarce commodity. Whenever any good becomes scarce, some means are necessary to bring the demand for the good in line with the existing supply.

There are five basic functions which must be performed by an economic system if the economy is to grow and develop.[2] One of these functions is

---

[1]Dennis Thomte, Allen Olson, and L. D. Loftsgard, "Changes in North Dakota's Water Law", North Dakota Farm Research, XXII (1963), p. 4.

[2]Richard H. Leftwich, The Price System and Resource Allocation (rev. ed., New York, 1960), p. 14.

to ration the supply of a good which is relatively limited in the short run.[3] The competition among users for a limited supply will cause the price to rise. Through the law of demand, an increase in price results in a decrease in the quantity demanded. This adjustment in price continues until an equilibrium exists between quantity demanded and the expected supply. If the supply is exceedingly large in relation to the quantity demanded, an equilibrium between supply and demand may exist only at a price of zero. Thus, water takes on a monetary value only as the supply of water becomes scarce relative to demand. That is, as the supply of water becomes more scarce, competition for a relatively limited quantity will force a rise in the equilibrium price.

The growing demand for water relative to supply is a matter of increasing public concern. Water is allocated among uses and users through public institutions rather than private markets. Watershed development creates both water supplies and institutions governing the allocation of these supplies. Thus, it is of major importance that knowledge of an efficient allocation of water among uses and users be available for incorporation into watershed development plans.

## Resource Allocation

A study by the Rand Corporation used the equimarginal returns principle of economic theory as the criterion for determining the optimum allocation of water in alternative uses.[4] Assuming profit maximization

---

[3]The other functions are: (1) determination of what is to be produced, (2) organization of production, (3) product distribution, and (4) economic maintenance and progress.

[4]Jack Hirschliefer, James C. DeHaven, and Jerome W. Milliman, Water Supply: Economics, Technology, and Policy (Chicago, 1960), pp. 72-73.

as the goal, each unit of a scarce resource, such as water, should be allocated where it receives the greatest marginal return. The final allocation of a scarce resource is optimum when the marginal value products of all uses are equal.[5] This principle provided the basic theoretical framework for the development of this study. The objectives of the model were to estimate the marginal value products of water in all uses and to determine optimum allocations of given water supplies within and among farms. A simplified farm resource situation is presented for illustrative purposes. The problem is to determine the optimum allocation of a given supply of irrigation water between alfalfa and cotton consistent with maximum profits.

The curves in Figures 2 and 3 are schedules of the marginal value product of water used in the production of cotton ($MVP_{wc}$) and alfalfa ($MVP_{wa}$) respectively. A water supply of $OA_1$ in Figure 2 yields maximum returns to water when the entire supply is allocated to cotton. The marginal value product of the last unit of water is OQ. Assuming that OQ in Figure 2 is greater than OT' in Figure 3, any transferring of water from cotton to alfalfa (given a water supply of $OA_1$) reduces total returns to water since the marginal value product of a unit of water transferred from cotton is greater than the marginal value product of a unit of water added to alfalfa. That is, the loss in returns which occurs by transferring a unit of water from cotton is greater than the gain in returns that occurs by adding a unit of water to alfalfa.

---

[5]This is the necessary condition for profit maximization. The second order or sufficient condition for profit maximization is that the marginal value product of water in each use decline as additional water is applied. The marginal value products as derived by linear programming and used throughout this dissertation are net marginal value products since a charge was made for opportunity and cash costs.

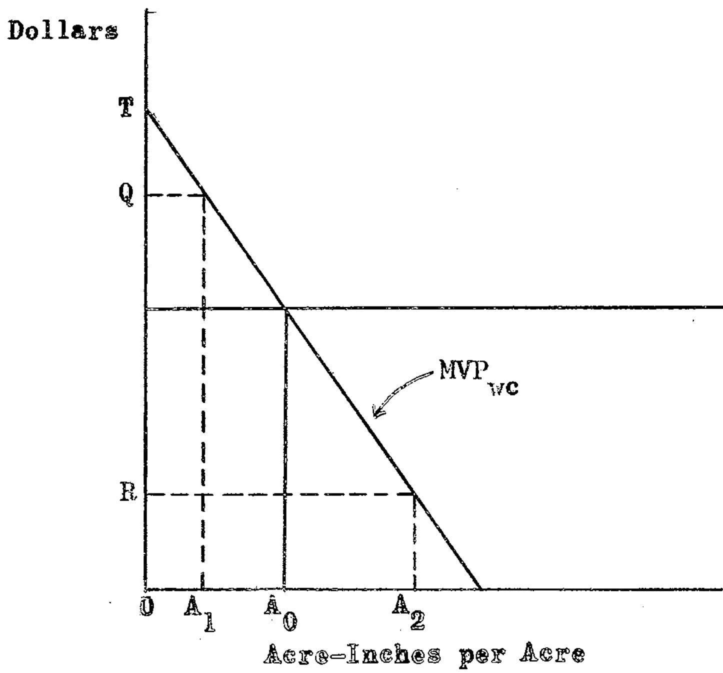


Figure 2. Hypothetical Marginal Value Product Curve for Water in the Production of Cotton.

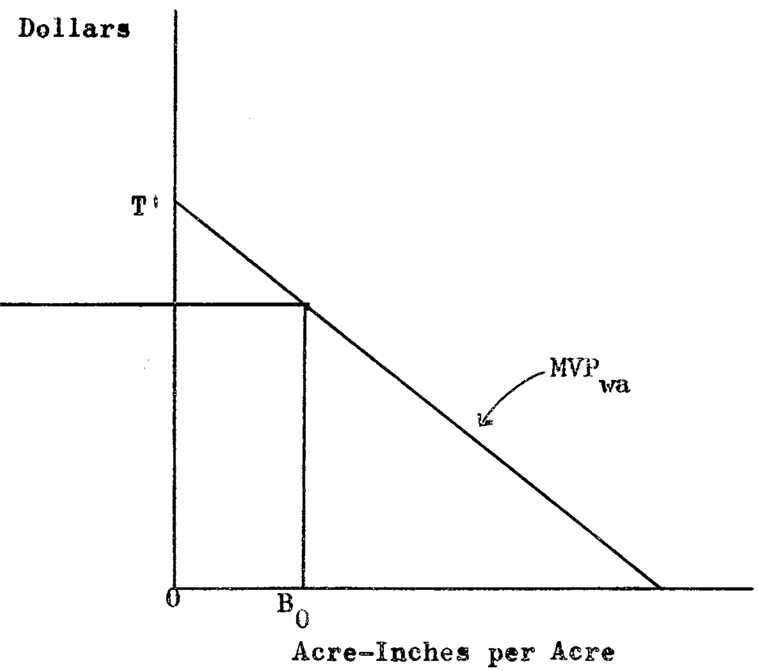


Figure 3. Hypothetical Marginal Value Product Curve for Water in the Production of Alfalfa.

Assume now a larger water supply, represented by $0A_2$ in Figure 2. If this entire supply is allocated to cotton, the marginal value product of the last unit of water allocated to cotton is 0R (Figure 2). According to the equimarginal return principle, using the entire supply on cotton is not the profit maximizing allocation of water supply $0A_2$ since $MVP_{wc} \neq MVP_{wa}$. The profit maximizing allocation of this water supply is $0A_0$ units to cotton and $0B_0$ units to alfalfa $(0A_0 + 0B_0 = 0A_2)$. That is, the marginal value products of water in the production of cotton and alfalfa are equated by shifting $A_0A_2$ units of water from cotton to alfalfa $(A_0A_2 = 0B_0)$ concurrently with an increase in the supply of water of $A_1A_2$.

This analysis could be applied for a series of fixed water supplies and n uses. A generalized formulation of the equilibrium condition when water is used in the production of several different products is expressed by the following condition:

$$MVP_{w1} = MVP_{w2} = \cdots = MVP_{wn} \geqslant MC_w$$

where $MVP_{w1} \cdots MVP_{wn}$ represents the marginal value product of water used in the production of n alternative products and $MC_w$ represents the marginal cost of another unit of water.

## Operational Model

The development of a model for analyzing a specific problem requires simplifying assumptions about physical and economic conditions relevant to the area of study. For this analysis, the following assumptions were made: (1) there is a fixed acreage of potentially irrigable land for each resource situation under study, (2) all land in a given productivity class with potential for irrigation is equally productive, (3) farm programs restrict the acreage of wheat and cotton in the organization; (4) individual farmers face a perfectly elastic demand curve for products sold, as well as a perfectly elastic resource supply curve, except for land and family labor, and (5) knowledge and management capabilities among farmers are equal.

Linear Programming

The conceptual analysis in the preceding section assumed that the existing production relationships were continuous. That is, there existed an infinite number of input-output combinations. The discrete nature of the data available for this study restricted the analysis to discontinuous, linear relationships. Linear programming is an operational technique used to analyze problems involving linear relationships such as those permitted by the data used in this study.

Linear programming was used to determine optimum farm organizations for one dryland and three irrigated programming models.[6] The three irrigated models assumed alternative levels of water availability per farm.

The dryland optimum farm organization was used as the base for computing and analyzing returns to alternative levels of water availability for each resource situation. This analysis was accomplished by computing the change in net returns and resource requirements of adding alternative levels of water to the present dryland optimum plan.

Unit of Analysis

The "typical whole farm" approach was used as the basic unit of

---

[6]For a complete discussion of the use of linear programming for formulating optimum farm plans, see Robert W. Llewellyn, Linear Programming (New York, 1964); Saul I. Gass, Linear Programming Methods and Applications (New York, 1964); and Earl O. Heady and Wilfred C. Candler, Linear Programming Methods (Ames, 1958).

analysis. This approach considers decisions of the entire farm rather than limit the scope of analysis to the portion of the farm containing only potentially irrigable land.

The use of the "typical whole farm" approach makes it possible to analyze changes in land use which take place on the bottomland as a result of irrigation. In addition, this approach indicates shifts in land use between upland and bottomland as additional irrigation water is available. Decisions on resource allocation are made by operators of farm units which may contain both bottomland and upland within the watershed. Thus, it appears that the important economic unit for analyzing problems of resource allocation is the farm unit as a part of the watershed complex rather than analyzing problems of resource allocation on only the bottomland portion of the farm. The "typical whole farm" approach recognizes and accounts for the interaction between the upland and bottomland components within a single economic unit.

## Developing the Analysis

Basic resource and other data necessary for the programming analysis were obtained by interviewing a sample of 65 farmers in Roger Mills County. The population from which the sample was chosen was defined as "farm units within the Washita River Basin of Roger Mills County operating bottomland." This population consisted of 150 farm units.

Information obtained from this survey included a complete inventory of land resources by tenure and class, the land use pattern of the previous years, present and historical dryland yields of common crops, and an inventory of livestock, crop and livestock machinery, and dairy equipment. A few of the farmers in the sample had irrigation experience. From these farmers, information was obtained on present and historical irrigated yields, investment in irrigation equipment, and practices unique to irrigation farming.

Soil Productivity Classes

The soils in Roger Mills County range from fertile bottomland to severely eroded, low producing native rangeland. The bottomland includes such soil units as Norwood Silt Loam, Yahola Fine Sandy Loam, and Cass Loams and include only about 4.7 per cent of the total land area of Roger Mills County.[7]

The purpose of the rather detailed study of soils in this study was to allow an aggregation of comparable soil units into uniform productivity classes. It was assumed that this would provide a more accurate evaluation of returns to irrigation water than could be expected when soils were classified simply as either cropland or rangeland (Table I).

The classification was facilitated by a recent detailed soil survey of Roger Mills County by the Soil Conservation Service, United States Department of Agriculture and the Department of Agronomy, Oklahoma State University.[8] This soil survey provided a complete description of all soil units in the County as well as long term average yields. This made it

---

[7]United States Department of Agriculture, Soil Conservation Service (unpub. data, Stillwater).

[8]United States Department of Agriculture, Soil Conservation Service, "Classification and Correlation of the Soils of Roger Mills County, Oklahoma" (unpub. report, Beltsville, February, 1961); and United States Department of Agriculture, Soil Conservation Service, "Descriptive Legend, Roger Mills County Standard Soil Survey" (unpub. report, Beltsville, 1960).

TABLE I

DEFINITION OF LAND PRODUCTIVITY CLASSES AS USED IN PROGRAMMING ANALYSIS, ROGER MILLS COUNTY

---

$L_1$ - Land Productivity Class I. Silty alluvial soil occurring in the flood plains of streams that drain areas of soils that have reddish parent materials of the permian red beds. Norwood Silt Loam.

$L_2$ - Land Productivity Class II. All bottomland soils with individual units varying from silty alluvial to sandy alluvial soils. Includes both first and second bottom soils. Yahola, Spur and Port, Reinach, and Cass Soils.

$L_3$ - Land Productivity Class III. Good quality upland. All capable of being cropped. Dill-Quinlan, Miles, Miles-Dill, Holdredge, and Woodward Soils.

$L_4$ - Land Productivity Class IV. Lower quality upland. Miles, Miles Springer, Springer, Woodward, Pratt, Brownfield-Nobscott Soils

$L_5$ - Land Productivity Class V. Bottomland soils subject to frequent flooding. Includes subirrigated range sites. Used exclusively for meadow and pasture. Lincoln and Sweetwater Soils.

$L_6$ - Land Productivity Class VI. Upland generally not suitable for cropping. Brownfield-Nobscot, Pratt Complex, Miles-Nobscott Complex, and Quinlan-Woodward Soils.

$L_7$ - Land Productivity Class VII. Rough and severely eroded upland range. Considerable lower and wider range in carrying capacity than $L_6$.

---

possible to aggregate the many different soil units of Roger Mills County into comparable productivity classes.[9] The final classification included four cropland and three rangeland productivity classes. The seven productivity classes are defined in Table I.

## Identifying Typical Farms

The survey of Roger Mills County provided a complete inventory of land resources. This inventory was a basis for stratifying the 65 farms of the survey into six typical resource strata or typical farms for programming purposes. The farms were stratified to test the hypothesis that type of farm and acres of bottomland are two influential variables explaining differences in returns to irrigation water. To test this hypothesis, the 65 farms in the sample were distributed into six strata according to the characteristics defined in Table II.

TABLE II

DEFINITION OF STRATA INTO WHICH THE 65 FARMS IN THE ROGER MILLS COUNTY SURVEY WERE DISTRIBUTED

| Resource Strata[a] | No. of Farms | Acres of: Rangeland | Cropland | Bottomland |
|---|---|---|---|---|
| A | 10 | 700 or less | less than 160 | 60 or less |
| B | 11 | 700 or less | less than 160 | more than 60 |
| C | 12 | 700 or less | 160 or more | 105 or less |
| D | 12 | 700 or less | 160 or more | more than 105 |
| E | 10 | more than 700 | unrestricted | 240 or less |
| F | 10 | more than 700 | unrestricted | more than 240 |

[a]The terms "resource strata" and "typical farm" will be used interchangeably throughout this manuscript.

[9]A description of the procedure used in developing the soil productivity classes is presented in Appendix B.

Following the grouping of these farms into the six resource strata, coefficients were computed representing the average acres of cropland, rangeland, and bottomland in each of the six resource strata. The coefficients for each of the six resource strata defined the six typical farms used to determine the value of irrigation water (Table III).

TABLE III

DISTRIBUTION OF LAND RESOURCES BY PRODUCTIVITY CLASS FOR SIX TYPICAL FARMS, ROGER MILLS COUNTY

| Item | Typical Farm | | | | | |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | F |
| | | | - Acres - | | | |
| Cropland Total | 80 | 103 | 248 | 236 | 321 | 537 |
| $L_1$ | 7 | 25 | 8 | 75 | 13 | 155 |
| $L_2$ | 31 | 60 | 57 | 88 | 99 | 147 |
| $L_3$ | 13 | 1 | 10 | 11 | 19 | 159 |
| $L_4$ | 29 | 17 | 173 | 62 | 190 | 76 |
| Rangeland Total | 196 | 275 | 406 | 353 | 1,413 | 2,149 |
| $L_5$ | 8 | 8 | 11 | 28 | 38 | 78 |
| $L_6$ | 115 | 211 | 378 | 316 | 1,244 | 994 |
| $L_7$ | 73 | 56 | 17 | 9 | 131 | 1,077 |
| Total Acres | 276 | 378 | 654 | 589 | 1,734 | 2,686 |

Farms A and B were defined to assess the relative effect on returns to irrigation water of varying acres of bottomland with cropland and rangeland held relatively constant. Farm B has 47 more acres of bottomland and 23 more acres of cropland than farm A. This is a 97 per cent increase in bottomland with only a 29 per cent increase in cropland.

Comparing optimum farm organizations for farms B and C makes it possible to evaluate the effect on returns to irrigation water of varying the acres of upland cropland included in the unit while maintaining bottomland relatively constant. The acres of upland cropland in farm C is about 141 per cent greater than farm B. The acres of bottomland in farm C is slightly lower than farm B. Farms C and D can be compared to analyze the influence of bottomland acreage on returns to irrigation water for a larger farm size.

## Types of Farming

Type of farming is a second variable hypothesized as being influential in explaining returns to irrigation water. Important considerations are the efficiency with which the services of irrigation are transformed into output, the capacity that crops have for utilizing water, and the relative prices of the product forthcoming from the production process.

A summary of the schedules taken in Roger Mills County indicated that the most common type of farming was a combination small grains-cotton-cow calf livestock farm. Other farm types indicated by the study were wheat-cotton-dairy and small grains-cotton-cow calf-buy sell farms. A definition of farms by type of farming is summarized in Table IV. This classification most nearly reflects the types of farming found in the Washita River Basin of Roger Mills County.

## Rainfall Conditions

The water supply available in the floodwater retarding structure of Roger Mills County appeared to be adequate for irrigation during a normal rainfall year, but insufficient to meet the irrigation water requirements during a period of prolonged drought. The supply of water available for irrigation relative to demand was hypothesized as a crucial variable influencing investment decisions in irrigation equipment. Therefore, it was necessary to stratify rainfall conditions in order to evaluate the relative demand for irrigation water and change in net returns associated with irrigation under alternative rainfall conditions.

TABLE IV

CLASSIFICATION OF TYPICAL FARMS BY TYPES OF FARMING, ROGER MILLS COUNTY

| Typical Farm | Farm Size and Type[a] Identification | Description of Farm Type |
|---|---|---|
| A | A-1 | Small grains-cotton-cow calf |
| B | B-1 | Small grains-cotton-cow calf |
| C | C-1 | Small grains-cotton-cow calf |
| C | C-2 | Wheat-cotton-dairy |
| D | D-1 | Small grains-cotton-cow calf |
| D | D-2 | Wheat-cotton-dairy |
| E | E-1 | Small grains-cotton-cow calf |
| E | E-2 | Wheat-cotton-dairy |
| F | F-1 | Small grains-cotton-cow calf |
| F | F-2 | Small grains-cotton-cow calf-buy sell |

[a]This designation of typical farms will be used for the respective farm types and sizes throughout the study.

The methodology used to evaluate the effect of rainfall on the demand for irrigation water and changes in net returns was to classify rainfall conditions into three general categories on the basis of 1914-1960 rainfall data for the area.[10] When these data for 46 years were summarized into a frequency distribution, three distinct groups were evident: (1) 10 years with an annual rainfall of 16.8 inches classified as below average rainfall, (2) 26 years with an annual rainfall of 23.8 inches classified as average rainfall, and (3) 10 years with an average rainfall of 36.2 inches classified as above average rainfall.

[10]United States Department of Commerce, Weather Bureau, Climatological Data, Oklahoma, 1914-1960. Data were incomplete for 1933. The rainfall data were recorded for Hammon, Oklahoma. These data are summarized in Appendix C, Table I.

Enterprise budgets were developed for all dryland and irrigated crops and the programming analysis was performed assuming average and below average rainfall conditions. The above average rainfall condition was excluded from the programming analysis. This decision was made on the basis of preliminary results which indicated that the cost of applying the relatively small quantity of water required during above average rainfall years was greater than the added returns from the water.

Irrigation Levels

The general objective of this research was to appraise and evaluate the potential value of water for irrigation in Roger Mills County. The source of this water supply was assumed to be water stored in floodwater retarding structures in the Washita River Basin of Roger Mills County. Since the water level of these structures, and thus the supply of water available for irrigation, fluctuates from year to year, three levels of water application per crop and three water levels per farm were assumed.

Crop Irrigation Levels. The three crop irrigation levels were designed to test the hypothesis that a decrease in the supply of irrigation water would result in a lower water application per acre rather than a reduction in acres irrigated.

The maximum irrigation level for each crop was determined by the water requirement of the crop and the expected rainfall.[11] The water requirement

[11]Expected rainfall refers to normal rainfall received during growing season of March-September for all crops except wheat. For wheat, the growing season is assumed to be August-May. The expected rainfall for the March-September period is 14 inches during below average rainfall years and 19 inches during average rainfall years. Expected rainfall for the August-May period is 12 inches during below average rainfall years and 17 inches during average rainfall years.

for each crop was computed from basic climatological data for Roger Mills County utilizing a method developed by Blaney and Criddle.[12] This procedure was used to compute total water requirements for crops consistent with optimum plant growth in relation to climatic factors in Roger Mills County.[13]

The high irrigation level for each crop ($I_3$ in Table V) was determined by finding the difference between the computed total water requirements and the moisture available from natural precipitation. For example, the total water requirement for cotton was 39 inches (Table V). Assuming average rainfall of 19 inches, the irrigation requirement was 20 inches. When below average rainfall of 14 inches prevailed, the irrigation requirement was increased to 25 inches to fulfill the total water requirement for cotton of 39 inches.

Irrigation levels $I_1$ and $I_2$ were based on experimental data of the Altus Irrigation Experiment Station, experience of soil scientists at Oklahoma State University, personnel of the Soil Conservation Service, and local agricultural workers in the area.

Farm Water Levels. The quantity of water available per farm was assumed at four levels (Table VI). The first level programmed was an unlimited supply represented by farm water level 4 in Table VI. The purpose of programming the unlimited supply first was to determine the

---

[12]Harry F. Blaney and Wayne D. Criddle, Determining Water Requirements in Irrigation Areas From Climatological Data, Soil Conservation Service, United States Department of Agriculture, SCS-TP-96 (Washington, 1950).

[13]The total water requirements for each crop were computed for the growing seasons defined in footnote 11, Chapter II. See Appendix D for a discussion of the procedure used in determining crop water requirements.

TABLE V

CROP IRRIGATION LEVELS, IRRIGATION WATER APPLIED, AND WATER AVAILABLE BY CROP, AVERAGE AND BELOW AVERAGE RAINFALL, ROGER MILLS COUNTY

| Crop | Levels of Irrigation[a] | Irrigation Water Applied[b]: Average Rainfall | Irrigation Water Applied[b]: Below Average Rainfall | Total Water Available[c] |
|---|---|---|---|---|
| | | - Acre-Inches - | | |
| Cotton | $I_1$ | 6 | 11[e] | 25 |
| | $I_2$ | 13 | 18 | 32 |
| | $I_3$ | 20 | 25 | 39[d] |
| Wheat | $I_1$ | 5 | 10[e] | 22 |
| | $I_2$ | 10 | 15 | 27 |
| | $I_3$ | 15 | 20 | 32[d] |
| Alfalfa | $I_1$ | 6 | 11[e] | 25 |
| | $I_2$ | 12 | 17 | 31 |
| | $I_3$ | 18 | 23 | 37[d] |
| Grain and Forage Sorghum | $I_1$ | 4 | 8[e] | 22 |
| | $I_2$ | 7 | 11 | 26 |
| | $I_3$ | 10 | 14 | 29[d] |
| Midland Bermuda | $I_1$ | 16 | 21[e] | 35[d] |

[a]Dryland conditions for each crop were represented by $I_0$.

[b]Irrigation level $I_3$ represents the amount of irrigation water required in addition to natural precipitation, to meet the total water requirements of optimum plant growth.

[c]Represents natural precipitation plus irrigation water applied. See footnote 11, Chapter II, for natural precipitation during average and below average rainfall years.

[d]Represents total water requirements consistent with optimum plant growth. See Appendix D for computational procedure used in computing total water requirements.

[e]Represents enough irrigation water to replace below average precipitation plus water applied during average rainfall conditions.

TABLE VI

FARM WATER LEVELS BY FARM SIZE AND TYPE AS USED IN THE PROGRAMMING ANALYSIS, ROGER MILLS COUNTY

| Farm Size and Type | Farm Water Levels[a] | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| A-1 | 0 | $1/3X_1$ | $2/3X_1$ | $X_1$ |
| B-1 | 0 | $1/3X_2$ | $2/3X_2$ | $X_2$ |
| C-1 | 0 | $1/3X_3$ | $2/3X_3$ | $X_3$ |
| C-2 | 0 | $1/3X_4$ | $2/3X_4$ | $X_4$ |
| D-1 | 0 | $1/3X_5$ | $2/3X_5$ | $X_5$ |
| D-2 | 0 | $1/3X_6$ | $2/3X_6$ | $X_6$ |
| E-1 | 0 | $1/3X_7$ | $2/3X_7$ | $X_7$ |
| E-2 | 0 | $1/3X_8$ | $2/3X_8$ | $X_8$ |
| F-1 | 0 | $1/3X_9$ | $2/3X_9$ | $X_9$ |
| F-2 | 0 | $1/3X_{10}$ | $2/3X_{10}$ | $X_{10}$ |

[a]$X_i$ represents the quantity of water necessary to satisfy the following equilibrium condition:

$$MVP_{w1} = MVP_{w2} = \cdots = MVP_{w6} \geqslant MC_w.$$

The four water levels apply to both average and below average rainfall conditions.

water requirement necessary to satisfy the following equilibrium condition:

$$MVP_{w1} = MVP_{w2} = \cdots = MVP_{w6} \geqslant MC_w$$

where $MVP_{w1} \cdots MVP_{w6}$ represents the marginal value product of water in the production of 6 products and $MC_w$ is the marginal cost of the last unit of water applied.

Farm water levels 2 and 3 were set at one-third and two-thirds, respectively, of the quantity of water necessary to satisfy the above equilibrium condition for each typical farm assuming average and below average rainfall. Farm water level 1 was programmed as a dryland situation for each typical farm and rainfall condition. The dryland optimum plan provided a basis for the analysis of changes in the profit maximizing farm organization, resource requirements, and net and marginal returns of increasing water availability for irrigation.[14]

Developing Budgets for Production Activities

The selection of production activities or enterprises for this study was based on the feasibility of production and the presence of adequate market outlets. Although it is conceptually possible for an infinite number of production activities or enterprises to be considered for a given area, it is reasonable to expect that relatively few alternatives are considered by farmers.

Basic Data. The survey of watershed farms provided much of the basic data for developing the enterprise budgets and other programming restrictions. These data were supplemented with data from secondary

---

[14]Net returns are returns to land, family labor, risk, and management. Marginal returns are returns to water, family labor, risk, and management associated with irrigation.

sources developed from other Western Oklahoma studies.[15] In addition, unpublished information and experience of staff members at Oklahoma State University and of the Soil Conservation Service were used extensively.

The product price assumptions used in developing the enterprise budgets were based on 1961 prices received by farmers in Western Oklahoma (Appendix A, Table I). The assumed prices paid for factors of production used in deriving the returns over variable costs for each enterprise are summarized in Appendix A, Table II. These cost items are assumed to be representative of 1961 prices paid by Western Oklahoma farmers.

The operator and other family labor available on farms in Roger Mills County was 2,398 hours per farm surveyed. Throughout this study, no charge was made for family labor and seasonal labor was assumed available at $1.00 per hour. Potential effects of alternative labor assumptions were not analyzed in this study. A summary of the labor requirements per crop is presented in Appendix E, Tables XXIV and XXV.

<u>Cropping Activities</u>. Crop budgets were developed for cotton, wheat, grain and forage sorghum, alfalfa, and bermuda for both dryland and irrigated conditions (Appendix E, Tables II-XXI). Dryland crop budgets for oats, sudan, and small grain hay and grazing were similar to budgets

---

[15] Larry J. Connor, William F. Lagrone, and James S. Plaxico, <u>Resource Requirements, Costs, and Expected Returns; Alternative Crop and Livestock Enterprises, Loam Soils of the Rolling Plains of Southwestern Oklahoma</u>, Oklahoma Agricultural Experiment Station and Farm Economics Division, ERS, USDA, Processed Series, P-368 (Stillwater, 1961); and Robert W. Greve, James S. Plaxico, and William F. Lagrone, <u>Resource Requirements, Costs and Expected Returns; Alternative Cropland and Livestock Enterprises; Rolling Plains, Northwestern, Oklahoma</u>, Oklahoma Agricultural Experiment Station and Farm Economics Division, ERS, USDA, Processed Series, P-390 (Stillwater, 1961).

developed for these crops in other studies.[16] Adjustments were made in these budgets to correspond to yield and price coefficients assumed in this study.

Wheat and cotton were restricted to the acreage allotments of the typical farms for the 1961 crop year. The soil bank and conservation reserve were excluded as land use alternatives

Livestock Alternatives. Although a beef cow-calf enterprise was the most prevalent livestock enterprise on Roger Mills County farms, various feeding enterprises appeared to be gaining popularity. This appeared on farms where bottomland was a significant portion of the farm's total land resources. In addition, dairying was an important livestock enterprise. For example, the value of dairy products sold in 1959 was $860,176 or about 12 per cent of the value of all farm products sold in Roger Mills County.[17] Thus, Grade A dairy was considered as a production alternative on resource situations III, IV, and V based on results of the survey of watershed farms.

Budgets were developed for a Grade A dairy enterprise, alternative spring and fall calving cow-calf enterprises, and alternative feeder enterprises (Appendix E, Tables XXVI-XXX).

Crop Yields.[18] The dryland yields were based primarily on crop

---

[16]Cited in footnote 14, Chapter II.

[17]United States Department of Commerce, Bureau of Census, United States Census of Agriculture for Oklahoma, 1959 (Washington, 1961).

[18]Fenton Gray, Department of Agronomy, Oklahoma State University, Odos Henson, Soil Scientist with the Soil Conservation Service located at Clinton, Oklahoma, and Charlie Burns, Roger Mills County Extension Agent provided valuable information and assistance in developing the dryland and irrigated yields.

yield estimates developed in connection with the detailed soil survey of Roger Mills County.[19] These yield estimates represent average long term yields that are expected from each productivity class using presently known technology. It was assumed that these yields were representative of average rainfall conditions. It was necessary to adjust these yields downward for the crop yields reflecting below average rainfall conditions.

Response to irrigation of various crops at the Altus Irrigation Experiment Station provided the basis for adjusting the dryland yields of Roger Mills County to represent irrigated yields at alternative levels of water application per acre.[20] In making these adjustments, it was assumed that crop response to irrigation in Roger Mills County was similar to the response reported at the Altus Irrigation Farm. The budgets for irrigated enterprises reflect costs of additional fertilizer application, insect control on cotton, and other factors necessary for irrigation farming which are not normally practiced under dryland farming conditions.[21]

## Method of Irrigation

Sprinkler irrigation methods were assumed throughout the study. Because the topography of much of the land classified as bottomland is uneven and slightly rolling, the sprinkler irrigation system is the more

---

[19] United States Department of Agriculture, Soil Conservation Service, "Crop Yield Estimates" (unpub. report, Stillwater).

[20] James E. Garton and A. D. Barefoot, Irrigation Experiments at Altus and El Reno, Oklahoma, Oklahoma Agricultural Experiment Station Bulletin B-534 (Stillwater, 1959); and Dudley Barefoot and James Garton, "Altus Experiment Station Field Day" (unpub. report, Stillwater, 1961).

[21] Dryland and irrigated yields are summarized in Appendix B, Table I.

practical method of water application. In many areas, the cost of preparing the land for an irrigation method other than a sprinkler is prohibitive.

The investment requirements in irrigation equipment were based on two basic sizes with combinations of these two making up five irrigation systems (Table VII). The total investment in irrigation equipment, including pump, motor, pipe, sprinklers, etc., ranged from $3,561 for the small system irrigating approximately 50 acres for best timeliness to $19,600 for a system designed to irrigate about 300 acres during peak water requirements.

## TABLE VII

## ESTIMATED TOTAL INVESTMENT AND ANNUAL FIXED COSTS OF IRRIGATION SYSTEMS DESIGNED FOR TYPICAL FARMS IN THIS STUDY, ROGER MILLS COUNTY[a]

| | Size of Irrigation System | | | | |
|---|---|---|---|---|---|
| Items | 50 Acres | 100 Acres | 150 Acres | 200 Acres | 300 Acres |
| | | | - Dollars - | | |
| Investment: | | | | | |
| Pump and Motor | 1,470 | 2,400 | 3,870 | 4,800 | 7,000 |
| Pipe, Mainline | 512 | 1,452 | 1,964 | 2,904 | 3,900 |
| Pipe, Laterals | 1,248 | 2,112 | 3,360 | 4,224 | 6,600 |
| Sprinklers | 252 | 594 | 846 | 1,188 | 1,650 |
| Risers | 29 | 50 | 79 | 100 | 150 |
| Miscellaneous Items | 50 | 100 | 150 | 200 | 300 |
| Total Investment | 3,561 | 6,708 | 10,269 | 13,416 | 19,600 |
| Salvage Value[b] | 356 | 671 | 1,027 | 1,342 | 1,960 |
| Average Annual Investment | 1,958 | 3,689 | 5,648 | 7,379 | 10,780 |
| Annual Fixed Cost: | | | | | |
| Depreciation[c] | 247 | 464 | 711 | 929 | 1,357 |
| Taxes and Insurance | 39 | 74 | 113 | 148 | 216 |
| Interest[d] | 117 | 221 | 339 | 443 | 647 |
| Total | 403 | 759 | 1,163 | 1,520 | 2,220 |

[a]Staff members of the Department of Agricultural Engineering, Oklahoma State University, provided technical assistance in designing the irrigation systems.

[b]Assumed to be 10 per cent of total investment.

[c]Annual depreciation = $\frac{\text{total investment - salvage value}}{13}$

[d]Interest on investment computed as six per cent of average annual investment.

# CHAPTER III

## RESULTS OF THE PROGRAMMING ANALYSIS

This chapter contains the results of programming optimum farm plans for the six typical farm resource situations under alternative assumptions about livestock systems, rainfall conditions, and available water for irrigation. The livestock systems considered in this study were beef cow-calf, dairy, and feeder cattle. The beef cow-calf system was the basic enterprise used in analyzing results of irrigation for each of the six farm resource situations. A dairy system was included as a production alternative on farm resource situations C, D, and E, and a comparison of the effects of dairy with beef cow systems upon responses of irrigation can be made only for these resource situations. The feeder cattle enterprise was programmed only on farm resource situation F for comparison with the cow-calf system.

Cotton, wheat, alfalfa, grain sorghum, and bermuda grass were crops included as irrigation alternatives. The non-irrigated cropping alternatives included oats, grazed out small grain, and sudan grass grazing in addition to the crops mentioned above. All crops considered as irrigated production alternatives entered into one or more of the final programmed farm organizations.

## Programmed Land Uses

### Farms With Beef Cow-Calf Enterprises

Generally, very little shifting of crops from upland to bottomland was attributable to changes in levels of irrigation for the farms with beef cow-calf enterprises (Tables VIII-XIII). Crops grown on upland under dryland conditions remained on these land classes as available irrigation water increased, farm size increased, or farm type varied. The major changes in land use as a result of alternative irrigation levels were between land classes $L_1$ and $L_2$. The relatively low producing land classes $L_3$ and $L_4$ were used to produce feed grains, mainly utilized on the farms, and wheat.

In general, the optimum level of irrigation for most crops was at the high level of water application. Even at very limited levels of water supply, it was more profitable to irrigate fewer acres at the highest level than to irrigate more acres at a lower level. Exceptions occurred when below average rainfall conditions were considered. In these situations, the optimum levels of irrigation for wheat and grain sorghum were at lower water application levels.

The second level of irrigation water available per farm provided more water than was necessary to irrigate the cotton allotment for all resource situations when the beef cow-calf enterprises were considered. There was also more water available than was required to irrigate all of land class $L_1$ except on resource situation F. This condition occurred because land class $L_1$ constituted more than half of the total irrigable land. On all other resource situations, the amount of $L_1$ land was a relatively small portion of the total irrigable land. As the level of water for

TABLE VIII

PROGRAMMED CROPLAND USES AND OPTIMUM LEVELS OF WATER USE PER ACRE BY FARM WATER LEVELS, FARM A-1, AVERAGE AND BELOW AVERAGE RAINFALL[a]

| | | Programmed Cropland Uses (Acres) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Optimum Level[c] of Water Use | Average Rainfall | | | | Below Average Rainfall | | | |
| | | Farm Water Levels[d] | | | | | | | |
| Land Classes[b] | Per Acre | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| $L_1$ and $L_2$ | | | | | | | | | |
| Irrigated | | | | | | | | | |
| Cotton | $I_3$ | 0 | 10 | 10 | 10 | 0 | 10 | 10 | 10 |
| Alfalfa | $I_3$ | 0 | 1 | 6 | 18 | 0 | 0 | 0 | 18 |
| Wheat | $I_2$ | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 0 |
| Wheat | $I_3$ | 0 | 1 | 10 | 10 | 0 | 0 | 5 | 10 |
| Grain Sorghum | $I_1$ | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 0 |
| Total | | 0 | 12 | 26 | 38 | 0 | 12 | 38 | 38 |
| Non-Irrigated | | | | | | | | | |
| Cotton | $I_0$ | 10 | 0 | 0 | 0 | 10 | 0 | 0 | 0 |
| Alfalfa | $I_0$ | 2 | 0 | 0 | 0 | 1 | 2 | 0 | 0 |
| Wheat | $I_0$ | 10 | 9 | 0 | 0 | 0 | 0 | 0 | 0 |
| Grain Sorghum | $I_0$ | 16 | 17 | 12 | 0 | 27 | 24 | 0 | 0 |
| Total | | 38 | 26 | 12 | 0 | 38 | 26 | 0 | 0 |
| $L_3$ and $L_4$ | | | | | | | | | |
| Non-Irrigated | | | | | | | | | |
| Wheat | $I_0$ | 0 | 0 | 0 | 0 | 10 | 8 | 0 | 0 |
| Grain Sorghum | $I_0$ | 13 | 13 | 13 | 13 | 3 | 5 | 13 | 13 |
| Other[e] | $I_0$ | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| Total | | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 |

[a]Typical farms are defined by resource situation and type in Tables II and IV of Chapter II.

[b]Land classes are defined in Table I of Chapter II.

[c]Crop irrigation levels per acre are defined in Table V of Chapter II.

[d]Farm water levels are defined in Table VI of Chapter II.

[e]Includes oats, small grain pasture, and idle cropland.

TABLE IX

PROGRAMMED CROPLAND USES AND OPTIMUM LEVELS OF WATER USE PER ACRE BY FARM WATER LEVELS, FARM B-1, AVERAGE AND BELOW AVERAGE RAINFALL[a]

| Land Classes[b] | Optimum Level[c] of Water Use Per Acre | Programmed Cropland Uses (Acres): Average Rainfall, Farm Water Levels[d] 1 | 2 | 3 | 4 | Below Average Rainfall, Farm Water Levels[d] 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|
| $L_1$ and $L_2$ | | | | | | | | | |
| Irrigated | | | | | | | | | |
| Cotton | $I_3$ | 0 | 16 | 16 | 16 | 0 | 16 | 16 | 16 |
| Alfalfa | $I_3$ | 0 | 9 | 18 | 46 | 0 | 6 | 8 | 44 |
| Wheat | $I_2$ | 0 | 0 | 0 | 0 | 0 | 5 | 17 | 0 |
| Wheat | $I_3$ | 0 | 1 | 23 | 23 | 0 | 0 | 6 | 23 |
| Grain Sorghum | $I_1$ | 0 | 0 | 0 | 0 | 0 | 3 | 37 | 0 |
| Bermuda Grass | $I_1$ | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| Total | | 0 | 26 | 57 | 85 | 0 | 30 | 85 | 85 |
| Non-Irrigated | | | | | | | | | |
| Cotton | $I_0$ | 16 | 0 | 0 | 0 | 16 | 0 | 0 | 0 |
| Alfalfa | $I_0$ | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Wheat | $I_0$ | 23 | 22 | 0 | 0 | 22 | 17 | 0 | 0 |
| Grain Sorghum | $I_0$ | 43 | 37 | 28 | 0 | 47 | 38 | 0 | 0 |
| Total | | 85 | 59 | 28 | 0 | 85 | 55 | 0 | 0 |
| $L_3$ and $L_4$ | | | | | | | | | |
| Non-Irrigated | | | | | | | | | |
| Grain Sorghum | $I_0$ | 1 | 1 | 18 | 18 | 1 | 1 | 1 | 1 |
| Other[e] | $I_0$ | 17 | 17 | 0 | 0 | 17 | 17 | 17 | 17 |
| Total | | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 |

[a]Typical farms are defined by resource situation and type in Tables II and IV of Chapter II.

[b]Land classes are defined in Table I of Chapter II.

[c]Crop irrigation levels per acre are defined in Table V of Chapter II.

[d]Farm water levels are defined in Table VI of Chapter II.

[e]Includes oats, small grain pasture, and idle cropland.

TABLE X

**PROGRAMMED CROPLAND USES AND OPTIMUM LEVELS OF WATER USE PER ACRE BY FARM WATER LEVELS, FARM C-1, AVERAGE AND BELOW AVERAGE RAINFALL[a]**

| Land Classes[b] | Optimum Level[c] of Water Use Per Acre | Programmed Cropland Uses (Acres) Average Rainfall Farm Water Levels[d] 1 | 2 | 3 | 4 | Below Average Rainfall 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|
| $L_1$ and $L_2$ | | | | | | | | | |
| Irrigated | | | | | | | | | |
| Cotton | $I_3$ | 0 | 11 | 11 | 11 | 0 | 11 | 11 | 11 |
| Alfalfa | $I_3$ | 0 | 1 | 1 | 18 | 0 | 0 | 1 | 15 |
| Wheat | $I_2$ | 0 | 0 | 0 | 0 | 0 | 12 | 27 | 0 |
| Wheat | $I_3$ | 0 | 8 | 32 | 36 | 0 | 0 | 0 | 36 |
| Grain Sorghum | $I_1$ | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 0 |
| Bermuda Grass | $I_1$ | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 |
| Total | | 0 | 20 | 44 | 65 | 0 | 23 | 65 | 65 |
| Non-Irrigated | | | | | | | | | |
| Cotton | $I_0$ | 11 | 0 | 0 | 0 | 11 | 0 | 0 | 0 |
| Alfalfa | $I_0$ | 6 | 0 | 0 | 0 | 0 | 5 | 0 | 0 |
| Wheat | $I_0$ | 0 | 0 | 0 | 0 | 26 | 14 | 0 | 0 |
| Grain Sorghum | $I_0$ | 39 | 45 | 21 | 0 | 28 | 23 | 0 | 0 |
| Other[e] | $I_0$ | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | | 65 | 45 | 21 | 0 | 65 | 42 | 0 | 0 |
| $L_3$ and $L_4$ | | | | | | | | | |
| Non-Irrigated | | | | | | | | | |
| Wheat | $I_0$ | 36 | 28 | 4 | 0 | 10 | 10 | 9 | 0 |
| Grain Sorghum | $I_0$ | 10 | 66 | 53 | 52 | 0 | 0 | 1 | 10 |
| Other[e] | $I_0$ | 137 | 89 | 126 | 131 | 173 | 173 | 173 | 173 |
| Total | | 183 | 183 | 183 | 183 | 183 | 183 | 183 | 183 |

[a]Typical farms are defined by resource situation and type in Tables II and IV of Chapter II.

[b]Land classes are defined in Table I of Chapter II.

[c]Crop irrigation levels per acre are defined in Table V of Chapter II.

[d]Farm water levels are defined in Table VI of Chapter II.

[e]Includes oats, small grain pasture, and idle cropland.

TABLE XI

PROGRAMMED CROPLAND USES AND OPTIMUM LEVELS OF WATER USE PER ACRE BY FARM WATER LEVELS, FARM D-1, AVERAGE AND BELOW AVERAGE RAINFALL[a]

| Land Classes[b] | Optimum Level[c] of Water Use Per Acre | Programmed Cropland Uses (Acres) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Average Rainfall | | | | Below Average Rainfall | | | |
| | | Farm Water Levels[d] | | | | | | | |
| | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| $L_1$ and $L_2$ | | | | | | | | | |
| Irrigated | | | | | | | | | |
| Cotton | $I_3$ | 0 | 7 | 7 | 7 | 0 | 7 | 7 | 7 |
| Alfalfa | $I_3$ | 0 | 23 | 68 | 85 | 0 | 11 | 15 | 85 |
| Wheat | $I_2$ | 0 | 0 | 0 | 0 | 0 | 20 | 0 | 0 |
| Wheat | $I_3$ | 0 | 19 | 26 | 69 | 0 | 0 | 69 | 69 |
| Grain Sorghum | $I_1$ | 0 | 0 | 0 | 0 | 0 | 57 | 49 | 0 |
| Grain Sorghum | $I_3$ | 0 | 19 | 19 | 0 | 0 | 0 | 0 | 0 |
| Bermuda Grass | $I_1$ | 0 | 0 | 0 | 2 | 0 | 0 | 4 | 2 |
| Total | | 0 | 68 | 120 | 163 | 0 | 95 | 144 | 163 |
| Non-Irrigated | | | | | | | | | |
| Cotton | $I_0$ | 7 | 0 | 0 | 0 | 7 | 0 | 0 | 0 |
| Alfalfa | $I_0$ | 6 | 0 | 43 | 0 | 0 | 0 | 0 | 0 |
| Wheat | $I_0$ | 69 | 50 | 0 | 0 | 68 | 38 | 0 | 0 |
| Grain Sorghum | $I_0$ | 81 | 45 | 0 | 0 | 88 | 30 | 19 | 0 |
| Total | | 163 | 95 | 43 | 0 | 163 | 68 | 19 | 0 |
| $L_3$ and $L_4$ | | | | | | | | | |
| Non-Irrigated | | | | | | | | | |
| Wheat | $I_0$ | 0 | 0 | 0 | 0 | 1 | 11 | 0 | 0 |
| Grain Sorghum | $I_0$ | 11 | 11 | 14 | 23 | 10 | 0 | 11 | 11 |
| Other[e] | $I_0$ | 62 | 62 | 59 | 50 | 62 | 62 | 62 | 62 |
| Total | | 73 | 73 | 73 | 73 | 73 | 73 | 73 | 73 |

[a]Typical farms are defined by resource situation and type in Tables II and IV of Chapter II.

[b]Land classes are defined in Table I of Chapter II.

[c]Crop irrigation levels per acre are defined in Table V of Chapter II.

[d]Farm water levels are defined in Table VI of Chapter II.

[e]Includes oats, small grain pasture, and idle cropland.

TABLE XII

PROGRAMMED CROPLAND USES AND OPTIMUM LEVELS OF WATER USE PER ACRE BY FARM WATER LEVELS, FARM E-1, AVERAGE AND BELOW AVERAGE RAINFALL[a]

| | | Programmed Cropland Uses (Acres) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Optimum Level[c] of Water Use | Average Rainfall | | | | Below Average Rainfall | | | |
| | | Farm Water Levels[d] | | | | | | | |
| Land Classes[b] | Per Acre | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| $L_1$ and $L_2$ | | | | | | | | | |
| Irrigated | | | | | | | | | |
| Cotton | $I_3$ | 0 | 9 | 9 | 9 | 0 | 9 | 9 | 9 |
| Alfalfa | $I_3$ | 0 | 13 | 13 | 17 | 0 | 3 | 13 | 48 |
| Wheat | $I_2$ | 0 | 0 | 0 | 0 | 0 | 34 | 29 | 0 |
| Wheat | $I_3$ | 0 | 12 | 51 | 86 | 0 | 0 | 10 | 55 |
| Grain Sorghum | $I_1$ | 0 | 0 | 0 | 0 | 0 | 1 | 34 | 0 |
| Grain Sorghum | $I_2$ | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 0 |
| Total | | 0 | 34 | 73 | 112 | 0 | 47 | 112 | 112 |
| Non-Irrigated | | | | | | | | | |
| Cotton | $I_0$ | 9 | 0 | 0 | 0 | 9 | 0 | 0 | 0 |
| Alfalfa | $I_0$ | 13 | 55 | 0 | 0 | 0 | 0 | 0 | 0 |
| Wheat | $I_0$ | 67 | 23 | 16 | 0 | 27 | 27 | 0 | 0 |
| Grain Sorghum | $I_0$ | 20 | 0 | 23 | 0 | 76 | 38 | 0 | 0 |
| Other[e] | $I_0$ | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | | 112 | 78 | 39 | 0 | 112 | 65 | 0 | 0 |
| $L_3$ and $L_4$ | | | | | | | | | |
| Non-Irrigated | | | | | | | | | |
| Wheat | $I_0$ | 19 | 19 | 19 | 0 | 59 | 25 | 47 | 31 |
| Grain Sorghum | $I_0$ | 0 | 0 | 0 | 19 | 0 | 0 | 0 | 0 |
| Other[e] | $I_0$ | 190 | 190 | 190 | 190 | 150 | 184 | 162 | 178 |
| Total | | 209 | 209 | 209 | 209 | 209 | 209 | 209 | 209 |

[a]Typical farms are defined by resource situation and type in Tables II and IV of Chapter II.

[b]Land classes are defined in Table I of Chapter II.

[c]Crop irrigation levels per acre are defined in Table V of Chapter II.

[d]Farm water levels are defined in Table VI of Chapter II.

[e]Includes oats, small grain pasture, and idle cropland.

TABLE XIII

PROGRAMMED CROPLAND USES AND OPTIMUM LEVELS OF WATER USE PER ACRE BY FARM WATER LEVELS, FARM F-1, AVERAGE AND BELOW AVERAGE RAINFALL[a]

| Land Classes[b] | Optimum Level[c] of Water Use Per Acre | Programmed Cropland Uses (Acres) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Average Rainfall | | | | Below Average Rainfall | | | |
| | | Farm Water Levels[d] | | | | | | | |
| | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| $L_1$ and $L_2$ | | | | | | | | | |
| Irrigated | | | | | | | | | |
| Cotton | $I_3$ | 0 | 26 | 26 | 26 | 0 | 26 | 26 | 26 |
| Alfalfa | $I_3$ | 0 | 55 | 126 | 129 | 0 | 4 | 1 | 128 |
| Wheat | $I_2$ | 0 | 0 | 0 | 0 | 0 | 29 | 5 | 0 |
| Wheat | $I_3$ | 0 | 11 | 38 | 147 | 0 | 0 | 129 | 147 |
| Grain Sorghum | $I_1$ | 0 | 0 | 0 | 0 | 0 | 125 | 127 | 0 |
| Forage Sorghum | $I_3$ | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Total | | 0 | 92 | 190 | 302 | 0 | 184 | 289 | 302 |
| Non-Irrigated | | | | | | | | | |
| Cotton | $I_0$ | 26 | 0 | 0 | 0 | 26 | 0 | 0 | 0 |
| Wheat | $I_0$ | 150 | 139 | 112 | 0 | 150 | 118 | 13 | 0 |
| Grain Sorghum | $I_0$ | 126 | 71 | 0 | 0 | 126 | 0 | 0 | 0 |
| Total | | 302 | 210 | 112 | 0 | 302 | 118 | 13 | 0 |
| $L_3$ and $L_4$ | | | | | | | | | |
| Non-Irrigated | | | | | | | | | |
| Wheat | $I_0$ | 159 | 159 | 159 | 162 | 159 | 162 | 162 | 162 |
| Grain Sorghum | $I_0$ | 0 | 0 | 0 | 73 | 0 | 0 | 0 | 0 |
| Other[e] | $I_0$ | 76 | 76 | 76 | 0 | 76 | 73 | 73 | 73 |
| Total | | 235 | 235 | 235 | 235 | 235 | 235 | 235 | 235 |

[a]Typical farms are defined by resource situation and type in Tables II and IV of Chapter II.

[b]Land classes are defined in Table I of Chapter II.

[c]Crop irrigation levels per acre are defined in Table V of Chapter II.

[d]Farm water levels are defined in Table VI of Chapter II.

[e]Includes oats, small grain pasture, and idle cropland.

irrigation increased, the number of acres irrigated also increased. At the high level of water availability, all of the potentially irrigable land was irrigated on all farm types and resource situations.

In general, cotton and alfalfa were the first crops to be irrigated under limited water supplies. Alfalfa was first to be irrigated on farms where the farm use value of alfalfa was higher than the market value.[1] For example, the second level of water on farm A-1 (Table VIII) was used to irrigate six acres of cotton and one acre of alfalfa on $L_1$ land and four acres of cotton and one acre of wheat on $L_2$ land. This indicated that the highest return to irrigation water was realized by irrigating one acre of alfalfa to be used in a beef cow-calf enterprise on the farm. Since another restriction limited the production of this livestock activity, cotton the next highest returning activity was irrigated on the remaining acres of $L_1$ land. The 10 acre cotton allotment exceeded the remaining six acres of $L_1$ land, therefore the remaining four acres were irrigated on $L_2$ land. The water supply was completely exhausted by irrigating one acre of wheat.

The land use pattern changed considerably as farm size increased. However, it is very difficult to project changes in land use for alternative farm water levels and differing farm sizes from results of this study. The programmed land use on any particular farm depended upon the relative proportion of $L_1$ and $L_2$ land as well as the basic acreage allotments for cotton and wheat.

---

[1]This occurred on farms A, B, and C. See Appendix G, Table I, for a summary of alfalfa produced and sold.

Farm With Feeder Cattle Enterprise

A substantial difference in land use occurred on farms F-1 and F-2 which represent two different farm types on the same basic land resource situation (compare Tables XIII and XIV). For example, more total acres were irrigated at levels 2 and 3 on farm F-2 than were irrigated at these levels on farm F-1 under average rainfall conditions. All potentially irrigable land was irrigated at level 4 on both farms. At irrigation level 3 under average rainfall conditions, 138 acres of wheat were irrigated on farm F-2 and only 38 acres were irrigated on farm F-1. Under the same conditions, 151 acres of alfalfa were irrigated on farm F-1 and only five acres were irrigated on farm F-2. Although no bermuda was irrigated on farm F-1, up to 35 acres of bermuda were irrigated on farm F-2. As the level of irrigation was increased to level 4, 81 acres of wheat were shifted from irrigated on $L_1$ land to non-irrigated on $L_3$ land. The wheat irrigated at water level 3 was replaced by irrigated alfalfa at market price at water level 4.

In general, there was very little shifting of crops between upland and bottomland as water availability changed for the farm with the feeder cattle enterprise. The only shift that took place was wheat being replaced on bottomland by more alfalfa as the available water supply increased. There were 33 acres of wheat on upland under farm irrigation level 1 and 159 acres at level 4. This shift did not occur under below average rainfall.

Farms With Dairy Enterprises

Increasing the amount of water available for irrigation beyond the second level caused no shifts in land use between upland and bottomland

TABLE XIV

PROGRAMMED CROPLAND USES AND OPTIMUM LEVELS OF WATER USE PER ACRE BY FARM WATER LEVELS, FARM F-2, AVERAGE AND BELOW AVERAGE RAINFALL[a]

| Land Classes[b] | Optimum Level[c] of Water Use Per Acre | Programmed Cropland Uses (Acres) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Average Rainfall | | | | Below Average Rainfall | | | |
| | | Farm Water Levels[d] | | | | | | | |
| | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| $L_1$ and $L_2$ | | | | | | | | | |
| Irrigated | | | | | | | | | |
| Cotton | $I_3$ | 0 | 26 | 26 | 26 | 0 | 26 | 26 | 26 |
| Alfalfa | $I_3$ | 0 | 5 | 5 | 91 | 0 | 3 | 3 | 92 |
| Wheat | $I_2$ | 0 | 0 | 0 | 0 | 0 | 51 | 107 | 0 |
| Wheat | $I_3$ | 0 | 39 | 138 | 150 | 0 | 0 | 31 | 150 |
| Grain Sorghum | $I_1$ | 0 | 0 | 0 | 0 | 0 | 68 | 92 | 0 |
| Forage Sorghum | $I_3$ | 0 | 4 | 5 | 5 | 0 | 3 | 4 | 4 |
| Bermuda Grass | $I_1$ | 0 | 26 | 35 | 30 | 0 | 4 | 27 | 30 |
| Total | | 0 | 100 | 209 | 302 | 0 | 155 | 290 | 302 |
| Non-Irrigated | | | | | | | | | |
| Cotton | $I_0$ | 26 | 0 | 0 | 0 | 26 | 0 | 0 | 0 |
| Wheat | $I_0$ | 276 | 202 | 93 | 0 | 150 | 112 | 12 | 0 |
| Grain Sorghum | $I_0$ | 0 | 0 | 0 | 0 | 96 | 0 | 0 | 0 |
| Other[e] | $I_0$ | 0 | 0 | 0 | 0 | 30 | 35 | 0 | 0 |
| Total | | 302 | 202 | 93 | 0 | 302 | 147 | 12 | 0 |
| $L_3$ and $L_4$ | | | | | | | | | |
| Non-Irrigated | | | | | | | | | |
| Wheat | $I_0$ | 33 | 68 | 78 | 159 | 159 | 146 | 159 | 159 |
| Grain Sorghum | $I_0$ | 0 | 91 | 81 | 0 | 0 | 0 | 0 | 0 |
| Forage Sorghum | $I_0$ | 37 | 0 | 0 | 0 | 54 | 0 | 0 | 0 |
| Other[e] | $I_0$ | 165 | 76 | 76 | 76 | 22 | 89 | 76 | 76 |
| Total | | 235 | 235 | 235 | 235 | 235 | 235 | 235 | 235 |

[a]Typical farms are defined by resource situation and type in Tables II and IV of Chapter II.

[b]Land classes are defined in Table I of Chapter II.

[c]Crop irrigation levels per acre are defined in Table V of Chapter II.

[d]Farm water levels are defined in Table VI of Chapter II.

[e]Includes oats, small grain pasture, and idle cropland.

on farms with dairy enterprises (Tables XV-XVII). The first increment of water resulted in a shift of all forage sorghum from $L_3$ and $L_4$ upland to $L_1$ and $L_2$ irrigated bottomland. This shift occurred for each of the three resource situations and both rainfall conditions. The crops replacing forage sorghum on the upland were wheat from $L_2$ to utilize the $L_3$ land and miscellaneous crops on $L_4$.

Rainfall conditions had some effect on the general land use pattern for these farms. More alfalfa was irrigated when average rainfall prevailed and more wheat was irrigated when below average rainfall was assumed. As total water supply increased it was profitable to shift to a higher level of water application per acre of wheat when below average rainfall was assumed. For example, as water availability was increased from level 2 to level 3 on farm C-2, the irrigated wheat enterprise shifted from 23 acres irrigated at 15 acre-inches per acre to 36 acres irrigated at 20 acre-inches per acre. Thus, increasing the farm water supply increased the acres irrigated as well as increasing the amount of water applied per acre. This shift in land use and water application occurred only when below average rainfall conditions prevailed.

Considerably more forage crops were produced and irrigated on resource situations C, D, and E considering a dairy enterprise, than on the same resource situations considering alternative beef cow-calf enterprises. For example, on resource situation E under average rainfall conditions, the farms including the beef cow-calf enterprises irrigated only 17 acres of forage and 86 acres of wheat. The same resource situation, with a dairy enterprise, irrigated 36 acres of forage and 67 acres of wheat. This comparison is made at irrigation level 4. In all cases, cotton was the most profitable crop considered for irrigation. The

TABLE XV

PROGRAMMED CROPLAND USES AND OPTIMUM LEVELS OF WATER USE PER ACRE BY FARM WATER LEVELS, FARM C-2, AVERAGE AND BELOW AVERAGE RAINFALL[a]

| Land Classes[b] | Optimum Level[c] of Water Use Per Acre | Programmed Cropland Uses (Acres): Average Rainfall, Farm Water Levels[d] 1 | 2 | 3 | 4 | Below Average Rainfall, Farm Water Levels[d] 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|
| $L_1$ and $L_2$ | | | | | | | | | |
| Irrigated | | | | | | | | | |
| Cotton | $I_3$ | 0 | 11 | 11 | 11 | 0 | 11 | 11 | 11 |
| Alfalfa | $I_3$ | 0 | 3 | 20 | 20 | 0 | 1 | 6 | 7 |
| Wheat | $I_2$ | 0 | 0 | 0 | 0 | 0 | 0 | 23 | 0 |
| Wheat | $I_3$ | 0 | 0 | 3 | 26 | 0 | 0 | 0 | 36 |
| Forage Sorghum | $I_3$ | 0 | 8 | 8 | 8 | 0 | 8 | 8 | 8 |
| Bermuda Grass | $I_1$ | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 3 |
| Total | | 0 | 22 | 42 | 65 | 0 | 22 | 49 | 65 |
| Non-Irrigated | | | | | | | | | |
| Cotton | $I_0$ | 11 | 0 | 0 | 0 | 11 | 0 | 0 | 0 |
| Alfalfa | $I_0$ | 20 | 17 | 0 | 0 | 11 | 0 | 0 | 0 |
| Wheat | $I_0$ | 34 | 26 | 23 | 0 | 36 | 26 | 3 | 0 |
| Forage Sorghum | $I_0$ | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| Other[e] | $I_0$ | 0 | 0 | 0 | 0 | 4 | 17 | 13 | 0 |
| Total | | 65 | 43 | 23 | 0 | 65 | 43 | 16 | 0 |
| $L_3$ and $L_4$ | | | | | | | | | |
| Non-Irrigated | | | | | | | | | |
| Wheat | $I_0$ | 2 | 10 | 10 | 10 | 0 | 10 | 10 | 0 |
| Forage Sorghum | $I_0$ | 53 | 0 | 0 | 0 | 61 | 0 | 0 | 0 |
| Other[e] | $I_0$ | 128 | 173 | 173 | 173 | 122 | 173 | 173 | 183 |
| Total | | 183 | 183 | 183 | 183 | 183 | 183 | 183 | 183 |

[a]Typical farms are defined by resource situation and type in Tables II and IV of Chapter II.

[b]Land classes are defined in Table I of Chapter II.

[c]Crop irrigation levels per acre are defined in Table V of Chapter II.

[d]Farm water levels are defined in Table VI of Chapter II.

[e]Includes oats, small grain pasture, and idle cropland.

TABLE XVI

PROGRAMMED CROPLAND USES AND OPTIMUM LEVELS OF WATER USE PER ACRE BY FARM WATER LEVELS, FARM D-2, AVERAGE AND BELOW AVERAGE RAINFALL[a]

| Land Classes[b] | Optimum Level of Water Use Per Acre[c] | Programmed Cropland Uses (Acres): Average Rainfall, Farm Water Levels[d] 1 | 2 | 3 | 4 | Below Average Rainfall, Farm Water Levels[d] 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|
| $L_1$ and $L_2$ | | | | | | | | | |
| Irrigated | | | | | | | | | |
| Cotton | $I_3$ | 0 | 7 | 7 | 7 | 0 | 7 | 7 | 7 |
| Alfalfa | $I_3$ | 0 | 39 | 89 | 90 | 0 | 39 | 68 | 81 |
| Wheat | $I_2$ | 0 | 0 | 0 | 0 | 0 | 0 | 33 | 0 |
| Wheat | $I_3$ | 0 | 0 | 0 | 58 | 0 | 0 | 0 | 69 |
| Forage Sorghum | $I_3$ | 0 | 6 | 8 | 8 | 0 | 7 | 7 | 6 |
| Total | | 0 | 52 | 104 | 163 | 0 | 53 | 115 | 163 |
| Non-Irrigated | | | | | | | | | |
| Cotton | $I_0$ | 7 | 0 | 0 | 0 | 7 | 0 | 0 | 0 |
| Alfalfa | $I_0$ | 20 | 53 | 1 | 0 | 17 | 22 | 0 | 0 |
| Wheat | $I_0$ | 69 | 58 | 58 | 0 | 69 | 69 | 36 | 0 |
| Forage Sorghum | $I_0$ | 42 | 0 | 0 | 0 | 43 | 0 | 0 | 0 |
| Other[e] | $I_0$ | 25 | 0 | 0 | 0 | 27 | 19 | 12 | 0 |
| Total | | 163 | 111 | 59 | 0 | 163 | 110 | 48 | 0 |
| $L_3$ and $L_4$ | | | | | | | | | |
| Non-Irrigated | | | | | | | | | |
| Wheat | $I_0$ | 0 | 11 | 11 | 11 | 0 | 0 | 0 | 0 |
| Forage Sorghum | $I_0$ | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 |
| Other[e] | $I_0$ | 73 | 62 | 62 | 62 | 62 | 73 | 73 | 73 |
| Total | | 73 | 73 | 73 | 73 | 73 | 73 | 73 | 73 |

[a]Typical farms are defined by resource situation and type in Tables II and IV of Chapter II.

[b]Land classes are defined in Table I of Chapter II.

[c]Crop irrigation levels per acre are defined in Table V of Chapter II.

[d]Farm water levels are defined in Table VI of Chapter II.

[e]Includes oats, small grain pasture, and idle cropland.

TABLE XVII

PROGRAMMED CROPLAND USES AND OPTIMUM LEVELS OF WATER USE PER ACRE BY FARM WATER LEVELS, FARM E-2, AVERAGE AND BELOW AVERAGE RAINFALL[a]

| Land Classes[b] | Optimum Level[c] of Water Use Per Acre | Programmed Cropland Uses (Acres) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Average Rainfall | | | | Below Average Rainfall | | | |
| | | Farm Water Levels[d] | | | | | | | |
| | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| $L_1$ and $L_2$ | | | | | | | | | |
| Irrigated | | | | | | | | | |
| Cotton | $I_3$ | 0 | 9 | 9 | 9 | 0 | 9 | 9 | 9 |
| Alfalfa | $I_3$ | 0 | 21 | 28 | 28 | 0 | 10 | 13 | 15 |
| Wheat | $I_2$ | 0 | 0 | 0 | 0 | 0 | 0 | 45 | 0 |
| Wheat | $I_3$ | 0 | 0 | 27 | 67 | 0 | 0 | 0 | 67 |
| Forage Sorghum | $I_3$ | 0 | 4 | 4 | 4 | 0 | 20 | 20 | 20 |
| Bermuda Grass | $I_1$ | 0 | 0 | 4 | 4 | 0 | 0 | 0 | 1 |
| Total | | 0 | 34 | 72 | 112 | 0 | 39 | 87 | 112 |
| Non-Irrigated | | | | | | | | | |
| Cotton | $I_0$ | 9 | 0 | 0 | 0 | 9 | 0 | 0 | 0 |
| Alfalfa | $I_0$ | 4 | 0 | 0 | 0 | 99 | 0 | 0 | 0 |
| Wheat | $I_0$ | 86 | 67 | 40 | 0 | 0 | 67 | 22 | 0 |
| Forage Sorghum | $I_0$ | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 |
| Other[e] | $I_0$ | 13 | 11 | 0 | 0 | 0 | 6 | 3 | 0 |
| Total | | 112 | 78 | 40 | 0 | 112 | 73 | 25 | 0 |
| $L_3$ and $L_4$ | | | | | | | | | |
| Non-Irrigated | | | | | | | | | |
| Wheat | $I_0$ | 0 | 19 | 19 | 19 | 0 | 19 | 19 | 19 |
| Forage Sorghum | $I_0$ | 209 | 0 | 0 | 0 | 166 | 0 | 0 | 0 |
| Other[e] | $I_0$ | 0 | 190 | 190 | 190 | 43 | 190 | 190 | 190 |
| Total | | 209 | 209 | 209 | 209 | 209 | 209 | 209 | 209 |

[a]Typical farms are defined by resource situation and type in Tables II and IV of Chapter II.

[b]Land classes are defined in Table I of Chapter II.

[c]Crop irrigation levels per acre are defined in Table V of Chapter II.

[d]Farm water levels are defined in Table VI of Chapter II.

[e]Includes oats, small grain pasture, and idle cropland.

entire cotton allotment was irrigated at the first irrigation level on $L_1$ land.

## Programmed Livestock Numbers

Increasing the quantity of water available for irrigation did not increase the number of cows included in the optimum farm organization for any resource situation (Table XVIII). However, there were resource situations where cow numbers included in optimum farm organizations decreased as water availability increased considering average rainfall conditions. For example, on farm C-1, the first increment of water resulted in a decrease of three cows and a shifting of an additional three cows to an alternative fall calving cow-calf enterprise. This shift to an alternative cow-calf enterprise resulted from competition for spring labor between irrigated crops and a spring calving cow-calf enterprise.

Farm E-1 is an example of a resource situation where the size of the cow herd remained the same at each level of water supply. However, the size of the fall calving enterprise increased and spring calving decreased at higher levels of water availability.

The results obtained when considering below average rainfall were somewhat different. Farm C-1 showed an increase in the number of cows as water became more readily available; thus, irrigation provided additional forage to supplement the low producing rangeland during below average rainfall years. Even at the highest level of irrigation, livestock production was considerably below the dryland situation for average rainfall conditions. Although irrigated grazing activities were considered in the programming tableau, these activities were never included in any of the optimum farm plans. Thus, the returns from irrigated grazing

TABLE XVIII

PROGRAMMED LIVESTOCK ENTERPRISES BY FARM WATER LEVELS AND FARM SIZE AND TYPE, AVERAGE AND BELOW AVERAGE RAINFALL[a]

| Farm and Enterprise | Unit | Average Rainfall | | | | Below Average Rainfall | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Farm Water Levels[b] | | | | | | | |
| | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Farm A-1 | | | | | | | | | |
| Cow-Calf[c] | Cow-Units[g] | 11 | 11 | 11 | 11 | 6 | 6 | 6 | 6 |
| Farm B-1 | | | | | | | | | |
| Cow-Calf[c] | Cow-Units[g] | 14 | 14 | 14 | 14 | 9 | 9 | 9 | 9 |
| Farm C-1 | | | | | | | | | |
| Cow-Calf[c] | Cow-Units[g] | 27 | 21 | 14 | 13 | 14 | 15 | 16 | 18 |
| Cow-Calf[d] | Cow-Units[g] | 0 | 3 | 10 | 11 | 0 | 0 | 0 | 0 |
| Farm C-2 | | | | | | | | | |
| Dairy | Cow-Units[h] | 23 | 23 | 23 | 23 | 17 | 23 | 22 | 21 |
| Farm D-1 | | | | | | | | | |
| Cow-Calf[c] | Cow-Units[g] | 27 | 27 | 27 | 24 | 16 | 16 | 22 | 15 |
| Cow-Calf[d] | Cow-Units[g] | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 4 |
| Farm D-2 | | | | | | | | | |
| Dairy | Cow-Units[h] | 23 | 23 | 23 | 23 | 19 | 23 | 20 | 17 |
| Farm E-1 | | | | | | | | | |
| Cow-Calf[c] | Cow-Units[g] | 79 | 76 | 72 | 68 | 50 | 50 | 50 | 46 |
| Cow-Calf[d] | Cow-Units[g] | 0 | 3 | 7 | 11 | 0 | 0 | 0 | 4 |
| Farm E-2 | | | | | | | | | |
| Dairy | Cow-Units[h] | 66 | 66 | 66 | 66 | 44 | 54 | 54 | 54 |
| Farm F-1 | | | | | | | | | |
| Cow-Calf[c] | Cow-Units[g] | 110 | 110 | 110 | 110 | 60 | 64 | 11 | 9 |
| Cow-Calf[d] | Cow-Units[g] | 0 | 0 | 0 | 0 | 9 | 5 | 46 | 48 |
| Farm F-2 | | | | | | | | | |
| Cow-Calf[c] | Cow-Units[g] | 69 | 69 | 69 | 69 | 0 | 48 | 46 | 46 |
| Cow-Calf[d] | Cow-Units[g] | 0 | 0 | 0 | 0 | 56 | 0 | 0 | 0 |
| Feeders[e] | Number | 139 | 137 | 164 | 149 | 67 | 84 | 111 | 121 |
| Feeders[f] | Number | 47 | 106 | 127 | 115 | 23 | 31 | 84 | 92 |

[a]Typical farms are defined by resource situation and type in Tables II and IV of Chapter II.

[b]Farm water levels are defined in Table VI of Chapter II.

(Continued)

TABLE XVIII (continued)

[c]Calving in March, selling good-choice feeder calves October 1, off native range; non-creep feeding, winter ration of alfalfa hay and range.

[d]Calving in November, selling good-choice feeder calves July 20; non-creep feeding, winter ration of range, forage sorghum silage, and cottonseed cake.

[e]Feeders purchased in October, wintered on small grain pasture with forage sorghum and cottonseed cake when off small grain; sold off grazed out small grain May 15.

[f]Feeders purchased in April, grazed through summer on midland bermuda range; sold off midland bermuda range October 15.

[g]Cow-units are numbers of cows in herd that include a bull, replacement heifers, and calves during spring and summer.

[h]Cow-units are number of dairy cows in herd that include a bull and replacement heifers.

enterprises were low relative to other land using production alternatives.

Increasing water availability had no effect on the size of the dairy herd under average rainfall conditions. However, the amount of water available for irrigation did effect the herd size assuming below average rainfall conditions. For example, on farms C-2 and D-2, the size of the dairy herd increased with the first level of irrigation and then decreased with increases in water availability to levels 2 and 3. This implies that water was more limiting than labor at the first level of irrigation. As water became more readily available, additional acreages of irrigated crops yielding a greater return to labor replaced part of the dairy herd. Thus, when labor became the most limiting resource, irrigated crops reduced the number of dairy cows included in the optimum farm organization.

Irrigation had more effect on the number of feeder cattle in the optimum farm organization than upon the size of the beef cow-calf enterprise. This occurred because the basic feed requirement of feeder cattle was alfalfa, sorghum, and other forage rather than grazing native pasture. Since the forages utilized by feeder cattle were included as irrigated activities in the programming tableau, the number of feeder cattle in a final optimum farm organization were directly related to the availability of irrigation water.

## Resource Requirements and Income

### Farms With Beef Cow-Calf Enterprises

Total labor and capital requirements and gross and net farm income increased for all farms with beef cow-calf enterprises as water supply per farm increased (Tables XIX-XXIV).

Labor and Non-Land Capital Investment. Family labor provided the additional labor required to irrigate farms A-1, B-1, and C-1 for all levels of irrigation and both rainfall conditions. The increase in family labor requirement for irrigation ranged from 330 hours to 811 hours for average rainfall conditions and 395 hours to 865 hours for below average rainfall conditions (Tables XIX-XXIV).

Farms D-1, E-1, and F-1 required hired labor in addition to the family labor supply for one or more of the irrigation levels even though the total annual family labor supply was not completely utilized. This situation was apparent for both rainfall conditions. The increase in total labor requirement ranged from 644 hours on farm E-1 to 1,979 hours on farm F-1 for average rainfall conditions. Slightly more labor was required for below average rainfall conditions.

The quantity of labor required per farm was directly related to farm size. That is, as farm size increased, the total labor requirement as well as hired labor, increased. For example, the total labor required for farm A-1 was 707 hours with no hired labor required. However, on farm F-1, the total labor required was 4,803 hours with 2,431 hours of labor hired.

Non-land capital requirements increased considerably for all farms in this group as quantities of water per farm increased. The largest incremental increase occurred from irrigation level 1 to irrigation level 2. Although the percentage increases in non-land capital requirements were somewhat lower on the larger farms (resource situations E and F), the absolute increases on these farms were much greater.

TABLE XIX

PROGRAMMED RESOURCE REQUIREMENTS AND INCOME BY FARM WATER LEVELS, FARM A-1, AVERAGE AND BELOW AVERAGE RAINFALL[a]

| Item | Average Rainfall | | | | Below Average Rainfall | | | |
|---|---|---|---|---|---|---|---|---|
| | Farm Water Levels[b] | | | | | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Total Water Used, Acre Feet | 0 | 18.75 | 37.50 | 56.25 | 0 | 24.00 | 48.00 | 72.00 |
| Labor Required: | | | | | | | | |
| Hired, Hours | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Family, Hours | 377 | 489 | 603 | 707 | 253 | 504 | 536 | 648 |
| Total, Hours | 377 | 489 | 603 | 707 | 253 | 504 | 536 | 648 |
| Capital Required, Dollars[c] | 3,150 | 5,040 | 5,297 | 5,686 | 1,995 | 3,680 | 4,285 | 4,720 |
| Gross Farm Income, Dollars[d] | 3,241 | 4,730 | 5,465 | 6,365 | 1,921 | 3,687 | 4,663 | 5,606 |
| Net Farm Income, Dollars[e] | 1,767 | 2,138 | 2,393 | 2,595 | 948 | 1,449 | 1,902 | 2,037 |
| Changes in Net Farm Income: | | | | | | | | |
| From No Irrigation, Dollars | 0 | 371 | 626 | 828 | 0 | 501 | 954 | 1,089 |
| From Preceding Level of Irrigation, Dollars | 0 | 371 | 255 | 202 | 0 | 501 | 453 | 135 |
| Marginal Returns Per Acre Foot of Water:[f] | | | | | | | | |
| From No Irrigation, Dollars | 0 | 19.79 | 16.69 | 14.72 | 0 | 20.88 | 19.88 | 15.12 |
| From Preceding Level of Irrigation, Dollars | 0 | 19.79 | 13.60 | 10.77 | 0 | 20.88 | 18.88 | 5.62 |

[a]Typical farms are defined by resource situation and type in Tables II and IV of Chapter II.
[b]Farm water levels are defined in Table VI of Chapter II.
[c]Includes all capital required except investment in land.
[d]Total value of all products produced on the farm.
[e]Returns to land, family labor, risk, and management.
[f]Marginal returns to water, family labor, risk, and management associated with irrigation.

TABLE XX

PROGRAMMED RESOURCE REQUIREMENTS AND INCOME BY FARM WATER LEVELS, FARM B-1, AVERAGE AND BELOW AVERAGE RAINFALL[a]

| | Average Rainfall | | | | Below Average Rainfall | | | |
|---|---|---|---|---|---|---|---|---|
| | Farm Water Levels[b] | | | | | | | |
| Item | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Total Water Used, Acre Feet | 0 | 41.50 | 83.00 | 124.50 | 0 | 53.17 | 106.34 | 159.51 |
| Labor Required: | | | | | | | | |
| Hired, Hours | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Family, Hours | 523 | 764 | 1,102 | 1,334 | 404 | 700 | 1,019 | 1,269 |
| Total, Hours | 523 | 764 | 1,102 | 1,334 | 404 | 700 | 1,019 | 1,269 |
| Capital Required, Dollars[c] | 4,494 | 8,556 | 8,989 | 9,950 | 3,280 | 7,380 | 8,405 | 9,355 |
| Gross Farm Income, Dollars[d] | 5,187 | 8,385 | 9,875 | 11,890 | 3,315 | 7,026 | 9,163 | 11,220 |
| Net Farm Income, Dollars[e] | 3,147 | 3,703 | 4,237 | 4,680 | 1,633 | 2,650 | 3,663 | 3,978 |
| Changes in Net Farm Income: | | | | | | | | |
| From No Irrigation, Dollars | 0 | 556 | 1,090 | 1,533 | 0 | 1,017 | 2,030 | 2,345 |
| From Preceding Level of Irrigation, Dollars | 0 | 556 | 534 | 443 | 0 | 1,017 | 1,013 | 315 |
| Marginal Returns Per Acre Foot of Water:[f] | | | | | | | | |
| From No Irrigation, Dollars | 0 | 13.40 | 13.13 | 12.31 | 0 | 19.13 | 19.09 | 14.70 |
| From Preceding Level of Irrigation, Dollars | 0 | 13.40 | 12.87 | 10.67 | 0 | 19.13 | 19.05 | 5.92 |

[a]Typical farms are defined by resource situation and type in Tables II and IV of Chapter II.
[b]Farm water levels are defined in Table VI of Chapter II.
[c]Includes all capital required except investment in land.
[d]Total value of all products produced on the farm.
[e]Returns to land, family labor, risk, and management.
[f]Marginal returns to water, family labor, risk, and management associated with irrigation.

## TABLE XXI

### PROGRAMMED RESOURCE REQUIREMENTS AND INCOME BY FARM WATER LEVELS, FARM C-1, AVERAGE AND BELOW AVERAGE RAINFALL[a]

| Item | Average Rainfall | | | | Below Average Rainfall | | | |
|---|---|---|---|---|---|---|---|---|
| | Farm Water Levels[b] | | | | | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Total Water Used, Acre Feet | 0 | 30.10 | 60.20 | 90.30 | 0 | 38.92 | 77.84 | 116.76 |
| Labor Required: | | | | | | | | |
| Hired, Hours | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Family, Hours | 1,027 | 1,507 | 1,581 | 1,772 | 418 | 851 | 882 | 1,080 |
| Total, Hours | 1,027 | 1,507 | 1,581 | 1,772 | 418 | 851 | 882 | 1,080 |
| Capital Required, Dollars[c] | 8,442 | 10,842 | 11,458 | 12,027 | 4,080 | 7,264 | 8,065 | 8,855 |
| Gross Farm Income, Dollars[d] | 6,946 | 8,915 | 9,750 | 11,120 | 3,320 | 5,588 | 7,080 | 8,262 |
| Net Farm Income, Dollars | 3,506 | 3,890 | 4,250 | 4,565 | 1,745 | 2,270 | 2,996 | 3,302 |
| Changes in Net Farm Income: | | | | | | | | |
| From No Irrigation, Dollars | 0 | 384 | 744 | 1,059 | 0 | 525 | 1,251 | 1,557 |
| From Preceding Level of Irrigation, Dollars | 0 | 384 | 360 | 315 | 0 | 525 | 726 | 306 |
| Marginal Returns Per Acre Foot of Water:[f] | | | | | | | | |
| From No Irrigation, Dollars | 0 | 12.76 | 12.36 | 11.73 | 0 | 13.49 | 16.67 | 13.34 |
| From Preceding Level of Irrigation, Dollars | 0 | 12.76 | 11.96 | 10.47 | 0 | 13.49 | 18.65 | 7.86 |

[a] Typical farms are defined by resource situation and type in Tables II and IV of Chapter II.
[b] Farm water levels are defined in Table VI of Chapter II.
[c] Includes all capital required except investment in land.
[d] Total value of all products produced on the farm.
[e] Returns to land, family labor, risk, and management.
[f] Marginal returns to water, family labor, risk, and management associated with irrigation.

TABLE XXII

PROGRAMMED RESOURCE REQUIREMENTS AND INCOME BY FARM WATER LEVELS, FARM D-1, AVERAGE AND BELOW AVERAGE RAINFALL[a]

| | Average Rainfall | | | | Below Average Rainfall | | | |
|---|---|---|---|---|---|---|---|---|
| | Farm Water Levels[b] | | | | | | | |
| Item | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Total Water Used, Acre Feet | 0 | 76.00 | 152.00 | 228.00 | 0 | 98.58 | 197.16 | 295.74 |
| Labor Required: | | | | | | | | |
| Hired, Hours | 0 | 0 | 70 | 283 | 0 | 0 | 26 | 305 |
| Family, Hours | 1,044 | 1,424 | 1,849 | 1,955 | 739 | 1,285 | 1,824 | 1,983 |
| Total, Hours | 1,044 | 1,424 | 1,919 | 2,238 | 739 | 1,285 | 1,850 | 2,288 |
| Capital Required, Dollars[c] | 8,570 | 16,306 | 17,963 | 19,385 | 5,735 | 13,670 | 15,778 | 17,215 |
| Gross Farm Income, Dollars[d] | 9,130 | 13,282 | 17,705 | 20,210 | 5,348 | 10,600 | 13,630 | 18,570 |
| Net Farm Income, Dollars[e] | 5,563 | 5,795 | 6,846 | 7,620 | 2,702 | 3,970 | 5,367 | 6,220 |
| Changes in Net Farm Income: | | | | | | | | |
| From No Irrigation, Dollars | 0 | 232 | 1,283 | 2,057 | 0 | 1,268 | 2,665 | 3,518 |
| From Preceding Level of Irrigation, Dollars | 0 | 232 | 1,051 | 774 | 0 | 1,263 | 1,396 | 853 |
| Marginal Returns Per Acre Foot of Water:[f] | | | | | | | | |
| From No Irrigation, Dollars | 0 | 3.05 | 8.44 | 9.02 | 0 | 12.86 | 13.52 | 11.90 |
| From Preceding Level of Irrigation, Dollars | 0 | 3.05 | 13.83 | 10.18 | 0 | 12.86 | 14.17 | 8.65 |

[a]Typical farms are defined by resource situation and type in Tables II and IV of Chapter II.
[b]Farm water levels are defined in Table VI of Chapter II.
[c]Includes all capital required except investment in land.
[d]Total value of all products produced on the farm.
[e]Returns to land, family labor, risk, and management.
[f]Marginal returns to water, family labor, risk, and management associated with irrigation.

TABLE XXIII

PROGRAMMED RESOURCE REQUIREMENTS AND INCOME BY FARM WATER LEVELS, FARM E-1, AVERAGE AND BELOW AVERAGE RAINFALL[a]

| Item | Average Rainfall | | | | Below Average Rainfall | | | |
|---|---|---|---|---|---|---|---|---|
| | Farm Water Levels[b] | | | | | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Total Water Used, Acre Feet | 0 | 49.25 | 98.50 | 147.75 | 0 | 67.42 | 134.84 | 202.26 |
| Labor Required: | | | | | | | | |
| Hired, Hours | 92 | 127 | 290 | 434 | 0 | 0 | 0 | 168 |
| Family, Hours | 1,676 | 1,703 | 1,892 | 1,978 | 1,070 | 1,358 | 1,773 | 1,866 |
| Total, Hours | 1,768 | 1,830 | 2,182 | 2,412 | 1,070 | 1,358 | 1,773 | 2,034 |
| Capital Required, Dollars[c] | 20,190 | 24,425 | 25,133 | 25,860 | 12,920 | 14,575 | 18,290 | 19,350 |
| Gross Farm Income, Dollars[d] | 13,471 | 16,115 | 17,525 | 19,050 | 9,470 | 10.405 | 13,402 | 15,500 |
| Net Farm Income, Dollars[e] | 8,075 | 8,355 | 8,835 | 9,270 | 4,737 | 5,040 | 6,222 | 6,635 |
| Changes in Net Farm Income: | | | | | | | | |
| From No Irrigation, Dollars | 0 | 280 | 760 | 1,195 | 0 | 303 | 1,485 | 1,898 |
| From Preceding Level of Irrigation, Dollars | 0 | 280 | 480 | 435 | 0 | 303 | 1,182 | 413 |
| Marginal Returns Per Acre Foot of Water:[f] | | | | | | | | |
| From No Irrigation, Dollars | 0 | 5.69 | 7.71 | 8.12 | 0 | 4.49 | 11.01 | 9.38 |
| From Preceding Level of Irrigation, Dollars | 0 | 5.69 | 9.75 | 8.83 | 0 | 4.49 | 17.53 | 6.13 |

[a]Typical farms are defined by resource situation and type in Tables II and IV of Chapter II.
[b]Farm water levels are defined in Table VI of Chapter II.
[c]Includes all capital required except investment in land.
[d]Total value of all products produced on the farm.
[e]Returns to land, family labor, risk, and management.
[f]Marginal returns to water, family labor, risk, and management associated with irrigation.

TABLE XXIV

PROGRAMMED RESOURCE REQUIREMENTS AND INCOME BY FARM WATER LEVELS, FARM F-1, AVERAGE AND BELOW AVERAGE RAINFALL[a]

| Item | Average Rainfall | | | | Below Average Rainfall | | | |
|---|---|---|---|---|---|---|---|---|
| | Farm Water Levels[b] | | | | | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Total Water Used, Acre Feet | 0 | 140.16 | 280.32 | 420.48 | 0 | 181.75 | 363.50 | 545.25 |
| Labor Required: | | | | | | | | |
| Hired, Hours | 462 | 1,108 | 1,885 | 2,431 | 0 | 915 | 1,176 | 2,048 |
| Family, Hours | 2,362 | 2,094 | 2,153 | 2,372 | 2,034 | 2,043 | 2,236 | 2,274 |
| Total, Hours | 2,824 | 3,202 | 4,038 | 4,803 | 2,034 | 2,958 | 3,412 | 4,322 |
| Capital Required, Dollars[c] | 30,010 | 43,000 | 45,845 | 47,775 | 23,790 | 30,295 | 33,160 | 37,515 |
| Gross Farm Income, Dollars[d] | 26,955 | 35,360 | 42,875 | 47,020 | 17,585 | 27,058 | 31,307 | 40,458 |
| Net Farm Income, Dollars[e] | 16,190 | 16,850 | 18,323 | 19,600 | 9,050 | 11,379 | 13,337 | 14,634 |
| Changes in Net Farm Income: | | | | | | | | |
| From No Irrigation, Dollars | 0 | 660 | 2,133 | 3,410 | 0 | 2,328 | 4,387 | 5,584 |
| From Preceding Level of Irrigation, Dollars | 0 | 660 | 1,473 | 1,277 | 0 | 2,328 | 1,958 | 1,298 |
| Marginal Returns Per Acre Foot of Water:[f] | | | | | | | | |
| From No Irrigation, Dollars | 0 | 4.71 | 7.61 | 8.11 | 0 | 12.81 | 12.59 | 10.24 |
| From Preceding Level of Irrigation, Dollars | 0 | 4.71 | 10.51 | 9.11 | 0 | 12.81 | 10.77 | 7.14 |

[a]Typical farms are defined by resource situation and type in Tables II and IV of Chapter II.
[b]Farm water levels are defined in Table VI of Chapter II.
[c]Includes all capital required except investment in land.
[d]Total value of all products produced on the farm.
[e]Returns to land, family labor, risk, and management.
[f]Marginal returns to water, family labor, risk, and management associated with irrigation.

The non-land capital requirements on farm A-1 increased from $3,150 for irrigation level 1 to $5,686 for irrigation level 4. The capital requirements for irrigation level 2 were $5,040 (Table XIX). Thus, the largest increase in capital requirements occurred as irrigation was first introduced, reflecting the investment in the irrigation equipment. Thereafter, only slight increases were observed as irrigation levels 3 and 4 were added. The largest percentage increase in capital requirements was 126 per cent on farm D-1 with an absolute increase of $10,815. However, the largest absolute increase occurred on farm F-1 where an increase of $17,765 occurred (59 per cent greater than the non-irrigated level).

Levels of Income. Net returns increased with each additional increment of water for all farms and rainfall conditions (Tables XIX-XXIV).[2] However, the increase in net returns from the preceding water level for the second and third increments of water was less than the first increment on farms A-1, B-1, and C-1 for average rainfall and on farms A-1, B-1, and F-1 for below average rainfall. For example, on farm A-1 (Table XIX), the first increment of water added $371 to net income. Then, as second and third increments were added, the increase in net returns from the preceding level dropped to $255 and $202, respectively. The same general relation held for below average rainfall conditions on this farm.

This relationship did not exist for farms D-1, E-1, and F-1 for average rainfall and farms C-1, D-1, and E-1 for below average rainfall. On these farms, the increase in net returns was greater for the second increment of water than for the first level. Then the net returns declined

---

[2]Water delivery costs from source of supply to farm were not included in the programming models.

for the third level. For example, on farm D-1 (Table XXII), the increase in net returns from irrigation level 1 to irrigation level 2 was $232. With the addition of irrigation level 3, net returns increased by $1,051 over the previous level. The addition of irrigation level 4 increased net returns by $774. On these farms the second and third increments of water were worth more than the first because of the inefficient use of the irrigation equipment at irrigation level 2.

The marginal returns per acre foot of water from the preceding irrigation level declined with each additional increment of water for only three of the six farms in this group. For the remaining three farms, the marginal returns per acre foot of water from the preceding level increased as the second increment of water was added and decreased as the third increment was added. On these farms, the second increment was worth more than the first because of the inefficient use of irrigation equipment at farm water level 2. Since the irrigation system for a particular resource situation was designed to efficiently irrigate all its irrigable land at level 3, the fixed cost per acre was extremely high for the relatively small number of acres irrigated at level 2.

However, when the total fixed costs of the irrigation equipment were not considered, the marginal returns per acre foot of water from the preceding farm water level declined with increases in water availability.[3] This condition occurred for all resource situations with beef cow-calf enterprises.

---

[3]The total fixed costs of irrigation equipment were subtracted from the programmed results which included these items. Marginal returns per acre foot of water from the preceding level are presented in Appendix G, Table II.

The land resource situations of the six typical farms were defined to permit a comparison of the effects on net farm income of alternative combinations of bottomland cropland and total cropland. Thus, it was possible to evaluate the relative magnitude of the change in returns due to scale relationships as compared to changes in the amount of bottomland cropland. This comparison is made under dryland conditions only and excludes all comparisons with alternative farm water levels.

Generally, increasing acres of bottomland had a greater impact on net returns than did other increases in farm size. The results were similar for both rainfall conditions. By comparing the net returns of farm A-1 with farm B-1, it was possible to evaluate the effect of increasing bottomland by 124 per cent with total cropland remaining nearly constant. For average rainfall, the increase in net returns associated with this land resource change is 78 per cent, and for below average rainfall, the increase in net returns is 72 per cent.[4] However, by comparing farm B-1 with farm C-1, it was possible to evaluate the effects of increasing farm size while keeping acres of bottomland nearly constant. The increase in net returns associated with a 119 per cent increase in farm size was only seven and 11 per cent for below average and average rainfall conditions, respectively. Comparisons similar to those above are difficult to make for farms E-1 and F-1 since all factors such as cropland, rangeland, and bottomland increase simultaneously.

Farm With Feeder Cattle Enterprise

Total labor and capital requirements and gross and net farm income

---

[4]Net returns to land, family labor, risk, and management.

increased for farm F-2 as the water supply increased (Table XXV). Although net farm income increased as more water became available, it increased at a decreasing rate. Marginal returns per acre foot of water from the preceding level decreased as additional water became available.

Labor and Non-Land Capital Investment. This farm type, which included alternative feeder enterprises as production activities hired a major portion of the labor required for irrigation. The total labor requirements for irrigation level 4 with average rainfall conditions were 5,146 hours. This was 2,580 hours greater than the non-irrigated plan and required 2,249 hours of hired labor.

Non-land capital requirements increased $12,115 under average rainfall conditions and $23,545 when below average rainfall conditions prevailed.

Comparing farm F-1 (Table XXIV) with farm F-2 (Table XXV) provided an opportunity to analyze the effect of changes in farm type on resource requirements and income. The labor requirements and non-land capital requirements are somewhat higher on farm F-2 than on farm F-1. For example, the capital requirements were $47,775 on farm F-1 and $56,625 on farm F-2 assuming farm water level 4 and average rainfall conditions.

Levels of Income. Net farm income increased and marginal returns per acre foot of water from the preceding level decreased on farm F-2 as farm irrigation levels increased. Net farm income increased from $17,500 for the non-irrigated plan to $22,211 for the irrigated program at level 4 for average rainfall conditions. With the same conditions prevailing, the marginal returns per acre foot of water from the preceding level decreased from $14.32 when the first increment was added to $8.06 when the third increment was added.

TABLE XXV

PROGRAMMED RESOURCE REQUIREMENTS AND INCOME BY FARM WATER LEVELS, FARM F-2, AVERAGE AND BELOW AVERAGE RAINFALL[a]

| Item | Average Rainfall | | | | Below Average Rainfall | | | |
|---|---|---|---|---|---|---|---|---|
| | Farm Water Levels[b] | | | | | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Total Water Used, Acre Feet | 0 | 137.25 | 274.50 | 411.75 | 0 | 179.25 | 358.50 | 537.75 |
| Labor Required: | | | | | | | | |
| Hired, Hours | 499 | 1,215 | 1,998 | 2,748 | 136 | 820 | 1,943 | 2,719 |
| Family, Hours | 2,067 | 2,300 | 2,398 | 2,398 | 1,922 | 2,173 | 2,398 | 2,398 |
| Total, Hours | 2,566 | 3,515 | 4,396 | 5,146 | 2,058 | 2,993 | 4,341 | 5,117 |
| Capital Required, Dollars[c] | 44,510 | 50,570 | 55,265 | 56,625 | 26,125 | 37,515 | 45,405 | 49,670 |
| Gross Farm Income, Dollars[d] | 50,675 | 66,260 | 76,880 | 81,346 | 29,655 | 41,545 | 59,012 | 68,965 |
| Net Farm Income, Dollars[e] | 17,500 | 19,465 | 21,105 | 22,211 | 10,505 | 12,512 | 15,377 | 16,817 |
| Changes in Net Farm Income: | | | | | | | | |
| From No Irrigation, Dollars | 0 | 1,965 | 3,605 | 4,711 | 0 | 2,007 | 4,872 | 6,312 |
| From Preceding Level of Irrigation, Dollars | 0 | 1,965 | 1,640 | 1,106 | 0 | 2,007 | 2,865 | 1,440 |
| Marginal Returns Per Acre Foot of Water:[f] | | | | | | | | |
| From No Irrigation, Dollars | 0 | 14.32 | 13.13 | 11.44 | 0 | 11.20 | 13.60 | 11.74 |
| From Preceding Level of Irrigation, Dollars | 0 | 14.32 | 11.95 | 8.06 | 0 | 11.20 | 15.98 | 8.03 |

[a]Typical farms are defined by resource situation and type in Tables II and IV of Chapter II.
[b]Farm water levels are defined in Table VI of Chapter II.
[c]Includes all capital required except investment in land.
[d]Total value of all products produced on the farm.
[e]Returns to land, family labor, risk, and management.
[f]Marginal returns to water, family labor, risk, and management associated with irrigation.

Farms With Dairy Enterprises

Total labor and capital requirements and gross and net farm income increased for the three farms with dairy enterprises as the water supply was increased (Tables XXVI-XXVIII).

Labor and Non-Land Capital Investment. The resource situation of these farms was the same as farms C-1, D-1, and E-1. Considerable differences were noted on the source of additional labor when a dairy enterprise was substituted for the beef cow-calf enterprises on resource situations C, D, and E. On the dairy farms, all or nearly all of the family labor supply was utilized before irrigation was considered as a production alternative. Thus, much greater demand was placed on hired labor for the dairy farms than was experienced on the same resource situations where beef cow-calf enterprises were considered. For example, the available family labor supply on farm D-2 was utilized at farm water level 1 and 364 hours of hired labor were required. The increase in hired labor as a result of maximum irrigation, ranged from 246 hours on farm C-2 with average rainfall conditions to 1,303 hours on farm E-2 with below average rainfall conditions.

The capital and labor requirements were much higher on resource situations with a dairy enterprise than on comparable resource situations with a beef cow-calf enterprise. For example, assuming below average rainfall, the capital requirements at irrigation level 4 were $8,855 for farm C-1 and $20,750 for farm C-2. Likewise, the total labor requirements were 1,080 hours and 2,476 hours for farms C-1 and C-2, respectively.

Levels of Income. Net farm income increased on all farms in this group as the quantity of water per farm increased. The marginal returns per acre foot of water from the preceding level decreased as water

TABLE XXVI

PROGRAMMED RESOURCE REQUIREMENTS AND INCOME BY FARM WATER LEVELS, FARM C-2, AVERAGE AND BELOW AVERAGE RAINFALL[a]

| Item | Average Rainfall | | | | Below Average Rainfall | | | |
|---|---|---|---|---|---|---|---|---|
| | Farm Water Levels[b] | | | | | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Total Water Used, Acre Feet | 0 | 29.33 | 58.66 | 88.00 | 0 | 37.00 | 74.00 | 111.00 |
| Labor Required: | | | | | | | | |
| Hired, Hours | 313 | 347 | 394 | 559 | 0 | 321 | 320 | 359 |
| Family, Hours | 2,377 | 2,398 | 2,398 | 2,398 | 2,141 | 2,064 | 2,096 | 2,117 |
| Total, Hours | 2,690 | 2,745 | 2,792 | 2,957 | 2,141 | 2,385 | 2,416 | 2,476 |
| Capital Required, Dollars[c] | 19,985 | 21,874 | 22,016 | 22,605 | 16,284 | 22,139 | 20,822 | 20,750 |
| Gross Farm Income, Dollars[d] | 11,877 | 13,492 | 14,595 | 15,545 | 8,416 | 12,870 | 13,175 | 13,810 |
| Net Farm Income, Dollars[e] | 3,903 | 4,308 | 4,643 | 4,855 | 2,388 | 3,313 | 3,928 | 4,198 |
| Changes in Net Farm Income: | | | | | | | | |
| From No Irrigation, Dollars | 0 | 405 | 740 | 952 | 0 | 925 | 1,540 | 1,810 |
| From Preceding Level of Irrigation, Dollars | 0 | 405 | 335 | 212 | 0 | 925 | 615 | 270 |
| Marginal Returns Per Acre Foot of Water:[f] | | | | | | | | |
| From No Irrigation, Dollars | 0 | 13.81 | 12.62 | 10.82 | 0 | 25.00 | 20.81 | 16.31 |
| From Preceding Level of Irrigation, Dollars | 0 | 13.81 | 11.42 | 7.23 | 0 | 25.00 | 16.62 | 7.30 |

[a]Typical farms are defined by resource situation and type in Tables II and IV of Chapter II.
[b]Farm water levels are defined in Table VI of Chapter II.
[c]Includes all capital required except investment in land.
[d]Total value of all products produced on the farm.
[e]Returns to land, family labor, risk, and management.
[f]Marginal returns to water, family labor, risk, and management associated with irrigation.

TABLE XXVII

PROGRAMMED RESOURCE REQUIREMENTS AND INCOME BY FARM WATER LEVELS, FARM D-2, AVERAGE AND BELOW AVERAGE RAINFALL[a]

| Item | Average Rainfall | | | | Below Average Rainfall | | | |
|---|---|---|---|---|---|---|---|---|
| | Farm Water Levels[b] | | | | | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Total Water Used, Acre Feet | 0 | 75.58 | 151.16 | 226.74 | 0 | 97.25 | 194.50 | 291.75 |
| Labor Required: | | | | | | | | |
| Hired, Hours | 364 | 883 | 1,243 | 1,508 | 154 | 743 | 870 | 1,039 |
| Family, Hours | 2,398 | 2,398 | 2,398 | 2,398 | 2,228 | 2,203 | 2,305 | 2,372 |
| Total, Hours | 2,762 | 3,281 | 3,641 | 3,906 | 2,382 | 2,946 | 3,175 | 3,411 |
| Capital Required, Dollars[c] | 20,190 | 28,076 | 28,908 | 30,500 | 17,795 | 27,820 | 26,875 | 26,500 |
| Gross Farm Income, Dollars[d] | 12,990 | 19,903 | 23,355 | 25,555 | 9,854 | 17,720 | 20,655 | 22,785 |
| Net Farm Income, Dollars[e] | 4,947 | 5,855 | 6,683 | 7,295 | 3,090 | 4,206 | 5,469 | 6,308 |
| Changes in Net Farm Income: | | | | | | | | |
| From No Irrigation, Dollars | 0 | 908 | 1,736 | 2,348 | 0 | 1,116 | 2,379 | 3,218 |
| From Preceding Level of Irrigation, Dollars | 0 | 908 | 828 | 612 | 0 | 1,116 | 1,263 | 839 |
| Marginal Returns Per Acre Foot of Water:[f] | | | | | | | | |
| From No Irrigation, Dollars | 0 | 12.01 | 11.48 | 10.36 | 0 | 11.48 | 12.23 | 11.03 |
| From Preceding Level of Irrigation, Dollars | 0 | 12.01 | 10.96 | 8.10 | 0 | 11.48 | 13.00 | 8.63 |

[a]Typical farms are defined by resource situation and type in Tables II and IV of Chapter II.
[b]Farm water levels are defined in Table VI of Chapter II.
[c]Includes all capital required except investment in land.
[d]Total value of all products produced on the farm.
[e]Returns to land, family labor, risk, and management.
[f]Marginal returns to water, family labor, risk, and management associated with irrigation.

TABLE XXVIII

PROGRAMMED RESOURCE REQUIREMENTS AND INCOME BY FARM WATER LEVELS, FARM E-2, AVERAGE AND BELOW AVERAGE RAINFALL[a]

| Item | Average Rainfall | | | | Below Average Rainfall | | | |
|---|---|---|---|---|---|---|---|---|
| | Farm Water Levels[b] | | | | | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Total Water Used, Acre Feet | 0 | 49.83 | 99.66 | 149.49 | 0 | 61.50 | 123.00 | 184.50 |
| Labor Required: | | | | | | | | |
| Hired, Hours | 4,114 | 4,372 | 4,708 | 4,970 | 1,164 | 1,898 | 2,151 | 2,467 |
| Family, Hours | 2,398 | 2,398 | 2,398 | 2,398 | 2,398 | 2,398 | 2,398 | 2,398 |
| Total, Hours | 6,512 | 6,770 | 7,106 | 7,368 | 3,562 | 4,296 | 4,549 | 4,865 |
| Capital Required, Dollars[c] | 69,310 | 72,015 | 73,050 | 73,650 | 38,390 | 46,215 | 46,370 | 47,305 |
| Gross Farm Income, Dollars[d] | 41,345 | 41,935 | 43,285 | 44,655 | 20,660 | 26,565 | 27,870 | 29,407 |
| Net Farm Income, Dollars[e] | 9,480 | 9,555 | 9,915 | 10,290 | 5,170 | 6,450 | 7,095 | 7,563 |
| Changes in Net Farm Income: | | | | | | | | |
| From No Irrigation, Dollars | 0 | 75 | 435 | 810 | 0 | 1,280 | 1,925 | 2,393 |
| From Preceding Level of Irrigation, Dollars | 0 | 75 | 360 | 375 | 0 | 1,280 | 645 | 468 |
| Marginal Returns Per Acre Foot of Water:[f] | | | | | | | | |
| From No Irrigation, Dollars | 0 | 1.51 | 4.36 | 5.42 | 0 | 20.81 | 15.65 | 12.97 |
| From Preceding Level of Irrigation, Dollars | 0 | 1.51 | 7.22 | 7.53 | 0 | 20.81 | 10.49 | 7.61 |

[a]Typical farms are defined by resource situation and type in Tables II and IV of Chapter II.
[b]Farm water levels are defined in Table VI of Chapter II.
[c]Includes all capital required except investment in land.
[d]Total value of all products produced on the farm.
[e]Returns to land, family labor, risk, and management.
[f]Marginal returns to water, family labor, risk, and management associated with irrigation.

availability increased on farms C-2 and D-2 when average rainfall conditions prevailed and on farm E-2 for below average rainfall conditions. Net farm income increased considerably as acres of bottomland increased (compare Table XXVI to XXVII) for both rainfall conditions. However, expanding the farm by increasing upland cropland resulted in a decrease in net income (compare Table XXVII to XXVIII).

Resource situations C, D, and E were programmed with dairy as the main livestock enterprise and with a beef cow-calf system as the main livestock enterprise. Net farm income was higher on the dairy farms for resource situations C and E. However, the beef cow-calf enterprise combined with the cropping activities generated more net farm income than occurred on the dairy-crop farms of resource situation D (compare Tables XXI-XXIII to XXVI-XVIII).

# CHAPTER IV

## INTERPRETATION AND APPLICATION OF RESULTS

The programming results discussed in Chapter III indicate that supplemental irrigation can significantly increase the income from farming in Roger Mills County. However, the availability of a water supply adequate to meet the programmed water requirements is extremely crucial to the attainment of these increases in income associated with irrigation.

The purposes of this chapter are to discuss the programming results of the 10 typical farms as these results apply in the aggregate and present alternative hypothesis concerning farmer reluctance to the adoption of irrigation.

### Aggregate Water Requirements

This study was limited to a population of 150 farmers in Roger Mills County. This population was defined as "farm units within the Washita River Basin of Roger Mills County operating bottomland". From this population, a random sample of 65 farmers were surveyed to obtain basic resource data and other information necessary for developing the programming analysis. This analysis was performed on 10 typical farms with alternative assumptions concerning rainfall conditions and water availability.[1]

[1] The definitions and assumptions underlying the programming analysis are presented in Chapter II.

The programmed water requirements of each of the typical farms provided the basis for extrapolating the total water requirements of all farms considered in this study. In order to make this extrapolation, it was necessary to determine the number of farms in each farm size and type group for the entire population (Table XXIX).[2] The total water requirements of each typical farm were determined at farm water levels 2-4 for average and below average rainfall (Tables XXIX and XXX). For example, the total water requirements for the 23 farms in the population of farm type A-1 at farm water level 4 were 1,292 acre-feet assuming average rainfall conditions and 1,656 acre-feet when below average rainfall conditions prevailed.

The aggregate water requirements for the 150 farms in the population are the summation of the total water requirements for the 10 typical farms (Tables XXIX and XXX). Assuming average weather conditions, 26,306 acre-feet of water were required to irrigate the 18,905 acres of bottomland in the study. That is, an average of 1.4 acre-feet of water per acre were required under average rainfall conditions to satisfy the equilibrium condition:[3]

$$MVP_{w1} = MVP_{w2} = \cdots = MVP_{w6} = MC_w.$$

Assuming below average rainfall, the quantity of water required to irrigate the 18,905 acres of irrigable land was 34,117 acre-feet. Thus,

---

[2]This extrapolation was made on the assumption that the number of farms in each farm size and type group of the population was the same proportion of the total farms as existed in the sample between a farm size and type group and the sample total.

[3]$MVP_{wi}$ refers to the marginal value product of water in the production of the $i^{th}$ product and $MC_w$ represents the marginal cost of the last unit of water.

TABLE XXIX

AGGREGATE ANNUAL IRRIGATION WATER REQUIREMENTS FOR THE POPULATION OF FARMS OPERATING BOTTOMLAND IN THE WASHITA RIVER BASIN OF ROGER MILLS COUNTY BY FARM WATER LEVELS FOR AVERAGE RAINFALL CONDITIONS

| Farm Size and Type[a] | Number of Farms in Population | Farm Water Levels[b] 2 Acres Irrigated | 2 Water Required (Acre-Feet) | 3 Acres Irrigated | 3 Water Required (Acre-Feet) | 4 Acres Irrigated | 4 Water Required (Acre-Feet) |
|---|---|---|---|---|---|---|---|
| A-1 | 23 | 276 | 447 | 598 | 855 | 874 | 1,292 |
| B-1 | 25 | 650 | 1,035 | 1,425 | 2,060 | 2,125 | 3,110 |
| C-1 | 12 | 240 | 358 | 528 | 718 | 780 | 1,085 |
| C-2 | 16 | 352 | 472 | 672 | 940 | 1,040 | 1,400 |
| D-1 | 21 | 1,428 | 1,601 | 2,520 | 3,202 | 3,423 | 4,790 |
| D-2 | 7 | 364 | 526 | 728 | 1,063 | 1,141 | 1,588 |
| E-1 | 16 | 544 | 792 | 1,168 | 1,572 | 1,792 | 2,368 |
| E-2 | 7 | 238 | 349 | 504 | 696 | 784 | 1,046 |
| F-1 | 18 | 1,656 | 2,512 | 3,420 | 5,037 | 5,436 | 7,570 |
| F-2 | 5 | 500 | 687 | 1,045 | 1,371 | 1,510 | 2,057 |
| Total | 150 | 6,248 | 8,779 | 12,608 | 17,514 | 18,905 | 26,306 |

[a] A description of farm size and type groups is presented in Tables II and IV of Chapter II.

[b] Farm water levels are defined in Table VI of Chapter II.

TABLE XXX

AGGREGATE ANNUAL IRRIGATION WATER REQUIREMENTS FOR THE POPULATION OF FARMS OPERATING BOTTOMLAND IN THE WASHITA RIVER BASIN OF ROGER MILLS COUNTY BY FARM WATER LEVELS FOR BELOW AVERAGE RAINFALL CONDITIONS

| Farm Size and Type[a] | Number of Farms in Population | Farm Water Levels[b] 2 Acres Irrigated | 2 Water Required (Acre-Feet) | 3 Acres Irrigated | 3 Water Required (Acre-Feet) | 4 Acres Irrigated | 4 Water Required (Acre-Feet) |
|---|---|---|---|---|---|---|---|
| A-1 | 23 | 276 | 537 | 874 | 1,091 | 874 | 1,656 |
| B-1 | 25 | 750 | 1,327 | 2,125 | 2,658 | 2,125 | 3,983 |
| C-1 | 12 | 276 | 455 | 780 | 927 | 780 | 1,403 |
| C-2 | 16 | 352 | 603 | 784 | 1,188 | 1,040 | 1,775 |
| D-1 | 21 | 1,995 | 2,072 | 3,024 | 4,158 | 3,423 | 6,216 |
| D-2 | 7 | 371 | 682 | 805 | 1,360 | 1,141 | 2,045 |
| E-1 | 16 | 752 | 1,083 | 1,792 | 2,157 | 1,792 | 3,239 |
| E-2 | 7 | 429 | 273 | 609 | 863 | 784 | 1,290 |
| F-1 | 18 | 3,312 | 3,266 | 5,202 | 6,537 | 5,436 | 9,822 |
| F-2 | 5 | 902 | 775 | 1,450 | 1,793 | 1,510 | 2,688 |
| Total | 150 | 9,415 | 11,073 | 17,445 | 22,732 | 18,905 | 34,117 |

[a]A description of farm size and type groups is presented in Tables II and IV of Chapter II.

[b]Farm water levels are defined in Table VI of Chapter II.

approximately 1.8 acre-feet of water per acre were required to satisfy the above equilibrium condition assuming below average rainfall. This is approximately 30 per cent greater than the total water required under average rainfall conditions.

The difference in water requirements at farm water level 4 between average and below average rainfall was the result of irrigation water substituted for a reduction in natural precipitation. The same amount of bottomland was irrigated at farm water level 4 under both rainfall conditions. However, the difference in water requirements at farm water levels 2 and 3 between the two weather conditions was explained by two factors. One factor was the result of irrigation water substituted for a reduction in natural precipitation. A second factor was that more acres of bottomland were irrigated at farm water levels 2 and 3 when below average rainfall years prevailed as compared to average rainfall years.

Assuming average rainfall conditions, a 33 per cent reduction in water availability resulted in a 33 per cent reduction in acres irrigated (farm water level 4 to 3). However, when a 33 per cent reduction in water availability occurred when below average rainfall prevailed, the result was an eight per cent reduction in acres irrigated (from water level 4 to 3). This difference in acres irrigated between the two weather conditions can be explained by a difference in the most profitable level of water application per acre for the irrigated crops.[4] All crops were irrigated at level $I_3$ for all levels of water availability assuming average rainfall conditions. Thus, a given percentage reduction

---

[4]Crop water levels are defined in Table V of Chapter II.

in water availability resulted in an equal percentage reduction in acres irrigated. However, a reduction in water availability assuming below average rainfall caused the most profitable level of water application per acre on some crops to shift to a lower level.[5] This shifting to a lower level of water application permitted more bottomland to be irrigated with a given amount of water.

Historical weather data for Roger Mills County indicate that natural precipitation would be adequate for optimum plant growth approximately two years out of every 10. In the remaining eight years there would be: (1) two years when irrigation would be required to supplement below average rainfall to achieve optimum plant growth and (2) six years when irrigation would be required to supplement average rainfall to achieve optimum plant growth. Thus, the expected aggregate water requirements for a 10 year period would be 226,070 acre-feet to irrigate the 18,905 acres of bottomland analyzed in this study at farm water level 4.

## Supply of Water

There are two potential sources of water for irrigation in Roger Mills County: (1) water stored in structures developed in association with the upstream flood protection program, and (2) ground water. The first source includes both sediment pools and flood pools of the structures. However, the flood pool storage is possible only if administrative arrangements permit. Information was not available for estimating the effect of upstream watershed development upon ground water supply. Thus,

---

[5]Wheat and grain sorghum were frequently irrigated at $I_3$ for farm water level 4 and shifted to $I_2$ as water availability was reduced to farm water level 3.

the magnitude of the effect of seepage from structures as a possible recharge of underground water supplies was excluded in estimates of irrigation water supply created by the watershed development program.

There were 143 floodwater retarding structures planned for the Washita River Basin of Roger Mills County. These structures had an aggregate sediment pool storage capacity of 43,783 acre-feet of water (Table XXXI). However, evaporation and seepage losses would reduce considerably the proportion of this water that actually would be delivered to farms for irrigation. Research conducted by Arnold on the Boggy Creek Watershed assumed that approximately 46 per cent of the water stored in structures is lost through evaporation.[6] Assuming that an evaporation loss of 46 per cent occurred from structures in Roger Mills County, there would be 23,643 acre-feet of water, net of evaporation, available for irrigation from the combined sediment pool storage of all floodwater retarding structures in Roger Mills County. Since this rate of evaporation is on an annual basis, it is reasonable to expect that this evaporation loss would be reduced somewhat if water was used for irrigation throughout the year rather than remaining in the sediment pool. In addition, irrigation losses incurred through seepage from sediment pools and conveyance ditches must also be considered when estimating water availability at the farm.

Studies conducted by irrigation engineers throughout the United States indicate that losses from conveyance ditches ranged from five to 50 per cent per mile of the initial quantity of water diverted.[7] Data

[6]Adlai F. Arnold, "Potential Economic Effects of Upstream Flood Control and Irrigation Development: Boggy Creek Watershed, Oklahoma" (unpub. Ph.D. dissertation, Oklahoma State University, 1962), p. 89.

[7]Evan E. Houk, Irrigation Engineering, Vol. 1 (New York, 1951), p. 392.

TABLE XXXI

DESIGNED SEDIMENT POOL SURFACE AREA AND STORAGE CAPACITY FOR THE TEN WATERSHEDS OF THE WASHITA RIVER BASIN OF ROGER MILLS COUNTY

| Watershed | Number of Structures | Sediment Pool[a] Surface Area (Acres) | Sediment Pool[a] Storage-Capacity (Acre-Feet) |
|---|---|---|---|
| Broken Leg | 2 | 76 | 684 |
| Dead Indian | 8 | 346 | 6,619 |
| White Shield | 20 | 136 | 769 |
| Upper Washita | 32 | 2,144 | 18,333 |
| Quartermaster | 38 | 790 | 6,060 |
| Nine Mile | 11 | 225 | 1,897 |
| Big Kiowa | 4 | 151 | 1,107 |
| Sargent Major | 2 | 77 | 962 |
| Sandstone | 24 | 702 | 6,312 |
| Beaver Dam | 3 | 117 | 1,040 |
| Total | 143 | 4,764 | 43,783 |

[a]These data were obtained from the Watershed Work Plans prepared by the Soil Conservation Service, United States Department of Agriculture.

were not available to estimate losses in transporting water from structure to field for Roger Mills County. Thus, it was impossible to estimate the effect of distance between structure and bottomland on irrigation efficiency.[8]

The total water required to irrigate all bottomland included in this study at farm water level 4 was 26,306 acre-feet assuming average weather conditions and 34,117 acre-feet assuming below average rainfall (Tables XXIX and XXX). Assuming a water supply of 43,783 acre-feet, the water losses would have to be less than 40 per cent to permit irrigation of all bottomland at farm water level 4 under average rainfall conditions and less than 22 per cent if all bottomland is to be irrigated when below average rainfall conditions prevail.

## Economic Interpretation of Programmed Increments to Net Income

The theoretical principle underlying this study pertained to the allocation of water to typical farm resource situations assuming profit maximization as the goal. This principle assigns priority for the use of water to those alternatives yielding highest marginal returns per unit of water added. The increases in net income determined by the programming analysis were graphed to illustrate the use of the marginal principle in water allocation among typical farm sizes and types (Figures 4 and 5).[9]

---

[8]Irrigation efficiency is the percentage of water released from a structure that reaches the farm.

[9]The data used in developing the curves in Figures 4 and 5 are presented in Appendix G, Table II. These data are exclusive of fixed cost of irrigation equipment.

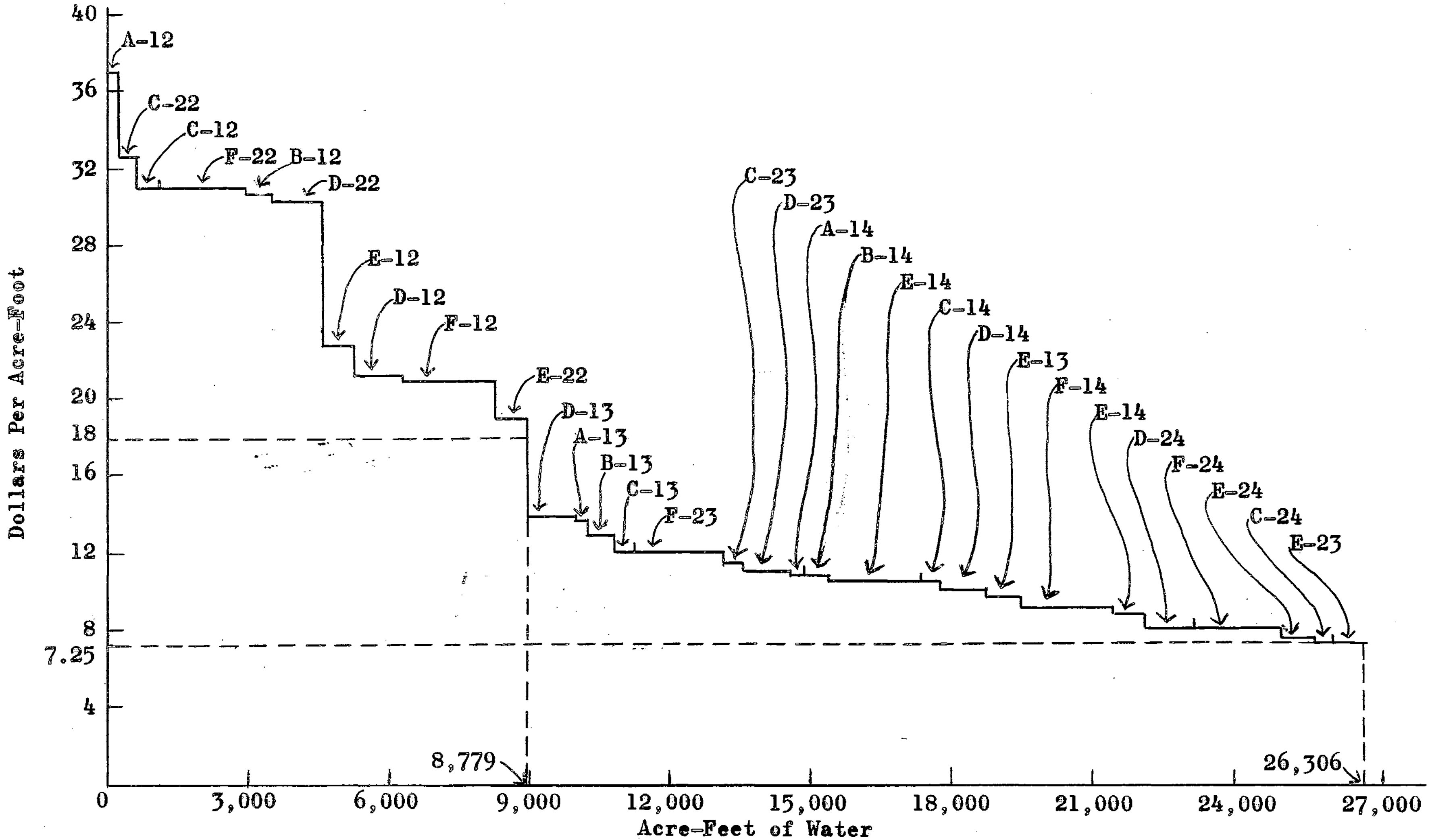


Figure 4. Marginal Returns Per Acre-Foot of Water and Acre-Feet of Water Used for Farms Operating Bottomland by Farm Size and Type and Farm Water Level for Average Rainfall Conditions.

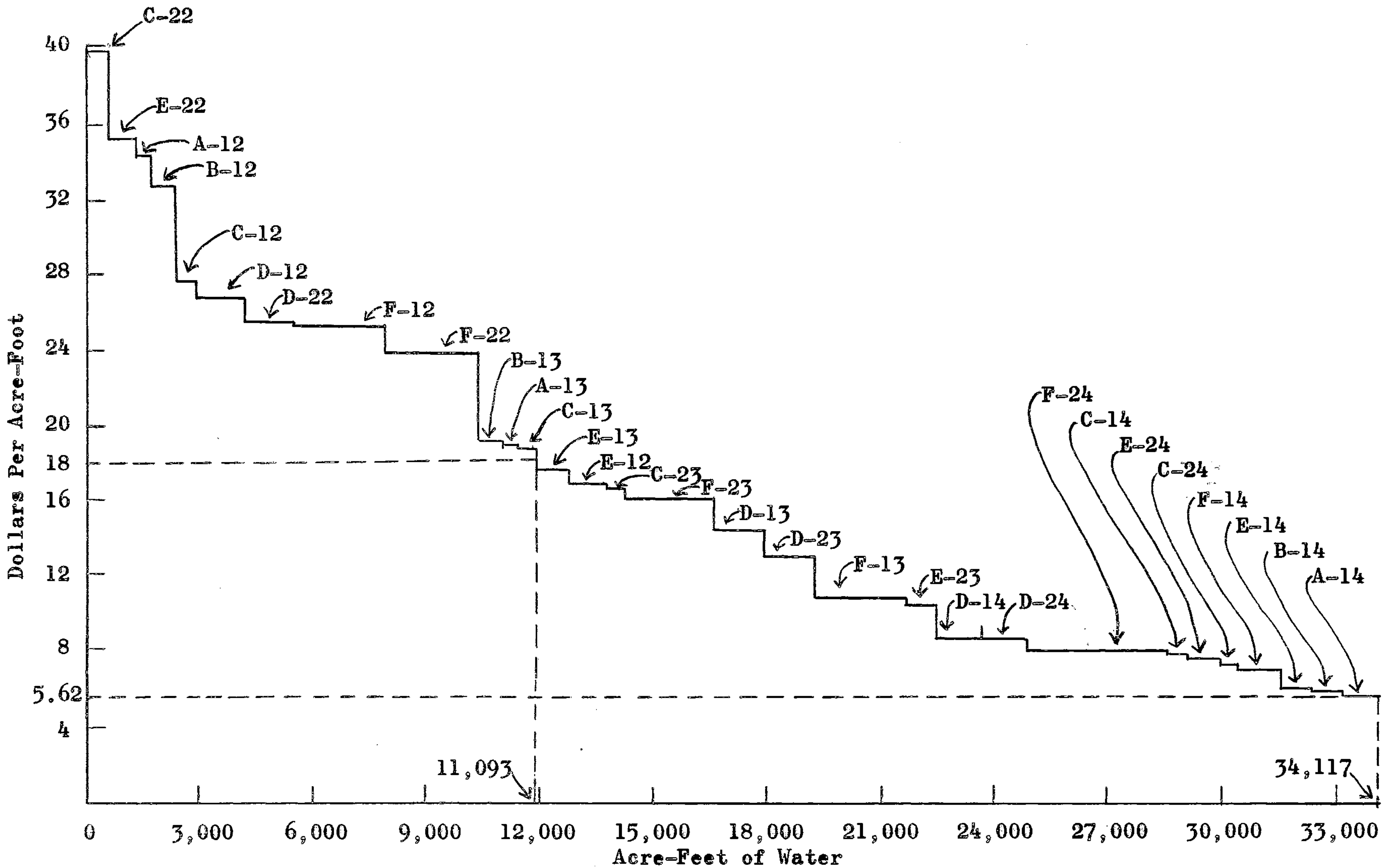


Figure 5. Marginal Returns Per Acre-Foot of Water and Acre-Feet of Water Used for Farms Operating Bottomland by Farm Size and Type and Farm Water Level for Below Average Rainfall Conditions.

The curves in Figures 4 and 5 were developed by arranging all programmed marginal returns to water per acre-foot in descending order of magnitude for cumulative increases in total water used. The horizontal segments of each curve represent the marginal value product of water for a given resource situation, farm type, and farm water level for average and below average rainfall.[10] In general, the linear segments provide an empirical approximation to a continuous curve sloping downward and to the right. When the water supply is relatively limited, the higher value crops tend to be irrigated on the best land. As water availability increases, higher water using, lower value crops were irrigated, thus bringing about the decreasing marginal value product for water. This arrangement of marginal value products of water depicted how any given supply of water was allocated among farms in order to obtain maximum net income to the area.

The values graphically depicted in Figures 4 and 5 represent the maximum price a farmer can afford to pay for a given quantity of water available at the farm since water delivery costs were not included in the programming analysis. Assuming average weather conditions, the cost of developing and delivering water to the farm would have to be less than $7.25 per acre-foot before it would be profitable to irrigate the entire 18,905 acres of bottomland analyzed in this study at farm water level 4 (Figure 4). When below average rainfall conditions prevail, the development and delivery costs would have to be less than $5.62 per

---

[10]The symbols describing each segment of the curves in Figures 4 and 5 refer to the resource situation, farm type, and farm water level. For example, A-12 refers to resource situation A, farm type 1, and farm water level 2. These variables are defined in Chapter II.

acre-foot for profitable development and delivery of the 34,117 acre-feet required to irrigate all bottomland at farm water level 4 (Figure 5).

As the cost of developing and delivering the water to the farm increases, the quantity of water profitable to use decreases. For example, if the development and delivery cost increases to $18 per acre-foot, the profit maximizing level of water use decreases considerably. For average rainfall conditions, it was profitable to irrigate only 6,248 acres requiring 8,779 acre-feet of water. All farms would have sufficient water to irrigate at farm water level 2. This would provide water for irrigation of the entire cotton allotment, alfalfa having a marginal value in use greater than the market price and a portion of the wheat allotment. For below average rainfall, it would be profitable to irrigate 7,465 acres which would require 11,093 acre-feet of water. This provides enough water for all farms except farm E-1 to irrigate at farm water level 2 and farms D-2, E-2, and F-2 to irrigate at farm water level 3.

The above discussion assumes that development costs on all farms were equal. However, it is conceivable that development and delivery costs could differ from one farm to the next depending upon location and equipment available. It then becomes necessary for costs and returns to be compared for each farm situation. The profit maximizing level of irrigation would be determined on each farm. The average returns per acre-foot of water at the profit maximizing level would then be the criterion upon which to base the allocation of a limited supply of water to the area. Economic allocation of resources would suggest that farms with the highest average return receive first priority.

## Aggregate Increases in Income

The magnitude of this annual increase in agricultural income in Roger Mills County attributable to irrigation is dependent upon rainfall conditions, available water supply, and the degree to which farmers owning and/or operating potentially irrigable land adopt irrigation.

The annual increase in net income to the agricultural sector of Roger Mills County attributable to irrigation was $254,667 and $406,911 assuming average and below average rainfall, respectively (Table XXXII). This assumes that an adequate supply of water was available to irrigate at farm water level 4 and that all potentially irrigable land was irrigated. Reducing the quantity of water available for irrigation had a greater impact on net returns during average rainfall years than during below average rainfall years. For example, when water availability was decreased from farm water level 4 to farm water level 3 (33 per cent decrease), the aggregate increase in income was reduced 20 per cent for below average rainfall years and 33 per cent for average rainfall years. Similar results occurred for other water level comparisons.

The number of farmers adopting irrigation would also have a significant effect on the magnitude of the aggregate increase in income. Assuming that the number of farmers adopting irrigation was 100 rather than 150, the resulting increase in income would be $166,269 and $270,192 for average and below average rainfall, respectively. This compares to $254,667 and $406,911 increases in income when all bottomland was irrigated.

TABLE XXXII

AGGREGATE ANNUAL INCREASE IN INCOME FROM PROGRAMMED DRYLAND CONDITIONS TO IRRIGATION LEVELS SPECIFIED, FOR THE POPULATION OF FARMS OPERATING BOTTOMLAND IN THE WASHITA RIVER BASIN OF ROGER MILLS COUNTY BY FARM WATER LEVELS FOR AVERAGE AND BELOW AVERAGE RAINFALL CONDITIONS[a]

| Farm Size and Type[b] | Number of Farms in Population | Average Rainfall | | | Below Average Rainfall | | |
|---|---|---|---|---|---|---|---|
| | | Farm Water Levels[c] | | | | | |
| | | 2 | 3 | 4 | 2 | 3 | 4 |
| | | - Dollars - | | | | | |
| A-1 | 23 | 8,533 | 14,398 | 19,044 | 11,523 | 21,942 | 25,047 |
| B-1 | 25 | 13,900 | 27,250 | 38,325 | 25,425 | 50,750 | 58,625 |
| C-1 | 12 | 4,608 | 8,928 | 12,708 | 6,300 | 15,012 | 18,684 |
| C-2 | 16 | 6,480 | 11,840 | 15,232 | 14,800 | 24,640 | 28,960 |
| D-1 | 21 | 4,872 | 26,943 | 43,197 | 26,628 | 55,965 | 73,878 |
| D-2 | 7 | 6,356 | 12,152 | 16,436 | 7,812 | 16,653 | 22,526 |
| E-1 | 16 | 4,480 | 12,160 | 19,120 | 4,848 | 23,760 | 30,368 |
| E-2 | 7 | 525 | 3,045 | 5,670 | 8,960 | 13,475 | 16,751 |
| F-1 | 18 | 11,880 | 38,394 | 61,380 | 41,904 | 78,966 | 100,512 |
| F-2 | 5 | 9,825 | 18,025 | 33,555 | 10,035 | 24,360 | 31,560 |
| Total | 150 | 71,457 | 173,135 | 254,667 | 117,936 | 325,523 | 406,911 |

[a]Represents increase in income from dryland condition to farm water level specified.

[b]A description of farm size and type groups is presented in Tables II and IV of Chapter II.

[c]Farm water levels are defined in Table VI of Chapter II.

## Adjustment Problems Associated With the Adoption of Irrigation

### Capital Requirements

The development of and transition to irrigation agriculture requires additional resource inputs as well as a reallocation of the present resources. Capital is a resource of special concern in this respect. Although detailed information was not obtained concerning the capital position of farmers in the survey in Roger Mills County, a large proportion of the farmers in the survey indicated that they would have to borrow part or all of the capital necessary to develop and integrate irrigation farming into their present farm organization. Thus, the quantity of capital required relative to the farmers equity position becomes an important consideration in formulating irrigation decisions.

The magnitude of the increase in capital requirements from the programmed dryland farm organizations to alternative farm irrigation levels varies by farm size and type, rainfall conditions, and acres of bottomland (Table XXXIII).

Farm type had a significant effect on the increase in non-land capital requirements as farm water levels increased. In general, capital requirements increased more on farms with a dairy enterprise than those farms with a beef cow-calf enterprise on the same resource situation. This occurred only when below average rainfall was assumed. For example, capital requirements increased $1,655 for the first increment of water applied on farm E-1. When the first increment of water was added to farm E-2, the capital requirements increased $7,825. However, assuming average rainfall conditions, the capital requirements increased more on

TABLE XXXIII

PROGRAMMED CAPITAL REQUIREMENTS BY FARM SIZE AND TYPE AND FARM IRRIGATION LEVELS FOR AVERAGE AND BELOW AVERAGE RAINFALL CONDITIONS

| Farm Size and Type[a] | Average Rainfall | | | | Below Average Rainfall | | | |
|---|---|---|---|---|---|---|---|---|
| | Farm Water Levels[b] | | | | | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| A-1 | 3,150 | 5,040 | 5,297 | 5,686 | 1,995 | 3,680 | 4,285 | 4,720 |
| B-1 | 4,494 | 8,556 | 8,989 | 9,950 | 3,280 | 7,380 | 8,405 | 9,355 |
| C-1 | 8,442 | 10,842 | 11,458 | 12,027 | 4,080 | 7,264 | 8,065 | 8,855 |
| C-2 | 19,985 | 21,874 | 22,016 | 22,605 | 16,284 | 22,139 | 20,822 | 20,750 |
| D-1 | 8,570 | 16,306 | 17,963 | 19,385 | 5,735 | 13,670 | 15,778 | 17,215 |
| D-2 | 20,190 | 28,076 | 28,908 | 30,500 | 17,795 | 27,820 | 26,875 | 26,500 |
| E-1 | 20,190 | 24,425 | 25,133 | 25,860 | 12,920 | 14,575 | 18,290 | 19,350 |
| E-2 | 69,310 | 72,015 | 73,050 | 73,650 | 38,390 | 46,215 | 46,370 | 47,305 |
| F-1 | 30,010 | 43,000 | 45,845 | 47,775 | 23,790 | 30,295 | 33,160 | 37,515 |
| F-2 | 44,510 | 50,570 | 55,265 | 56,625 | 26,125 | 37,515 | 45,405 | 49,670 |

[a]A description of farm size and type groups is presented in Tables II and IV of Chapter II.

[b]Farm water levels are defined in Table VI of Chapter II.

the beef cow-calf farms than on the dairy or feeder farms on comparable resource situations. Since only bottomland was considered irrigable in this study, there was a greater increase in non-land capital requirements when acres of bottomland increased than was noted when acres of cropland increased.

An implied assumption of the programming analysis is perfect knowledge about input-output coefficients, irrigation requirements, prices, decision maker's objective, and managerial ability of the decision maker. Hence, the programming results presented in Chapter III are based on perfect knowledge of these factors. Whether or not these results could be attained by the individual farmer depends upon his ability to achieve the efficiency inherently assumed in a profit maximizing, static linear programming framework. Perfect knowledge about necessary factors of production implies a riskless production situation. However, the Great Plains is a high risk agricultural producing region. Risk aversion results in farmers restricting the amount of capital invested in their operations to a level less than that which is most profitable under a perfect knowledge situation.

There appears to be a reluctance on the part of Roger Mills County farmers to invest in irrigation equipment. One basic problem is the additional capital required to purchase the necessary equipment for irrigation. Suppose these farmers are unwilling to invest the capital they have accumulated over time in irrigation equipment. By so doing, these farmers are placing an internal restriction on capital investment in irrigation equipment in order to avert the risk associated with debts against their operation.

Farmers generally are aware that the rate of risk is directly related to the amount of capital invested. Kalecki indicates that there are two reasons for the marginal risk to increase as the amount of capital invested increases. These reasons are:[11] (1) the greater the investment of an entrepreneur by use of borrowed funds, the more his own capital is endangered in the event of unsuccessful business, and (2) the danger of illiquidity as the size of investment increases.

Both of these factors are important in explaining why farmers may hesitate in committing the capital necessary for an irrigation unit. The first factor points out that as a farmer intensifies or expands his operations by use of borrowed capital, the chance of losing his accumulated capital increases. The results of this study indicate that irrigation is profitable for farmers operating bottomland. However, these results were obtained under conditions of perfect knowledge about the level of water availability. In general, farmers in this area are reluctant to either invest their own capital or borrow the capital necessary to purchase irrigation equipment without more definite knowledge about the availability of an adequate water supply during prolonged periods of drought when irrigation is most urgent. The actual quantity of water available in the structures for any given year is very difficult to predict. In addition, the status of the water rights to this water is uncertain. Although ground water is a potential source of water for irrigation, the extent of this supply is unknown. Therefore, the uncertainty that farmers face concerning the availability of irrigation water is a possible cause for the reluctance on the part of farmers to make the investments necessary

---

[11] M. Kalecki, "Principles of Increasing Risk", Economica, New Series (1937), p. 442.

to adjust from dryland to irrigated farming on part of their farm units.

## Labor Requirements

The increased labor required for irrigation is another factor that will greatly influence the adoption of irrigation farming in Roger Mills County. Although an adequate annual family labor supply exists on most farms in the County, irrigation uses large amounts of seasonal labor. Since timing of application is very important in attaining maximum profits from irrigation, a dependable labor supply is necessary.

The magnitude of the increase in labor requirements from programmed dryland organizations to alternative farm irrigation levels depends on farm size and type, acres of bottomland, and rainfall conditions (Table (Table XXXIV). For example, the increase on farm A-1 from dryland to the first irrigation level was 112 hours for average rainfall conditions. For below average rainfall the increase was 253 hours. The same number of acres were irrigated for both rainfall conditions. The inclusion of a buy-sell enterprise into the basic farm organization resulted in the greatest increase in labor requirements from the dryland optimum organization to any one of the three alternative irrigation levels for both weather conditions. The greatest increase was 3,059 hours. This occurred between dryland and farm water level 4 for below average rainfall conditions.

## Age of Farm Operators

The age of farmers operating bottomland in Roger Mills County will likely be an influential factor in the adoption of irrigation. Results of the survey taken in Roger Mills County indicated that the average age of the farmers surveyed was about 60 years. In view of the age of farm

TABLE XXXIV

PROGRAMMED TOTAL LABOR REQUIREMENTS BY FARM SIZE AND TYPE AND FARM IRRIGATION LEVELS FOR AVERAGE AND BELOW AVERAGE RAINFALL CONDITIONS

| Farm Size and Type[a] | Average Rainfall | | | | Below Average Rainfall | | | |
|---|---|---|---|---|---|---|---|---|
| | Farm Water Levels[b] | | | | | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| A-1 | 377 | 489 | 603 | 707 | 253 | 504 | 536 | 648 |
| B-1 | 523 | 764 | 1,102 | 1,334 | 404 | 700 | 1,019 | 1,269 |
| C-1 | 1,027 | 1,507 | 1,581 | 1,772 | 418 | 851 | 882 | 1,080 |
| C-2 | 2,690 | 2,745 | 2,792 | 2,957 | 2,141 | 2,385 | 2,416 | 2,476 |
| D-1 | 1,044 | 1,424 | 1,919 | 2,238 | 739 | 1,285 | 1,850 | 2,288 |
| D-2 | 2,762 | 3,281 | 3,641 | 3,906 | 2,382 | 2,946 | 3,175 | 3,411 |
| E-1 | 1,768 | 1,830 | 2,182 | 2,412 | 1,070 | 1,358 | 1,773 | 2,034 |
| E-2 | 6,512 | 6,770 | 7,106 | 7,368 | 3,562 | 4,296 | 4,549 | 4,865 |
| F-1 | 2,824 | 3,202 | 4,038 | 4,803 | 2,034 | 2,958 | 3,412 | 4,322 |
| F-2 | 2,566 | 3,515 | 4,396 | 5,146 | 2,058 | 2,993 | 4,341 | 5,117 |

[a]A description of farm size and type groups is presented in Tables II and IV of Chapter II.

[b]Farm water levels are defined in Table VI of Chapter II.

operators, it is reasonable to assume that the planning horizon of these farmers is considerably shorter than the time necessary to recover the fixed investment in an irrigation system. In general, farmers in this age group are not planning to make long run capital investments in their farming operations, but rather they are accumulating capital for their retirement. Thus, extensive investment in a long run capital asset such as irrigation equipment appears fairly remote when considering farmers 60 years of age with a relatively short planning horizon.

# CHAPTER V

## SUMMARY AND CONCLUSIONS

Water stored in upstream reaches of a watershed or river basin is potentially beneficial to the immediate area surrounding the storage facility as well as downstream locations. The value of water available in a particular area depends upon the returns from potential uses. The potential value of water in upstream uses represents the opportunity cost of using this water downstream. That is, water used in downstream locations at the expense of upstream users represents a loss of income to the upstream users. Therefore, the use value of water in an upstream area such as Roger Mills County has a strong economic impact on any decision to transfer water to downstream uses. If water is to make a contribution to the watershed or river basin equal to what water contributes from the upstream use alone, the returns to water in its downstream use must be at least equal to the loss of income to the upstream user plus the cost in its present use.

This study is concerned with appraising and evaluating the potential value of water for irrigation in Roger Mills County. The specific objectives are: (1) to determine the amount of farm land in the area of study with physical and economic potential for irrigation; (2) to determine the value of water used to irrigate crops and pastures for (a) alternative crop systems and varying levels of water availability, (b) alternative farm resource situations, and (c) alternative systems of farming within a given resource situation; (3) to estimate the optimum allocation of alternative levels of available water among crops and farms in the area; and (4) to appraise the availability of water for irrigation relative to programmed demands for water.

This study was conducted in Roger Mills County in Western Oklahoma and was limited to a population of 150 farmers. This population was defined as "farm units within the Washita River Basin of Roger Mills County operating bottomland". From the population of 150 farm units, three resource strata were defined representing (1) small cropland and small rangeland, (2) large cropland and small rangeland; and (3) large cropland and large rangeland. A survey of a random sample of 65 farm units from the population was conducted to obtain basic resource data and other information necessary for developing the programming analysis. Each of the original three resource strata were classified into two substrata on the basis of acres of bottomland. In addition, two different farm types were included on four of the resource strata resulting in 10 typical farms for the programming analysis.

## Programming Analysis

The 150 farms in the Washita River Basin of Roger Mills County operating bottomland had a total of 18,905 acres of land which was potentially irrigable. This bottomland was subdivided into two productivity classes ($L_1$ and $L_2$) to improve the accuracy of the analysis.

Linear programming was used to determine the profit maximizing allocation of water and other resources and corresponding farm organization. Three rainfall conditions were defined on the basis of historical rainfall data for Roger Mills County for 1914-1960. Enterprise budgets were developed for all dryland and irrigated crops and the programming analysis was performed assuming average and below average rainfall conditions. The above average rainfall condition was excluded from the programming analysis on the basis of preliminary results which indicated that the cost of adding the water was greater than the added returns. Four alternative programs were analyzed for each strata. The first series of programs were without irrigation as an alternative. This provided the benchmark for measuring the value of irrigation for each of three farm water levels.

Land Use and Livestock Numbers

Generally, there was very little shifting of crops from upland to bottomland attributable to changes in levels of irrigation. The only shifts that did occur between upland and bottomland occurred with the first increment of water. There were no significant changes in this result as farm size increased or farm type varied with both average and below average rainfall conditions.

Most crops were irrigated at the high level of water application per acre even though lower application levels were included in the programming model. Even at very limited water supplies, it was more profitable to irrigate fewer acres at the highest level than to irrigate more acres at a lower level. Exceptions occurred when below average rainfall conditions were considered.

Considerably more forage crops were produced and irrigated on resource situations C, D, and E considering a dairy enterprise than on the same resource situation considering beef cow-calf enterprises. The addition of a feeder enterprise on resource situation F resulted in a substantial increase in acres irrigated at farm water levels 2 and 3 as compared to the same resource situation with beef cow-calf enterprises.

Increasing the quantity of water available for irrigation did not increase the number of beef cows included in the optimum farm organization assuming average rainfall conditions. However, there were certain resource situations where the number of beef cows decreased as water availability increased. There were instances when below average rainfall conditions were assumed that beef cow numbers increased as water availability increased. Dairy and beef feeders showed a greater response to water availability than did the beef cow-calf enterprises. Competition for labor between livestock enterprises and irrigation resulted in a decrease in programmed livestock numbers as water availability increased.

Resource Requirements and Income

Total labor and capital requirements and gross and net farm income increased for all farm sizes, farm types, and rainfall conditions as water supply per farm increased.

Family labor was adequate at all irrigation levels for resource situations A, B, and C for both rainfall conditions when cow-calf enterprises were considered. Hired labor was required for all other farm types at one or more farm water levels. The farms with dairy required more hired labor than any other farm type.

Marginal returns per acre-foot of water from the preceding level of irrigation generally declined with increases in water availability. For some situations, the second increment was worth more than the first because of the inefficient use of irrigation equipment at level one. The marginal returns per acre-foot of water at the highest level of irrigation increased as farm size increased for some resource situations assuming below average rainfall conditions.

The profitability of developing an irrigation water supply adequate to irrigate at farm water level 4 depended upon the farm resource situation, farm type, and rainfall condition. The net marginal value products of irrigation water for the last acre-foot applied was $5.62 and $7.25 per acre-foot for below average and average rainfall conditions, respectively. The total water required to irrigate the 18,905 acres of bottomland analyzed in this study at the highest farm water level was 26,306 acre-feet and 34,117 acre-feet, assuming average and below average rainfall conditions, respectively. The above net marginal value product of water assuming average rainfall is somewhat higher than the net marginal value product of water assuming below average rainfall because a considerably larger water supply was required for irrigation during below average rainfall years.

When average rainfall conditions prevailed, the cost of delivering irrigation water to the farm would have to range between $7.25 and $10.77 per acre-foot for all farm types analyzed to profitably irrigate at farm water level 4. Assuming below average rainfall conditions, the delivery costs would have to range between $5.62 and $8.65 per acre-foot. The net marginal products derived in this study do not include a charge for family labor.

## Irrigation Potential in Roger Mills County

The results of this study indicated that irrigation can significantly increase the income from farming in Roger Mills County. The annual increase in net income to the agricultural sector of Roger Mills County attributable to irrigation was $254,667 and $406,911, assuming average and below average rainfall conditions, respectively. However, the availability of a water supply adequate to meet the programmed water requirements is extremely crucial to the attainment of these increases in income associated with irrigation.

There were 143 floodwater retarding structures planned for the Washita River Basin of Roger Mills County. These structures were designed with an aggregate sediment pool storage capacity of 43,783 acre-feet of water. However, irrigation losses incurred through evaporation and seepage from sediment pools and conveyance ditches would reduce this supply of water considerably before the water reaches the land to be irrigated. If the designed storage capacity is to provide a water supply adequate to irrigate all bottomland at farm water level 4, the irrigation losses due to evaporation and seepage would have to be less than 40 per cent for average rainfall conditions and less than 22 per cent for below average rainfall conditions. Any increase in irrigation losses beyond these limits would decrease the amount of water available to the farms below the quantity necessary to irrigate all bottomland at irrigation level 4. Thus, there would be a smaller annual increase in net income to the agricultural sector of Roger Mills County attributed to irrigation.

## Usefulness of the Results

The programming analysis of this study was developed from input-output coefficients, prices and costs, resource situations, technology factors, and other restraints applicable to Roger Mills County conditions.

These factors make the results of this study directly applicable only to Roger Mills County.

The results of this study indicate that irrigation can significantly increase the income from farming in Roger Mills County. The estimates of the value of irrigation water derived in this study are useful for several purposes. First, the programmed marginal value products of water can be used by farmers as a guide for planning the development of and transition to irrigation farming. Secondly, these estimates provide watershed planners with a basis for estimating the value of providing additional storage for irrigation on floodwater retarding structures. Thirdly, these estimates are useful to upstream users in appraising the value of water stored in the local area.

## SELECTED BIBLIOGRAPHY


Aanderud, W. G. "Income Variability of Alternative Plans, Selected Farm and Ranch Situations, Rolling Plains of Northwest Oklahoma." Unpublished Ph. D. dissertation, Oklahoma State University, Stillwater, 1964.

Arnold, Adlai. "Potential Economic Effects of Upstream Flood Control and Irrigation Development: Boggy Creek Watershed, Oklahoma" Unpublished Ph. D. dissertation, Oklahoma State University, Stillwater, 1962.

Back, W. B. "Economics of Development and Use of Water in Local Areas." Proceedings of Agricultural Economics and Rural Sociology Section. Proceedings of Association of Southern Agricultural Workers at Jackson, Mississippi, February, 1961.

Bagley, J. M. and W. D. Criddle. Evaluation of Sprinkler Irrigation Systems in Northern Utah. Logan: Utah Agricultural Experiment Station in cooperation with the U. S. Department of Agriculture, Bulletin 387.

Barefoot, D. and J. Garton. "Altus Irrigation Station Field Day." Unpublished report, Stillwater, 1961.

Blaney, H. F. and W. D. Criddle. Determining Water Requirements in Irrigation Areas From Climatological Data. Soil Conservation Service, USDA, SCS-TP-96. Washington: 1950.

Connor, L. J., W. F. Lagrone, and J. S. Plaxico. Resource Requirements, Costs, and Expected Returns; Alternative Crop and Livestock Enterprises; Loam Soils of the Rolling Plains of Southwestern Oklahoma. Stillwater: Oklahoma Agricultural Experiment Station and Farm Economics Division, ERS, USDA, Processed Series P-368, February, 1961.

Eckstein, O. Water Resource Development. Cambridge: Harvard University Press, 1958.

Edwards, C. "Resource Fixity and Farm Organization." Journal of Farm Economics, XLI (November, 1959), 747-759.

Garton, J. E. and A. D. Barefoot. Irrigation Experiments at Altus and El Reno, Oklahoma. Stillwater: Oklahoma Agricultural Experiment Station Bulletin B-534, July, 1959.

Garton, J. E. and W. D. Criddle. Estimates of Consumptive-Use and Irrigation Water Requirements of Crops in Oklahoma. Stillwater: Oklahoma Agricultural Experiment Station Technical Bulletin No. T-57, 1955.

Gass, Saul I. Linear Programming, Methods and Applications. New York: McGraw-Hill Book Company, 1964.

Gray, F. and H. M. Galloway. Soils of Oklahoma. Stillwater: Oklahoma Agricultural Experiment Station Miscellaneous Publication No. 56, July, 1956.

Greve, R. W., J. S. Plaxico, and W. F. Lagrone. Resource Requirements, Costs, and Expected Returns; Alternative Crop and Livestock Enterprises; Rolling Plains, Northwestern Oklahoma. Stillwater: Oklahoma Agricultural Experiment Station and Farm Economics Division, ERS, USDA, Processed Series, P-390, August, 1961.

Heady, E. O. Economics of Agricultural Production and Resource Use. Englewood Cliffs: Prentice-Hall, Inc., 1952.

_______ and W. C. Candler. Linear Programming Methods. Ames: Iowa State University Press, 1958.

Herpich, R. and R. D. McKinney. Irrigation Farming for Profit. Manhattan: Kansas Agricultural Experiment Station Circular 372, July, 1959.

Hirschleifer, J., J. C. DeHaven, and J. W. Millman. Water Supply: Economics, Technology, and Policy. Chicago: University of Chicago Press, 1960.

Huffman, R. E. Irrigation Development and Public Water Policy. New York: The Ronald Press Company, 1953.

Hughes, W. F. and A. C. Mager. Some Economic Effects of Adjusting to a Changing Water Supply, Texas High Plains. College Station: Texas Agricultural Experiment Station Bulletin 966, October, 1960.

_______. Water and Associated Costs in the Production of Cotton and Grain Sorghum, Texas High Plains, 1955. College Station: Texas Agricultural Experiment Station in cooperation with the U. S. Department of Agriculture, Bulletin 851, March, 1957.

_______, et al. Economics of Water Management for Cotton and Grain Sorghum Production, High Plains. College Station: Texas Agricultural Experiment Station in cooperation with the U. S. Department of Agriculture, Bulletin 931, May, 1959.

Isrealsen, O. W. Irrigation Principles and Practices, 2nd ed. New York: John Wiley and Sons, Inc., 1950.

Kalecki, M. "The Principles of Increasing Risk." Economica, IV (November, 1937) 440-447.

Kneese, A. Water Resources: Development and Use. Kansas City: Federal Reserve Bank of Kansas City, 1959.

Krutilla, J. and O. Eckstein. Multiple Purpose River Development. Baltimore: The Johns Hopkins Press, 1958.

Leftwich, R. H. The Price System and Resource Allocation, rev. ed. New York: Rinehart and Company, Inc., 1960.

Llewellyn, Robert W. Linear Programming. New York: Holt, Rinehart and Winston, 1964.

Maas, A., et al. Design of Water-Resource Systems. Cambridge: Harvard University Press, 1962.

Moreell, B. Our Nation's Water Resources - Policies and Politics. Chicago: University of Chicago Law School, 1956.

Otto, M. L. and W. H. Pine. Sprinkler Irrigation Costs and Returns, South-Central Kansas. Manhattan: Kansas Agricultural Experiment Station Circular No. 372, August, 1956.

President's Water Resources Council. Policies, Standards, and Procedures in the Formulation, Evaluation and Review of Plans for Use and Development of Water and Related Land Resources. Senate Document No. 97, 87th Congress, 2d Session. Washington: Government Printing Office, May, 1962.

Schaffner, L. W., L. D. Loftsgard, and D. C. Vochrodt. Production and Income Variability for Farm Enterprises on Irrigation and Dryland. Fargo: North Dakota Agricultural Experiment Station Technical Bulletin 445, 1963.

Steele, H. A. "Economics of Small Watershed Development." Agricultural Economics Research, VII (January, 1956) 17-23.

Subcommittee on Evaluation Standards of the Inter-Agency Committee on Water Resources. Proposed Practices for Economic Analysis of River Basin Projects. Washington: Government Printing Office, 1958.

Thomte, D., A. Olson, and L. D. Loftsgard. "Changes In North Dakota's Water Law." North Dakota Farm Research, XXII (1963) 4.

Thorne, D. W. and H. B. Peterson. Irrigated Soils, Their Fertility and Managemement, 2nd ed. New York: The Blakiston Company, Inc., 1954.

Timmons, J. F. "Economic Framework for Watershed Development." Journal of Farm Economics, XXXVI (December, 1954) 1170-1183.

Tolley, G. S. and F. E. Riggs, eds. Economics of Watershed Planning. Ames: Iowa State University Press, 1961.

United States Congress. United States Statutes at Large. 78th Congress, 2d Session, Public Law 534, Vol. 58, Part One. Washington: Government Printing Office, 1944, pp. 887-907.

United States Department of Agriculture, Soil Conservation Service. "Classification and Correlation of the Soils of Roger Mills County, Oklahoma." Unpublished report, Beltsville, February, 1961.

_______. "Crop Yield Estimates." Unpublished report, Stillwater.

_______. "Descriptive Legend, Roger Mills County Standard Soil Survey." Unpublished report, Beltsville, 1960.

_______. Progress Report. Stillwater: 1963. (Mimeographed.)

United States Department of Commerce, Bureau of Census. United States Census of Agriculture for Oklahoma, 1959, Vol. 1, Counties, Part 36, Oklahoma. Washington: 1961.

_______, Weather Bureau. Climatological Data, Oklahoma, 1914-1960, Volumes 23-69. Washington: 1960.

Voelker, S. W. and J. Muehlbeier. "Institutional Arrangements for Watershed Programs." Journal of Farm Economics, XXXVI (December, 1954) 1184-1196.

Western Agricultural Economics Research Council, Water Resources Development Committee. Water Resources and Economic Development of the West. Report No. 6, Small Watershed Development. Conference Proceedings, Berkeley, California, November, 1957.

_______. Water Resources and Economic Development of the West. Report No. 7, Alternative Water Uses. Conference Proceedings, Denver, Colorado, November, 1958.

Wallman, N. The Volue of Water in Alternative Uses. Albuquerque: University of New Mexico Press, 1962.

# A P P E N D I X E S

APPENDIX A, TABLE I

ASSUMED PRICES RECEIVED AS USED IN PROGRAMMING ANALYSIS[a]

| Item | Unit | Price (Dollars) |
|---|---|---|
| Crops: | | |
| Wheat | bu. | 1.80 |
| Barley | bu. | 0.83 |
| Grain Sorghum | cwt. | 1.70 |
| Oats | bu. | 0.64 |
| Cotton (Lint) | cwt. | 30.00 |
| Cotton (Seed) | cwt. | 2.50 |
| Alfalfa Hay | ton | 20.00 |
| Cattle: | | |
| Good Feeders (March) | cwt. | 22.12 |
| Good Feeders (May) | cwt. | 22.29 |
| Good Feeders (Oct.) | cwt. | 20.23 |
| Calves | | |
| Steers (July) | cwt. | 24.20 |
| Steers (Oct.) | cwt. | 23.42 |
| Heifers (July) | cwt. | 22.20 |
| Heifers (Oct.) | cwt. | 21.42 |
| Cull Cows (July) | cwt. | 13.95 |
| Cull Cows (Oct.) | cwt. | 13.13 |
| Dairy: | | |
| Milk | cwt. | 4.60 |
| Calves | head | 15.00 |
| Cull Heifers (1 yr.) | cwt. | 18.00 |
| Cull Heifers (2 yrs.) | cwt. | 16.00 |
| Cull Cows | cwt. | 12.50 |

[a]Prices are weighted average of 1961 prices. These prices are assumed to reflect as nearly as possible current prices.

APPENDIX A, TABLE II

ASSUMED PRICES PAID AS USED IN PROGRAMMING ANALYSIS

| Item | Unit | Price (Dollars) |
|---|---|---|
| Seed and Feed:[a] | | |
| Cotton Seed, Delinted | cwt. | 10.00 |
| Wheat Seed | bu. | 2.20 |
| Oat Seed | bu. | 1.00 |
| Barley Seed | bu. | 1.20 |
| Grain Sorghum Seed (Hybrid) | cwt. | 15.00 |
| Forage Sorghum Seed | cwt. | 7.00 |
| Sudan Seed (Sweet) | cwt. | 6.00 |
| Alfalfa Seed | lb. | 0.32 |
| Bermuda Sprigs | acre | 14.00 |
| Cottonseed Cake | ton | 76.00 |
| Cottonseed Meal | cwt. | 3.90 |
| Wheat Bran | cwt. | 2.50 |
| Salt | cwt. | 1.00 |
| Custom Rates: | | |
| Combining | acre | 3.00 |
| Cotton Stripping | cwt. S.C. | 0.75 |
| Cotton Snapping | cwt. S.C. | 2.00 |
| Cotton Ginning and Wrapping | cwt. S.C. | 0.85 |
| Cotton Defoliation | acre | 3.50 |
| Cotton Insect Control | acre | 2.50 |
| Pre-Emergence Chemical | acre | 2.50 |
| Hay Baling | bale | 0.16 |
| Grinding Feed | cwt. | 0.15 |
| Bermuda Sprigging | acre | 14.00 |

[a]Prices paid for small grains are current market price plus a charge for cleaning, treating, and hauling seed in addition to a slight handling charge.

# APPENDIX B

## LAND PRODUCTIVITY CLASSES AND ASSUMED YIELDS

The survey of watershed farmers in Roger Mills County provided a detailed description of land resources on each farm. This description included acres of cropland and non-cropland distributed between bottomland and upland. The legal description of each farm was obtained from the Roger Mills County Agricultural Stabilization and Conservation Office. A complete breakdown of all soil units in the study area was obtained from the Soil Conservation Service Office. These soil units were combined into classes having relatively equal productivity as measured by long-time yields and comparable physical characteristics. The final classification is defined in Table I, Chapter II.

After the productivity classes were defined, it was necessary to determine the number of acres of each productivity class included in the total land resources of each farm. Using the legal description of each farm and the detailed soils survey maps, the acres of each soil unit were measured for 40 of the 65 farms that were surveyed. The soil units on each farm were aggregated according to the definitions of the seven productivity classes. This aggregation provided the breakdown of land classes in Table III of Chapter II.

Crop yields were developed for each soil unit in connection with the detailed soil survey. Thus, the crop yields for each productivity class represents a weighted average of the yield of each soil unit in a given productivity class. The estimated yields of $L_1$ and $L_2$ land used in the programming analysis are presented in Table I of this Appendix.

APPENDIX B, TABLE I

ESTIMATED YIELDS FOR SELECTED CROPS ON LAND CLASSES $L_1$ AND $L_2$ WITH AVERAGE AND BELOW AVERAGE RAINFALL, BY LEVELS OF IRRIGATION (PER ACRE)[a]

| Crop and Levels of Irrigation | Unit | Average Rainfall $L_1$ Land | Average Rainfall $L_2$ Land | Below Average Rainfall $L_1$ Land | Below Average Rainfall $L_2$ Land |
|---|---|---|---|---|---|
| Cotton | | | | | |
| $I_0$ | lbs. lint | 290 | 257 | 207 | 184 |
| $I_1$ | " | 490 | 430 | 490 | 430 |
| $I_2$ | " | 620 | 550 | 620 | 550 |
| $I_3$ | " | 725 | 650 | 725 | 650 |
| Wheat | | | | | |
| $I_0$ | bu. | 22.00 | 18.00 | 14.00 | 11.00 |
| $I_1$ | " | 29.00 | 24.00 | 29.00 | 24.00 |
| $I_2$ | " | 36.00 | 32.00 | 36.00 | 32.00 |
| $I_3$ | " | 41.00 | 37.00 | 41.00 | 37.00 |
| Alfalfa | | | | | |
| $I_0$ | ton | 2.60 | 2.00 | 1.90 | 1.40 |
| $I_1$ | " | 4.30 | 3.20 | 4.30 | 3.20 |
| $I_2$ | " | 5.50 | 4.20 | 5.50 | 4.20 |
| $I_3$ | " | 6.40 | 5.00 | 6.40 | 5.00 |
| Grain Sorghum | | | | | |
| $I_0$ | cwt. | 21.00 | 16.50 | 13.30 | 10.50 |
| $I_1$ | " | 36.00 | 29.25 | 36.00 | 29.25 |
| $I_2$ | " | 39.50 | 31.75 | 39.50 | 31.75 |
| $I_3$ | " | 41.00 | 33.00 | 41.00 | 33.00 |
| Forage Sorghum | | | | | |
| $I_0$ | ton | 2.80 | 2.20 | 1.80 | 1.40 |
| $I_1$ | " | 8.50 | 7.00 | 8.50 | 7.00 |
| $I_2$ | " | 11.80 | 9.30 | 11.80 | 9.30 |
| $I_3$ | " | 14.00 | 11.00 | 14.00 | 11.00 |
| Bermuda | | | | | |
| $I_0$ | AUM | 4.00 | 3.50 | 2.00 | 1.50 |
| $I_1$ | " | 16.00 | 13.00 | 16.00 | 13.00 |

[a]Crop irrigation levels per acre are defined in Table V of Chapter II.

## APPENDIX C, TABLE I

## AVERAGE ANNUAL RAINFALL FOR HAMMON, OKLAHOMA, 1914-1960[a]

| Year | Annual Rainfall (Inches) | Year | Annual Rainfall (Inches) |
|---|---|---|---|
| 1914 | 15.65 | 1938 | 23.13 |
| 1915 | 41.39 | 1939 | 25.08 |
| 1916 | 17.44 | 1940 | 22.05 |
| 1917 | 16.61 | 1941 | 36.84 |
| 1918 | 31.17 | 1942 | 35.84 |
| 1919 | 26.97 | 1943 | 21.07 |
| 1920 | 36.81 | 1944 | 24.93 |
| 1921 | 21.77 | 1945 | 18.69 |
| 1922 | 24.63 | 1946 | 23.24 |
| 1923 | 46.00 | 1947 | 20.64 |
| 1924 | 23.49 | 1948 | 25.92 |
| 1925 | 21.04 | 1949 | 26.51 |
| 1926 | 33.56 | 1950 | 24.39 |
| 1927 | 23.47 | 1951 | 23.17 |
| 1928 | 27.39 | 1952 | 14.75 |
| 1929 | 25.51 | 1953 | 16.07 |
| 1930 | 24.77 | 1954 | 18.85 |
| 1931 | 23.80 | 1955 | 23.74 |
| 1932 | 25.06 | 1956 | 13.71 |
| 1933[b] | | 1957 | 32.76 |
| 1934 | 17.56 | 1958 | 22.51 |
| 1935 | 22.40 | 1959 | 35.27 |
| 1936 | 21.23 | 1960 | 32.55 |
| 1937 | 18.71 | | |

[a]The mean annual rainfall for 1914-1960 is 24.96 inches.

[b]Data were incomplete for 1933.

Source: United States Department of Commerce, Weather Bureau, Climatological Data, Oklahoma, 1914-1960.

## APPENDIX D

## DETERMINING TOTAL WATER REQUIREMENTS

The total water requirements of each crop for optimum plant growth was the basis for defining the highest level of irrigation. The total water requirement for each crop was computed by utilizing a procedure developed by Blaney and Criddle (Footnote 12, Chapter II). This procedure makes it possible to compute the total water requirement of each crop if the monthly temperature, latitude, and growing period of the crop are known and if the computed monthly percentage of annual daytime hours are available.

Estimated seasonal total water requirements in inches were computed from the following formula:

$$V = KF$$

where V = water use in inches

K = empirical seasonal coefficient for each crop - essentially a constant in an area where irrigation is practiced

F = sum of monthly factors (f) for the growing season [sum of the products of mean monthly temperature (t) and monthly percentage of annual daytime hours (p)].

The following example will illustrate the use of this procedure for computing the total water requirements for alfalfa for the month of April. The necessary coefficients are K = 0.85; t = 59.3; and p = 8.83.

$$V = \frac{0.85 \times 59.3 \times 8.83}{100} = 4.45 \text{ inches}$$

The total water requirement for alfalfa during April, consistent with optimum plant growth, was 4.45 inches. Assuming that the normal rainfall for April was 1.2 inches, the highest irrigation level for April would be 2.25 inches.

The total water requirements for the growing season were obtained by computing a monthly water requirement for each month during the growing season and summing the monthly requirements.

APPENDIX E

ENTERPRISE BUDGETS

The survey of watershed farms in Roger Mills County provided an inventory of machinery on these farms in 1961. These data indicated that a two-plow tractor with its complement of equipment predominated on farms classified as resource situations A, B, C, and D, while a four-plow tractor and its complement of machinery occurred on farms defined as resource situations E and F. Thus, the programming analysis was performed with coefficients consistent with two-plow tractor and equipment on resource situations A, B, C, and D, and using coefficients consistent with a four-plow tractor and equipment on resource situations E and F. Estimated cost per hour of use for two- and four-plow equipment is presented in Table I of this Appendix.

The enterprise budgets for activities included in this study were developed using machinery coefficients for a two-plow tractor and equipment (Tables II-XXI of this Appendix). The machinery costs in these budgets were adjusted to reflect cost coefficients for a four-plow tractor and set of equipment. Tables XXII and XXIII of this Appendix summarize gross income, production costs, and net income for the four-plow tractor and equipment. Tables XXIV and XXV show estimated labor requirements for dryland and irrigated crops for both two- and four-plow equipment.

The beef cow-calf and beef feeder enterprises included in one or more of the programmed optimum farm plans are presented in Tables XXVI-XXIX of this Appendix.

A Grade A dairy enterprise was included as a production activity in this study. The coefficients for this enterprise were developed from recommendations of staff members in the Department of Dairy, Oklahoma State University. A budget for this enterprise is presented in Table XXX of this Appendix.

APPENDIX E, TABLE I

ESTIMATED COST PER HOUR OF USE FOR SPECIFIED MACHINERY ASSOCIATED WITH TWO- AND FOUR-PLOW TRACTORS

| | Two-Plow | | Four-Plow | |
|---|---|---|---|---|
| Item | Specifications | Cost Per Hour of Use | Specifications | Cost Per Hour of Use |
| Tractor | 3 or 2-16 tricycle, L.P., P.S., PTO, 3-point, hydraulic system, 43 h.p. | 1.00 | 4 or 3-16 tricycle, L.P., P.S., PTO, hydraulic system, 51 h.p. | 1.27 |
| Moldboard Plow | 2-16" integral | 0.25 | 4-14" integral | 0.46 |
| One-Way | 8' | 0.33 | 12' | 0.57 |
| Tool Bar (Hoeme) | 8' | 0.26 | 12' | 0.34 |
| Tandem Disk | 6-7' integral | 0.13 | 10' wheel type | 0.29 |
| Cultivator | 2-row | 0.15 | 4-row | 0.32 |
| Rotary Hoe | 7' integral | 0.17 | 14' | 0.29 |
| Spike Tooth Harrow | 18' | 0.05 | 24' | 0.07 |
| Planter | 2-row | 0.33 | 4-row | 0.77 |
| Grain Drill | 16-8" press wheel fertilizer | 0.78 | 16-8" press wheel fertilizer | 0.78 |
| Power Mower | 7' integral | 0.27 | 7' integral | 0.27 |
| Side Delivery Rake | 10' P.T.O. | 0.34 | 7' P.T.O. | 0.34 |
| Gyromor (Stalk Cutter) | 5' | 0.22 | 5' | 0.22 |

Source: William F. Lagrone, unpublished data. Cost per hour of use includes repair, lubrication, depreciation due to wear, fuel, and oil. All figures are based on the assumption that the equipment will wear out before it becomes obsolete.

APPENDIX E, TABLE II

PRODUCTION COSTS AND RETURNS FOR COTTON ON LAND CLASS $L_1$ WITH AVERAGE RAINFALL, BY LEVELS OF IRRIGATION (PER ACRE)

| Item | Unit | Price or Cost per Unit | Levels of Irrigation[a] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $I_0$ | | $I_1$ | | $I_2$ | | $I_3$ | |
| | | | Quantity | Value or Cost | Quantity | Value or Cost | Quantity | Value or Cost | Quantity | Value or Cost |
| Production: | | | | | | | | | | |
| Lint | cwt. | 30.00 | 2.90 | 87.00 | 4.90 | 147.00 | 6.20 | 186.00 | 7.25 | 217.50 |
| Seed | cwt. | 2.50 | 4.84 | 12.10 | 8.18 | 20.45 | 10.35 | 25.88 | 12.10 | 30.25 |
| Total | | | | 99.10 | | 167.45 | | 211.88 | | 247.75 |
| Inputs: | | | | | | | | | | |
| Seed | lb. | 0.10 | 22.00 | 2.20 | 22.00 | 2.20 | 22.00 | 2.20 | 22.00 | 2.20 |
| Power | hr. | 1.00 | 5.56 | 5.56 | 5.56 | 5.56 | 5.56 | 5.56 | 5.56 | 5.56 |
| Other Machinery | hr. | 0.20 | 5.05 | 1.01 | 5.05 | 1.01 | 5.05 | 1.01 | 5.05 | 1.01 |
| Irrigation | | | | | | | | | | |
| Fuel and Oil | acre | | | | | 4.50 | | 9.75 | | 15.00 |
| Fixed Cost and Maint. | acre | 8.06 | | | 1.00 | 8.06 | 1.00 | 8.06 | 1.00 | 8.06 |
| Insecticide | acre | 2.50 | 1.00 | 2.50 | 4.00 | 10.00 | 4.00 | 10.00 | 4.00 | 10.00 |
| Hoeing | acre | 2.00 | 1.00 | 2.00 | 1.00 | 2.00 | 1.00 | 2.00 | 1.00 | 2.00 |
| Desiccant | acre | 3.00 | 0.67 | 2.00 | 1.00 | 3.00 | 1.00 | 3.00 | 1.00 | 3.00 |
| Pre-Emergence Chemical | acre | 2.50 | 1.00 | 2.50 | 1.00 | 2.50 | 1.00 | 2.50 | 1.00 | 2.50 |
| Fertilizer 0-33-0 | cwt. | 4.00 | 0.80 | 3.20 | 4.00 | 4.00 | 1.00 | 4.00 | 1.00 | 4.00 |
| Fertilizer 16-20-0 | cwt. | 4.45 | - | - | 1.50 | 6.68 | 1.50 | 6.68 | 1.50 | 6.68 |
| Snapping | cwt. S.C. | 2.00 | 6.82 | 13.64 | 11.53 | 23.06 | 14.59 | 29.18 | 17.06 | 34.12 |
| Stripping | cwt. S.C. | 0.75 | 4.55 | 3.41 | 7.69 | 5.77 | 9.73 | 7.30 | 11.37 | 8.53 |
| Hauling | cwt. S.C. | 0.25 | 11.37 | 2.84 | 19.22 | 4.80 | 24.32 | 6.08 | | 7.11 |
| Gin and Wrap | cwt. S.C. | 0.85 | 11.37 | 9.66 | 19.22 | 16.34 | 24.32 | 20.67 | 28.43 | 24.17 |
| Interest on Operating Capital | dol. | 0.06 | 27.83 | 1.67 | 83.71 | 5.02 | 87.26 | 5.24 | 91.57 | 5.49 |
| Total Specified Costs | dol. | | | 52.19 | | 104.50 | | 123.23 | | 139.43 |
| Returns to Land, Labor, Risk, and Management | dol. | | | 46.91 | | 62.95 | | 88.65 | | 108.32 |

[a] See Table V of Chapter II for definition of irrigation levels.

APPENDIX E, TABLE III

PRODUCTION COSTS AND RETURNS FOR COTTON ON LAND CLASS $L_2$ WITH AVERAGE RAINFALL BY LEVELS OF IRRIGATION (PER ACRE)

| Item | Unit | Price or Cost per Unit | Levels of Irrigation[a] $I_0$ Quantity | $I_0$ Value or Cost | $I_1$ Quantity | $I_1$ Value or Cost | $I_2$ Quantity | $I_2$ Value or Cost | $I_3$ Quantity | $I_3$ Value or Cost |
|---|---|---|---|---|---|---|---|---|---|---|
| Production: | | | | | | | | | | |
| Lint | cwt. | 30.00 | 2.57 | 77.10 | 4.30 | 129.00 | 5.50 | 165.00 | 6.50 | 195.00 |
| Seed | cwt. | 2.50 | 4.29 | 10.72 | 7.18 | 17.95 | 9.20 | 23.00 | 10.85 | 27.12 |
| Total | | | | 87.82 | | 146.95 | | 188.00 | | 222.12 |
| Inputs: | | | | | | | | | | |
| Seed | lb. | 0.10 | 22.00 | 2.20 | 22.00 | 2.20 | 22.00 | 2.20 | 22.00 | 2.20 |
| Power | hr. | 1.00 | 5.56 | 5.56 | 5.56 | 5.56 | 5.56 | 5.56 | 5.56 | 5.56 |
| Other Machinery | hr. | 0.20 | 5.05 | 1.01 | 5.05 | 1.01 | 5.05 | 1.01 | 5.05 | 1.01 |
| Irrigation | | | | | | | | | | |
| Fuel and Oil | acre | | - | | - | 4.50 | - | 9.75 | - | 15.00 |
| Fixed Cost and Maint. | acre | 8.06 | - | | 1.00 | 8.06 | 1.00 | 8.06 | 1.00 | 8.06 |
| Insecticide | acre | 2.50 | 1.00 | 2.50 | 4.00 | 10.00 | 4.00 | 10.00 | 4.00 | 10.00 |
| Hoeing | acre | 2.00 | 1.00 | 2.00 | 1.00 | 2.00 | 1.00 | 2.00 | 1.00 | 2.00 |
| Desiccant | acre | 3.00 | 0.67 | 2.00 | 1.00 | 3.00 | 1.00 | 3.00 | 1.00 | 3.00 |
| Pre-Emergence Chemical | acre | 2.50 | 1.00 | 2.50 | 1.00 | 2.50 | 1.00 | 2.50 | 1.00 | 2.50 |
| Fertilizer 0-33-0 | cwt. | 4.00 | 0.80 | 3.20 | 4.00 | 4.00 | 1.00 | 4.00 | 1.00 | 4.00 |
| Fertilizer 16-20-0 | cwt. | 4.45 | - | - | 1.50 | 6.68 | 1.50 | 6.68 | 1.50 | 6.68 |
| Snapping | cwt. S.C. | 2.00 | 6.05 | 12.10 | 10.12 | 20.24 | 12.97 | 25.94 | 15.30 | 30.60 |
| Stripping | cwt. S.C. | 0.75 | 4.03 | 3.02 | 6.75 | 5.06 | 8.65 | 6.49 | 10.20 | 7.65 |
| Hauling | cwt. S.C. | 0.25 | 10.08 | 2.52 | 16.87 | 4.22 | 21.62 | 5.40 | 25.50 | 6.38 |
| Gin and Wrap | cwt. S.C. | 0.85 | 10.08 | 8.57 | 16.87 | 14.34 | 21.62 | 18.38 | 25.50 | 21.68 |
| Interest on Operating Capital | dol. | 0.06 | 27.83 | 1.67 | 83.71 | 5.02 | 87.26 | 5.24 | 91.57 | 5.49 |
| Total Specified Costs | dol | | | 48.85 | | 98.39 | | 116.21 | | 131.81 |
| Returns to Land, Labor, Risk and Management | dol. | | | 38.97 | | 48.56 | | 71.79 | | 90.31 |

[a]See Table V of Chapter II for definitions of irrigation levels.

APPENDIX E, TABLE IV

PRODUCTION COSTS AND RETURNS FOR COTTON ON LAND CLASS $L_1$ WITH BELOW AVERAGE RAINFALL, BY LEVELS OF IRRIGATION (PER ACRE)

| | | | Levels of Irrigation[a] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $I_0$ | | $I_1$ | | $I_2$ | | $I_3$ | |
| Item | Unit | Price or Cost per Unit | Quantity | Value or Cost | Quantity | Value or Cost | Quantity | Value or Cost | Quantity | Value or Cost |
| Production: | | | | | | | | | | |
| Lint | cwt. | 30.00 | 2.07 | 62.10 | 4.90 | 147.00 | 6.20 | 186.00 | 7.25 | 217.50 |
| Seed | cwt. | 2.50 | 3.45 | 8.62 | 8.18 | 20.45 | 10.35 | 25.88 | 12.10 | 30.25 |
| Total | | | | 70.72 | | 167.45 | | 211.88 | | 247.75 |
| Inputs: | | | | | | | | | | |
| Seed | lb. | 0.10 | 22.00 | 2.20 | 22.00 | 2.20 | 22.00 | 2.20 | 22.00 | 2.20 |
| Power | hr. | 1.00 | 5.56 | 5.56 | 5.56 | 5.56 | 5.56 | 5.56 | 5.56 | 5.56 |
| Other Machinery | hr. | 0.20 | 5.05 | 1.01 | 5.05 | 1.01 | 5.05 | 1.01 | 5.05 | 1.01 |
| Irrigation | | | | | | | | | | |
| Fuel and Oil | acre | 3.00 | | | | 8.25 | | 13.50 | | 18.75 |
| Fixed Cost and Maint. | acre | 8.06 | | | 1.00 | 8.06 | 1.00 | 8.06 | 1.00 | 8.06 |
| Insecticide | acre | 2.50 | 1.00 | 2.50 | 4.00 | 10.00 | 4.00 | 10.00 | 4.00 | 10.00 |
| Hoeing | acre | 2.00 | 1.00 | 2.00 | 1.00 | 2.00 | 1.00 | 2.00 | 1.00 | 2.00 |
| Desiccant | acre | 3.00 | 0.67 | 2.00 | 1.00 | 3.00 | 1.00 | 3.00 | 1.00 | 3.00 |
| Pre-Emergence Chemical | acre | 2.50 | 1.00 | 2.50 | 1.00 | 2.50 | 1.00 | 2.50 | 1.00 | 2.50 |
| Fertilizer 0-33-0 | cwt. | 4.00 | 0.80 | 3.20 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 |
| Fertilizer 16-20-0 | cwt. | 4.45 | - | - | 1.50 | 6.68 | 1.50 | 6.68 | 1.50 | 6.68 |
| Snapping | cwt. S.C. | 2.00 | 4.86 | 9.72 | 11.53 | 23.06 | 14.59 | 29.18 | 17.06 | 34.12 |
| Stripping | cwt. S.C. | 0.75 | 3.24 | 2.43 | 7.69 | 5.77 | 9.73 | 7.30 | 11.37 | 8.53 |
| Hauling | cwt. S.C. | 0.25 | 8.10 | 2.02 | 19.22 | 4.80 | 24.32 | 6.08 | 28.43 | 7.11 |
| Gin and Wrap | cwt. S.C. | 0.85 | 8.10 | 6.88 | 19.22 | 16.34 | 24.32 | 20.67 | 28.43 | 24.17 |
| Interest on Operating Capital | dol. | 0.06 | 27.83 | 1.67 | 86.51 | 5.19 | 90.44 | 5.43 | | 5.66 |
| Total Specified Costs | dol. | | | 43.69 | | 108.42 | | 127.17 | | 143.35 |
| Returns to Land, Labor, Risk, and Management | dol. | | | 27.03 | | 59.03 | | 84.71 | | 104.40 |

[a]See Table V of Chapter II for definition of irrigation levels.

APPENDIX E, TABLE V

PRODUCTION COSTS AND RETURNS FOR COTTON ON LAND CLASS $L_2$ WITH BELOW AVERAGE RAINFALL, BY LEVELS OF IRRIGATION (PER ACRE)

| Item | Unit | Price or Cost per Unit | Levels of Irrigation[a] $I_0$ Quantity | $I_0$ Value or Cost | $I_1$ Quantity | $I_1$ Value or Cost | $I_2$ Quantity | $I_2$ Value or Cost | $I_3$ Quantity | $I_3$ Value or Cost |
|---|---|---|---|---|---|---|---|---|---|---|
| Production: | | | | | | | | | | |
| Lint | cwt. | 30.00 | 1.84 | 55.20 | 4.30 | 129.00 | 5.50 | 165.00 | 6.50 | 195.00 |
| Seed | cwt. | 2.50 | 3.06 | 7.65 | 7.18 | 17.95 | 9.20 | 23.00 | 10.85 | 27.12 |
| Total | | | | 62.85 | | 146.95 | | 188.00 | | 222.12 |
| Inputs: | | | | | | | | | | |
| Seed | lb. | 0.10 | 22.00 | 2.20 | 22.00 | 2.20 | 22.00 | 2.20 | 22.00 | 2.20 |
| Power | hr. | 1.00 | 5.56 | 5.56 | 5.56 | 5.56 | 5.56 | 5.56 | 5.56 | 5.56 |
| Other Machinery | hr. | 0.20 | 5.05 | 1.01 | 5.05 | 1.01 | 5.05 | 1.01 | 5.05 | 1.01 |
| Irrigation | | | | | | | | | | |
| Fuel and Oil | acre | 3.00 | | | | 8.25 | | 13.50 | | 18.75 |
| Fixed Cost and Maint. | acre | 8.06 | | | 1.00 | 8.06 | 1.00 | 8.06 | 1.00 | 8.06 |
| Insecticide | acre | 2.50 | 1.00 | 2.50 | 4.00 | 10.00 | 4.00 | 10.00 | 4.00 | 10.00 |
| Hoeing | acre | 2.00 | 1.00 | 2.00 | 1.00 | 2.00 | 1.00 | 2.00 | 1.00 | 2.00 |
| Desiccant | acre | 3.00 | 0.67 | 2.00 | 1.00 | 3.00 | 1.00 | 3.00 | 1.00 | 3.00 |
| Pre-Emergence Chemical | acre | 2.50 | 1.00 | 2.50 | 1.00 | 2.50 | 1.00 | 2.50 | 1.00 | 2.50 |
| Fertilizer 0-33-0 | cwt. | 4.00 | 0.80 | 3.20 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 |
| Fertilizer 16-20-0 | cwt. | 4.45 | | | 1.50 | 6.68 | 1.50 | 6.68 | 1.50 | 6.68 |
| Snapping | cwt. S.C. | 2.00 | 4.31 | 8.62 | 10.12 | 20.24 | 12.97 | 25.94 | 15.30 | 30.60 |
| Stripping | cwt. S.C. | 0.75 | 2.88 | 2.16 | 6.75 | 5.06 | 8.65 | 6.49 | 10.20 | 7.65 |
| Hauling | cwt. S.C. | 0.25 | 7.19 | 1.80 | 16.87 | 4.22 | 21.62 | 5.40 | 25.50 | 6.38 |
| Gin and Wrap | cwt. S.C. | 0.85 | 7.19 | 6.11 | 16.87 | 14.34 | 21.62 | 18.38 | 25.50 | 21.68 |
| Interest on Operating Capital | dol. | 0.06 | 27.83 | 1.67 | 86.51 | 5.19 | 90.44 | 5.43 | 94.38 | 5.66 |
| Total Specified Costs | dol. | | | 41.33 | | 102.31 | | 120.15 | | 135.73 |
| Returns to Land, Labor, Risk, and Management | dol. | | | 21.52 | | 44.64 | | 67.85 | | 86.39 |

[a]See Table V of Chapter II for definition of irrigation levels.

## APPENDIX E, TABLE VI

## PRODUCTION COSTS AND RETURNS FOR WHEAT ON LAND CLASS $L_1$ WITH AVERAGE RAINFALL, BY LEVELS OF IRRIGATION (PER ACRE)

| Item | Unit | Price or Cost per Unit | Level of Irrigation[a] $I_0$ Quantity | $I_0$ Value or Cost | $I_1$ Quantity | $I_1$ Value or Cost | $I_2$ Quantity | $I_2$ Value or Cost | $I_3$ Quantity | $I_3$ Value or Cost |
|---|---|---|---|---|---|---|---|---|---|---|
| Production: | | | | | | | | | | |
| Wheat | bu. | 1.80 | 22.00 | 39.60 | 29.00 | 52.20 | 36.00 | 64.80 | 41.00 | 73.80 |
| Grazing | AUM | | 0.50 | | 0.65 | | 0.75 | | 0.85 | |
| Total | | | | 39.60 | | 52.20 | | 64.80 | | 73.80 |
| Inputs: | | | | | | | | | | |
| Seed | bu. | 2.20 | 1.00 | 2.20 | 1.00 | 2.20 | 1.00 | 2.20 | 1.00 | 2.20 |
| Power | hr. | 1.00 | 2.08 | 2.08 | 2.08 | 2.08 | 2.08 | 2.08 | 2.08 | 2.08 |
| Other Machinery | hr. | 0.24 | 1.89 | 0.45 | 1.89 | 0.45 | 1.89 | 0.45 | 1.89 | 0.45 |
| Irrigation | | | | | | | | | | |
| Fuel and Oil | acre | 2.85 | | | | 3.56 | | 7.12 | | 10.69 |
| Fixed Cost and Maint. | acre | 8.06 | | | 1.00 | 8.06 | 1.00 | 8.06 | 1.00 | 8.06 |
| Fertilizer 33-0-0 | cwt. | 4.00 | 0.80 | 2.00 | 0.75 | 3.00 | 0.75 | 3.00 | 0.75 | 3.00 |
| Fertilizer 0-45-0 | cwt. | 3.95 | | | 0.50 | 1.98 | 0.50 | 1.98 | 0.50 | 1.98 |
| Combining | acre | 3.00 | 1.00 | 3.10 | 1.00 | 3.45 | 1.00 | 3.80 | 1.00 | 4.00 |
| Hauling | bu. | 0.07 | 22.00 | 1.54 | 29.00 | 2.03 | 36.00 | 2.52 | 41.00 | 2.87 |
| Interest on Operating Capital | dol. | 0.06 | 13.10 | 0.79 | 59.84 | 3.59 | 62.51 | 3.75 | 63.27 | 3.79 |
| Total Specified Costs | dol. | | | 12.16 | | 30.40 | | 34.96 | | 39.12 |
| Returns to Land, Labor, Risk, and Management | dol. | | | 27.44 | | 21.80 | | 29.84 | | 34.68 |

[a]See Table V of Chapter II for definition of irrigation levels.

APPENDIX E, TABLE VII

PRODUCTION COSTS AND RETURNS FOR WHEAT ON LAND CLASS $L_2$ WITH AVERAGE RAINFALL, BY LEVELS OF IRRIGATION (PER ACRE)

| Item | Unit | Price of Cost per Unit | Levels of Irrigation[a] $I_0$ Quantity | $I_0$ Value or Cost | $I_1$ Quantity | $I_1$ Value or Cost | $I_2$ Quantity | $I_2$ Value or Cost | $I_3$ Quantity | $I_3$ Value or Cost |
|---|---|---|---|---|---|---|---|---|---|---|
| **Production:** | | | | | | | | | | |
| Wheat | bu. | 1.80 | 18.00 | 32.40 | 24.00 | 43.20 | 32.00 | 57.60 | 37.00 | 66.60 |
| Grazing | AUM | -- | 0.40 | | 0.50 | | 0.65 | | 0.70 | |
| Total | | | | 32.40 | | 43.20 | | 57.60 | | 66.60 |
| **Inputs:** | | | | | | | | | | |
| Seed | bu. | 2.20 | 1.00 | 2.20 | 1.00 | 2.20 | 1.00 | 2.20 | 1.00 | 2.20 |
| Power | hr. | 1.00 | 2.08 | 2.08 | 2.08 | 2.08 | 2.08 | 2.08 | 2.08 | 2.08 |
| Other Machinery | hr. | 0.24 | 1.89 | 0.45 | 1.89 | 0.45 | 1.89 | 0.45 | 1.89 | 0.45 |
| Irrigation | | | | | | | | | | |
| Fuel and Oil | acre | 2.85 | | | | 3.56 | | 7.12 | | 10.69 |
| Fixed Cost and Maint. | acre | 8.06 | | | 1.00 | 8.06 | 1.00 | 8.06 | 1.00 | 8.06 |
| Fertilizer 33-0-0 | cwt. | 4.00 | 0.50 | 2.00 | 0.75 | 3.00 | 0.75 | 3.00 | 0.75 | 3.00 |
| Fertilizer 0-45-0 | cwt. | 3.95 | | | 0.50 | 1.98 | 0.50 | 1.98 | 0.50 | 1.98 |
| Combining | acre | 3.00 | 1.00 | 3.00 | 1.00 | 3.45 | 1.00 | 3.60 | 1.00 | 3.85 |
| Hauling | bu. | 0.07 | 18.00 | 1.26 | 24.00 | 1.68 | 32.00 | 2.24 | 37.00 | 2.59 |
| Interest on Operating Capital | dol. | 0.06 | 13.10 | 0.79 | 59.84 | 3.59 | 62.51 | 3.75 | 63.21 | 3.79 |
| Total Specified Costs | dol. | | | 11.78 | | 29.80 | | 34.48 | | 38.69 |
| Returns to Land, Labor, Risk, and Management | dol. | | | 20.62 | | 13.40 | | 23.12 | | 27.91 |

[a]See Table V of Chapter II for definition of irrigation levels.

APPENDIX E, TABLE VIII

PRODUCTION COSTS AND RETURNS FOR WHEAT ON LAND CLASS $L_1$ WITH BELOW AVERAGE RAINFALL, BY LEVELS OF IRRIGATION (PER ACRE)

| | | | Level of Irrigation[a] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $I_0$ | | $I_1$ | | $I_2$ | | $I_3$ | |
| Item | Unit | Price of Cost per Unit | Quantity | Value or Cost | Quantity | Value or Cost | Quantity | Value or Cost | Quantity | Value or Cost |
| Production: | | | | | | | | | | |
| Wheat | bu. | 1.80 | 14.00 | 25.20 | 29.00 | 52.20 | 36.00 | 64.80 | 41.00 | 73.80 |
| Grazing | AUM | | 0.35 | | 0.65 | | 0.75 | | 0.85 | |
| Total | | | | 25.20 | | 52.20 | | 64.80 | | 73.80 |
| Inputs: | | | | | | | | | | |
| Seed | bu. | 2.20 | 1.00 | 2.20 | 1.00 | 2.20 | 1.00 | 2.20 | 1.00 | 2.20 |
| Power | hr. | 1.00 | 2.08 | 2.08 | 2.08 | 2.08 | 2.08 | 2.08 | 2.08 | 2.08 |
| Other Machinery | hr. | 0.24 | 1.89 | 0.45 | 1.89 | 0.45 | 1.89 | 0.45 | 1.89 | 0.45 |
| Irrigation | | | | | | | | | | |
| Fuel and Oil | acre | 2.85 | | | | 5.70 | | 9.68 | | 14.25 |
| Fixed Cost and Maint. | acre | 8.06 | | | 1.00 | 8.06 | 1.00 | 8.06 | 1.00 | 8.06 |
| Fertilizer 33-0-0 | cwt. | 4.00 | 0.50 | 2.00 | 0.75 | 3.00 | 0.75 | 3.00 | 0.75 | 3.00 |
| Fertilizer 0-45-0 | cwt. | 3.95 | | | 0.50 | 1.98 | 0.50 | 1.98 | 0.50 | 1.98 |
| Combining | acre | 3.00 | 1.00 | 3.00 | 1.00 | 3.45 | 1.00 | 3.80 | 1.00 | 4.15 |
| Hauling | bu. | 0.07 | 14.00 | 0.98 | 29.00 | 2.03 | 36.00 | 2.52 | 43.00 | 3.01 |
| Interest on Operating Capital | dol. | 0.06 | 13.10 | 0.79 | 61.45 | 3.69 | 64.43 | 3.87 | 67.86 | 4.07 |
| Total Specified Cost | dol. | | | 11.50 | | 32.64 | | 37.64 | | 43.25 |
| Returns to Land, Labor, Risk, and Management | dol. | | | 13.70 | | 19.56 | | 27.16 | | 30.55 |

[a]See Table V of Chapter II for definition of irrigation levels.

APPENDIX E, TABLE IX

PRODUCTION COSTS AND RETURNS FOR WHEAT ON LAND CLASS $L_2$ WITH BELOW AVERAGE RAINFALL, BY LEVELS OF IRRIGATION (PER ACRE)

| Item | Unit | Price or Cost per Unit | Level of Irrigation[a] $I_0$ Quantity | $I_0$ Value or Cost | $I_1$ Quantity | $I_1$ Value or Cost | $I_2$ Quantity | $I_2$ Value or Cost | $I_3$ Quantity | $I_3$ Value or Cost |
|---|---|---|---|---|---|---|---|---|---|---|
| Production: | | | | | | | | | | |
| Wheat | bu. | 1.80 | 11.00 | 19.80 | 24.00 | 43.20 | 32.00 | 57.60 | 37.00 | 66.60 |
| Grazing | AUM | | 0.25 | | 0.50 | | 0.65 | | 0.70 | |
| Total | | | | 19.80 | | 43.20 | | 57.60 | | 66.60 |
| Inputs: | | | | | | | | | | |
| Seed | bu. | 2.20 | 1.00 | 2.20 | 1.00 | 2.20 | 1.00 | 2.20 | 1.00 | 2.20 |
| Power | hr. | 1.00 | 2.08 | 2.08 | 2.08 | 2.08 | 2.08 | 2.08 | 2.08 | 2.08 |
| Other Machinery | hr. | 0.24 | 1.89 | 0.45 | 1.89 | 0.45 | 1.89 | 0.45 | 1.89 | 0.45 |
| Irrigation | | | | | | | | | | |
| Fuel and Oil | acre | 2.85 | | | | 5.70 | | 9.68 | | 14.25 |
| Fixed Cost and Maint. | acre | 8.06 | | | 1.00 | 8.06 | 1.00 | 8.06 | 1.00 | 8.06 |
| Fertilizer 33-0-0 | cwt. | 4.00 | 0.50 | 2.00 | 0.75 | 3.00 | 0.75 | 3.00 | 0.75 | 3.00 |
| Fertilizer 0-45-0 | cwt. | 3.95 | | | 0.50 | 1.98 | 0.50 | 1.98 | 0.50 | 1.98 |
| Combining | acre | 3.00 | 1.00 | 3.00 | 1.00 | 3.45 | 1.00 | 3.60 | 1.00 | 3.85 |
| Hauling | bu. | 0.07 | 11.00 | 0.77 | 24.00 | 1.68 | 32.00 | 2.24 | 37.00 | 2.59 |
| Interest on Operating Capital | dol. | 0.06 | 13.10 | 0.79 | 61.45 | 3.69 | 64.43 | 3.87 | 67.86 | 4.07 |
| Total Specified Costs | dol. | | | 11.29 | | 32.29 | | 37.16 | | 42.53 |
| Returns to Land, Labor, Risk, and Management | dol. | | | 8.51 | | 10.91 | | 20.44 | | 24.07 |

[a]See Table V of Chapter II for definition of irrigation levels.

APPENDIX E, TABLE X

PRODUCTION COSTS AND RETURNS FOR GRAIN SORGHUM ON LAND CLASS $L_1$ WITH AVERAGE RAINFALL, BY LEVELS OF IRRIGATION (PER ACRE)

| | | | Level of Irrigation[a] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $I_0$ | | $I_1$ | | $I_2$ | | $I_3$ | |
| Item | Unit | Price or Cost per Unit | Quantity | Value or Cost | Quantity | Value or Cost | Quantity | Value or Cost | Quantity | Value or Cost |
| Production: | | | | | | | | | | |
| Milo Grain | cwt. | 1.70 | 21.00 | 35.70 | 36.00 | 61.20 | 39.50 | 67.15 | 41.00 | 69.70 |
| Total | | | | 35.70 | | 61.20 | | 67.15 | | 69.70 |
| Inputs: | | | | | | | | | | |
| Seed | lb. | 0.15 | 5.00 | 0.75 | 5.00 | 0.75 | 5.00 | 0.75 | 5.00 | 0.75 |
| Power | hr. | 1.00 | 3.05 | 3.05 | 3.05 | 3.05 | 3.05 | 3.05 | 3.05 | 3.05 |
| Other Machinery | hr. | 0.27 | 2.18 | 0.59 | 2.18 | 0.59 | 2.18 | 0.59 | 2.18 | 0.59 |
| Irrigation | | | | | | | | | | |
| Fuel and Oil | acre | 2.85 | | | | 2.85 | | 4.99 | | 7.12 |
| Fixed Cost and Maint. | acre | 8.06 | | | 1.00 | 8.06 | 1.00 | 8.06 | 1.00 | 8.06 |
| Fertilizer 0-45-0 | cwt. | 3.95 | | | 0.50 | 1.98 | 0.50 | 1.98 | 0.50 | 1.98 |
| Fertilizer 32-0-0 | cwt. | 4.00 | | | 1.00 | 4.00 | 1.00 | 4.00 | 1.00 | 4.00 |
| Combining | acre | 3.00 | 1.00 | 3.05 | 1.00 | 3.80 | 1.00 | 3.95 | 1.00 | 4.00 |
| Hauling | cwt. | 0.13 | 21.00 | 2.73 | 36.50 | 4.68 | 39.50 | 5.14 | 41.00 | 5.33 |
| Interest on Operating Capital | dol. | 0.06 | 11.16 | 0.67 | 59.48 | 3.57 | 61.08 | 3.66 | 62.68 | 3.76 |
| Total Specified Costs | dol. | | | 10.84 | | 33.33 | | 36.17 | | 38.64 |
| Returns to Land, Labor, Risk, and Management | dol. | | | 24.86 | | 27.87 | | 30.98 | | 31.06 |

[a]See Table V of Chapter II for definition of irrigation levels.

APPENDIX E, TABLE XI

PRODUCTION COSTS AND RETURNS FOR GRAIN SORGHUM ON LAND CLASS $L_2$ WITH AVERAGE RAINFALL, BY LEVELS OF IRRIGATION (PER ACRE)

| | | | Levels of Irrigation[a] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $I_0$ | | $I_1$ | | $I_2$ | | $I_3$ | |
| Item | Unit | Price or Cost per Unit | Quantity | Value or Cost | Quantity | Value or Cost | Quantity | Value or Cost | Quantity | Value or Cost |
| Production: | | | | | | | | | | |
| Milo Grain | cwt. | 1.70 | 16.50 | 28.05 | 29.25 | 49.72 | 31.75 | 53.98 | 33.00 | 56.10 |
| Total | | | | 28.05 | | 49.72 | | 53.98 | | 56.10 |
| Inputs: | | | | | | | | | | |
| Seed | lb. | 0.15 | 5.00 | 0.75 | 5.00 | 0.75 | 5.00 | 0.75 | 5.00 | 0.75 |
| Power | hr. | 1.00 | 3.05 | 3.05 | 3.05 | 3.05 | 3.05 | 3.05 | 3.05 | 3.05 |
| Other Machinery | hr. | 0.27 | 2.18 | 0.59 | 2.18 | 0.59 | 2.18 | 0.59 | 2.18 | 0.59 |
| Irrigation | | | | | | | | | | |
| Fuel and Oil | acre | 2.85 | | | | 2.85 | | 4.99 | | 7.12 |
| Fixed Cost and Maint | acre | 8.06 | | | 1.00 | 8.06 | 1.00 | 8.06 | 1.00 | 8.06 |
| Fertilizer 0-45-0 | cwt. | 3.95 | | | 0.50 | 1.98 | 0.50 | 1.98 | 0.50 | 1.98 |
| Fertilizer 32-0-0 | cwt. | 4.00 | | | 1.00 | 4.00 | 1.00 | 4.00 | 1.00 | 4.00 |
| Combining | acre | 3.00 | 1.00 | 3.00 | 1.00 | 3.46 | 1.00 | 3.60 | 1.00 | 3.65 |
| Hauling | cwt. | 0.13 | 16.50 | 2.14 | 29.25 | 3.80 | 31.75 | 4.13 | 33.00 | 4.29 |
| Interest on Operating Capital | dol. | 0.06 | 11.16 | 0.67 | 59.48 | 3.57 | 61.08 | 3.66 | 62.68 | 3.76 |
| Total Specified Costs | dol. | | | 10.20 | | 32.11 | | 34.81 | | 37.25 |
| Returns to Land, Labor, Risk, and Management | dol. | | | 17.85 | | 17.61 | | 19.17 | | 18.85 |

[a]See Table V of Chapter II for definition of irrigation levels.

APPENDIX E, TABLE XII

PRODUCTION COSTS AND RETURNS FOR GRAIN SORGHUM ON LAND CLASS $L_1$ WITH BELOW AVERAGE RAINFALL, BY LEVELS OF IRRIGATION (PER ACRE)

| Item | Unit | Price or Cost per Unit | Levels of Irrigation[a] $I_0$ Quantity | $I_0$ Value or Cost | $I_1$ Quantity | $I_1$ Value or Cost | $I_2$ Quantity | $I_2$ Value or Cost | $I_3$ Quantity | $I_3$ Value or Cost |
|---|---|---|---|---|---|---|---|---|---|---|
| Production: | | | | | | | | | | |
| Milo Grain | cwt. | 1.70 | 13.30 | 22.61 | 36.00 | 61.20 | 39.50 | 67.15 | 41.00 | 69.70 |
| Total | | | | 22.61 | | 61.20 | | 67.15 | | 69.70 |
| Inputs: | | | | | | | | | | |
| Seed | lb. | 0.15 | 5.00 | 0.75 | 5.00 | 0.75 | 5.00 | 0.75 | 5.00 | 0.75 |
| Power | hr. | 1.00 | 3.05 | 3.05 | 3.05 | 3.05 | 3.05 | 3.05 | 3.05 | 3.05 |
| Other Machinery | hr. | 0.27 | 2.18 | 0.59 | 2.18 | 0.59 | 2.18 | 0.59 | 2.18 | 0.59 |
| Irrigation | | | | | | | | | | |
| Fuel and Oil | acre | 2.85 | | | | 5.70 | | 7.84 | | 9.98 |
| Fixed Cost and Maint. | acre | 8.06 | | | 1.00 | 8.06 | 1.00 | 8.06 | 1.00 | 8.06 |
| Fertilizer 0-45-0 | cwt. | 3.95 | | | 0.50 | 1.98 | 0.50 | 1.98 | 0.50 | 1.98 |
| Fertilizer 32-0-0 | cwt. | 4.00 | | | 1.00 | 4.00 | 1.00 | 4.00 | 1.00 | 4.00 |
| Combining | acre | 3.00 | 1.00 | 3.00 | 1.00 | 3.00 | 1.00 | 3.95 | 1.00 | 4.00 |
| Hauling | cwt. | 0.13 | 13.30 | 1.73 | 36.00 | 4.68 | 39.50 | 5.14 | 41.00 | 5.33 |
| Interest on Operating Capital | dol. | 0.06 | 11.16 | 0.67 | 61.62 | 3.70 | 63.22 | 3.79 | 64.82 | 3.89 |
| Total Specified Costs | dol. | | | 9.79 | | 35.51 | | 39.15 | | 41.63 |
| Returns to Land, Labor, Risk, and Management | dol. | | | 12.82 | | 25.69 | | 28.00 | | 28.07 |

[a]See Table V of Chapter II for definition of irrigation levels.

## APPENDIX E, TABLE XIII

### PRODUCTION COSTS AND RETURNS FOR GRAIN SORGHUM ON LAND CLASS $L_2$ WITH BELOW AVERAGE RAINFALL, BY LEVELS OF IRRIGATION (PER ACRE)

| Item | Unit | Price or Cost per Unit | Levels of Irrigation[a] $I_0$ Quantity | $I_0$ Value or Cost | $I_1$ Quantity | $I_1$ Value or Cost | $I_2$ Quantity | $I_2$ Value or Cost | $I_3$ Quantity | $I_3$ Value or Cost |
|---|---|---|---|---|---|---|---|---|---|---|
| Production: | | | | | | | | | | |
| Milo Grain | cwt. | 1.70 | 10.50 | 17.85 | 29.25 | 49.72 | 31.75 | 53.98 | 33.00 | 56.10 |
| Total | | | | 17.85 | | 49.72 | | 53.98 | | 56.10 |
| Inputs: | | | | | | | | | | |
| Seed | lb. | 0.15 | 5.00 | 0.75 | 5.00 | 0.75 | 5.00 | 0.75 | 5.00 | 0.75 |
| Power | hr. | 1.00 | 3.05 | 3.05 | 3.05 | 3.05 | 3.05 | 3.05 | 3.05 | 3.05 |
| Other Machinery | hr. | 0.27 | 2.18 | 0.59 | 2.18 | 0.59 | 2.18 | 0.59 | 2.18 | 0.59 |
| Irrigation | | | | | | | | | | |
| Fuel and Oil | acre | 2.85 | | | | 5.70 | | 7.84 | | 9.98 |
| Fixed Cost and Maint. | acre | 8.06 | | | 1.00 | 8.06 | 1.00 | 8.06 | 1.00 | 8.06 |
| Fertilizer 0-45-0 | cwt. | 3.95 | | | 0.50 | 1.98 | 0.50 | 1.98 | 0.50 | 1.98 |
| Fertilizer 32-0-0 | cwt. | 4.00 | | | 1.00 | 4.00 | 1.00 | 4.00 | 1.00 | 4.00 |
| Combining | acre | 3.00 | 1.00 | 3.00 | 1.00 | 3.00 | 1.00 | 3.60 | 1.00 | 3.65 |
| Hauling | cwt. | 0.13 | 10.50 | 1.36 | 29.25 | 3.80 | 31.75 | 4.13 | 33.00 | 4.29 |
| Interest on Operating Capital | dol. | 0.06 | 11.16 | 0.67 | | | | | | |
| Total Specified Costs | dol. | | | 9.42 | | 34.63 | | 37.79 | | 40.24 |
| Returns to Land, Labor, Risk, and Management | dol. | | | 8.43 | | 15.09 | | 16.19 | | 15.86 |

[a]See Table V of Chapter II for definition of irrigation levels.

## APPENDIX E, TABLE XIV

### PRODUCTION COSTS AND RETURNS FOR ALFALFA ON LAND CLASS $L_1$ WITH AVERAGE RAINFALL, BY LEVELS OF IRRIGATION (PER ACRE)

| | | | Levels of Irrigation[a] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $I_0$ | | $I_1$ | | $I_2$ | | $I_3$ | |
| Item | Unit | Price or Cost per Unit | Quantity | Value or Cost | Quantity | Value or Cost | Quantity | Value or Cost | Quantity | Value or Cost |
| Production: | | | | | | | | | | |
| Hay | ton | 20.00 | 2.60 | 52.00 | 4.30 | 86.00 | 5.50 | 110.00 | 6.40 | 128.00 |
| Total | | | | 52.00 | | 86.00 | | 110.00 | | 128.00 |
| Inputs:[b] | | | | | | | | | | |
| Seed | lb. | 0.32 | 5.00 | 1.60 | 5.00 | 1.60 | 5.00 | 1.60 | 5.00 | 1.60 |
| Power | hr. | 1.00 | 3.90 | 3.90 | 3.90 | 3.90 | 3.90 | 3.90 | 3.90 | 3.90 |
| Other Machinery | hr. | 0.38 | 3.55 | 1.35 | 3.55 | 1.35 | 3.55 | 1.35 | 3.55 | 1.35 |
| Irrigation | | | | | | | | | | |
| Fuel and Oil | acre | 2.85 | | | | 4.28 | | 8.55 | | 12.82 |
| Fixed Cost and Maint. | acre | 8.06 | | | 1.00 | 8.06 | 1.00 | 8.06 | 1.00 | 8.06 |
| Fertilizer 0-45-0 | cwt. | 3.95 | | | 1.50 | 5.92 | 1.50 | 5.92 | 1.50 | 5.92 |
| Baling | ton | 4.80 | 2.60 | 12.48 | 4.30 | 20.64 | 5.50 | 26.40 | 6.20 | 29.76 |
| Hauling | ton | 2.50 | 2.60 | 6.50 | 4.30 | 10.75 | 5.50 | 13.75 | 6.20 | 15.50 |
| Interest on Operating Capital | dol. | 0.06 | 27.74 | 1.66 | 75.61 | 4.54 | 78.81 | 4.73 | 81.42 | 4.89 |
| Total Specified Costs | dol. | | | 27.49 | | 61.04 | | 74.26 | | 83.80 |
| Returns to Land, Labor, Risk, and Management | dol. | | | 24.51 | | 24.96 | | 35.74 | | 44.20 |

[a]See Table V of Chapter II for definition of irrigation levels.

[b]Establishment costs prorated over four years are included.

APPENDIX E, TABLE XV

PRODUCTION COSTS AND RETURNS FOR ALFALFA ON LAND CLASS $L_2$ WITH AVERAGE RAINFALL, BY LEVELS OF IRRIGATION (PER ACRE)

| | | | Levels of Irrigation[a] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $I_0$ | | $I_1$ | | $I_2$ | | $I_3$ | |
| Item | Unit | Price or Cost per Unit | Quantity | Value or Cost | Quantity | Value or Cost | Quantity | Value or Cost | Quantity | Value or Cost |
| Production: | | | | | | | | | | |
| Hay | ton | 20.00 | 2.00 | 40.00 | 3.20 | 64.00 | 4.20 | 84.00 | 5.00 | 100.00 |
| Total | | | | 40.00 | | 64.00 | | 84.00 | | 100.00 |
| Inputs:[b] | | | | | | | | | | |
| Seed | lb. | 0.32 | 5.00 | 1.60 | 5.00 | 1.60 | 5.00 | 1.60 | 5.00 | 1.60 |
| Power | hr. | 1.00 | 3.90 | 3.90 | 3.90 | 3.90 | 3.90 | 3.90 | 3.90 | 3.90 |
| Other Machinery | hr. | 0.38 | 3.55 | 1.35 | 3.55 | 1.35 | 3.55 | 1.35 | 3.55 | 1.35 |
| Irrigation | | | | | | | | | | |
| Fuel and Oil | acre | 2.85 | | | | 4.28 | | 8.55 | | 12.82 |
| Fixed Cost and Maint. | acre | 8.06 | | | 1.00 | 8.06 | 1.00 | 8.06 | 1.00 | 8.06 |
| Fertilizer 0-45-0 | cwt. | 3.95 | | | 1.50 | 5.92 | 1.50 | 5.92 | 1.50 | 5.92 |
| Baling | ton | 4.80 | 2.00 | 9.60 | 3.20 | 15.36 | 4.20 | 20.16 | 5.00 | 24.00 |
| Hauling | ton | 2.50 | 2.00 | 5.00 | 3.20 | 8.00 | 4.20 | 10.50 | 5.00 | 12.50 |
| Interest on Operating Capital | dol. | 0.06 | 27.74 | 1.66 | 75.61 | 4.54 | 78.81 | 4.73 | 81.42 | 4.89 |
| Total Specified Costs | dol. | | | 23.11 | | 53.01 | | 64.77 | | 75.04 |
| Returns to Land, Labor, Risk, and Management | dol. | | | 16.89 | | 10.99 | | 19.23 | | 24.96 |

[a]See Table V of Chapter II for definition of irrigation levels.

[b]Establishment costs prorated over four years are included.

## APPENDIX E, TABLE XVI

### PRODUCTION COSTS AND RETURNS FOR ALFALFA ON LAND CLASS $L_1$ WITH BELOW AVERAGE RAINFALL BY LEVELS OF IRRIGATION (PER ACRE)

| | | | Levels of Irrigation[a] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $I_0$ | | $I_1$ | | $I_2$ | | $I_3$ | |
| Item | Unit | Price or Cost per Unit | Quantity | Value or Cost | Quantity | Value or Cost | Quantity | Value or Cost | Quantity | Value or Cost |
| Production: | | | | | | | | | | |
| Hay | ton | 20.00 | 1.90 | 38.00 | 4.30 | 86.00 | 5.50 | 110.00 | 6.40 | 128.00 |
| Total | | | | 38.00 | | 86.00 | | 110.00 | | 128.00 |
| Inputs:[b] | | | | | | | | | | |
| Seed | lb. | 0.32 | 5.00 | 1.60 | 5.00 | 1.60 | 5.00 | 1.60 | 5.00 | 1.60 |
| Power | hr. | 1.00 | 3.90 | 3.90 | 3.90 | 3.90 | 3.90 | 3.90 | 3.90 | 3.90 |
| Other Machinery | hr. | 0.38 | 3.55 | 1.35 | 3.55 | 1.35 | 3.55 | 1.35 | 3.55 | 1.35 |
| Irrigation | | | | | | | | | | |
| Fuel and Oil | acre | 2.85 | | | | 7.84 | | 12.11 | | 16.39 |
| Fixed Cost and Maint. | acre | 8.06 | | | 1.00 | 8.06 | 1.00 | 8.06 | 1.00 | 8.06 |
| Fertilizer 0-45-0 | cwt. | 3.95 | | | 1.50 | 5.92 | 1.50 | 5.92 | 1.50 | 5.92 |
| Baling | ton | 4.80 | 1.90 | 9.12 | 4.30 | 20.64 | 5.50 | 26.40 | 6.40 | 29.76 |
| Hauling | ton | 2.50 | 1.90 | 4.75 | 4.30 | 10.75 | 5.50 | 13.75 | 6.40 | 15.50 |
| Interest on Operating Capital | dol. | 0.06 | 27.74 | 1.66 | 78.28 | 4.70 | 81.48 | 4.89 | 84.70 | 5.08 |
| Total Specified Costs | dol. | | | 22.38 | | 64.76 | | 77.98 | | 87.56 |
| Returns to Land, Labor, Risk, and Management | dol. | | | 15.62 | | 21.24 | | 32.02 | | 40.44 |

[a]See Table V of Chapter II for definition of irrigation levels.

[b]Establishment costs prorated over four years are included.

APPENDIX E, TABLE XVII

PRODUCTION COSTS AND RETURNS FOR ALFALFA ON LAND CLASS $L_2$ WITH BELOW AVERAGE RAINFALL, BY LEVELS OF IRRIGATION (PER ACRE)

| | | | Levels of Irrigation[a] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $I_0$ | | $I_1$ | | $I_2$ | | $I_3$ | |
| Item | Unit | Price or Cost per Unit | Quantity | Value or Cost | Quantity | Value or Cost | Quantity | Value or Cost | Quantity | Value or Cost |
| Production: | | | | | | | | | | |
| Hay | ton | 20.00 | 1.40 | 28.00 | 3.20 | 64.00 | 4.20 | 84.00 | 5.00 | 100.00 |
| Total | | | | 28.00 | | 64.00 | | 84.00 | | 100.00 |
| Inputs:[b] | | | | | | | | | | |
| Seed | lb. | 0.32 | 5.00 | 1.60 | 5.00 | 1.60 | 5.00 | 1.60 | 5.00 | 1.60 |
| Power | hr. | 1.00 | 3.90 | 3.90 | 3.90 | 3.90 | 3.90 | 3.90 | 3.90 | 3.90 |
| Other Machinery | hr. | 0.38 | 3.55 | 1.35 | 3.55 | 1.35 | 3.55 | 1.35 | 3.55 | 1.35 |
| Irrigation | | | | | | | | | | |
| Fuel and Oil | acre | 2.85 | | | | 7.84 | | 12.11 | | 16.39 |
| Fixed Cost and Maint. | acre | 8.06 | | | 1.00 | 8.06 | 1.00 | 8.06 | 1.00 | 8.06 |
| Fertilizer 0-45-0 | cwt. | 3.95 | | | 1.50 | 5.92 | 1.50 | 5.92 | 1.50 | 5.92 |
| Baling | ton | 4.80 | 1.40 | 6.72 | 3.20 | 15.36 | 4.20 | 20.16 | 5.00 | 24.00 |
| Hauling | ton | 2.50 | 1.40 | 3.50 | 3.20 | 8.00 | 4.20 | 10.50 | 5.00 | 12.50 |
| Interest on Operating Capital | dol. | 0.06 | 27.74 | 1.66 | 78.28 | 4.70 | 81.48 | 4.89 | 84.70 | 5.08 |
| Total Specified Costs | dol. | | | 18.73 | | 56.73 | | 68.49 | | 78.80 |
| Returns to Land, Labor, Risk, and Management | dol. | | | 9.27 | | 7.27 | | 15.51 | | 21.20 |

[a]See Table V of Chapter II for definition of irrigation levels.

[b]Establishment costs prorated over four years are included.

## APPENDIX E, TABLE XVIII

## PRODUCTION COSTS AND RETURNS FOR FORAGE SORGHUM SILAGE ON LAND CLASS $L_1$ WITH AVERAGE RAINFALL, BY LEVELS OF IRRIGATION (PER ACRE)

| Item | Unit | Price or Cost per Unit | Levels of Irrigation[a] $I_0$ Quantity | $I_0$ Value or Cost | $I_1$ Quantity | $I_1$ Value or Cost | $I_2$ Quantity | $I_2$ Value or Cost | $I_3$ Quantity | $I_3$ Value or Cost |
|---|---|---|---|---|---|---|---|---|---|---|
| Production: | | | | | | | | | | |
| Silage | ton | | 2.80 | | 8.50 | | 11.80 | | 14.00 | |
| Inputs: | | | | | | | | | | |
| Seed | lb. | 0.07 | 6.00 | 0.42 | 6.00 | 0.42 | 6.00 | 0.42 | 6.00 | 0.42 |
| Power | hr. | 1.00 | 4.69 | 4.69 | 4.69 | 4.69 | 4.69 | 4.69 | 4.69 | 4.69 |
| Other Machinery | hr. | 0.25 | 4.26 | 1.06 | 4.26 | 1.06 | 4.26 | 1.06 | 4.26 | 1.06 |
| Irrigation | | | | | | | | | | |
| Fuel and Oil | acre | 2.85 | | | | 2.85 | | 4.99 | | 7.12 |
| Fixed Cost and Maint. | acre | 8.06 | | | 1.00 | 8.06 | 1.00 | 8.06 | 1.00 | 8.06 |
| Fertilizer 32-0-0 | cwt. | 4.00 | | | 0.75 | 3.00 | 0.75 | 3.00 | 0.75 | 3.00 |
| Harvesting | ton | 4.80 | 2.80 | 13.44 | 8.00 | 38.40 | 11.80 | 56.64 | 14.00 | 7.20 |
| Hauling | ton | 2.40 | 2.40 | 6.72 | 8.00 | 19.20 | 11.80 | 28.32 | 14.00 | 33.60 |
| Interest on Operating Capital | dol. | 0.06 | 37.18 | 2.23 | 83.02 | 4.98 | 83.55 | 5.01 | 84.15 | 5.05 |
| Total Specified Costs Above Land, Labor, Risk, and Management | dol. | | | 28.56 | | 82.66 | | 112.19 | | 130.20 |

[a]See Table V of Chapter II for definition of irrigation levels.

APPENDIX E, TABLE XIX

PRODUCTION COSTS AND RETURNS FOR FORAGE SORGHUM SILAGE ON LAND CLASS $L_2$ WITH AVERAGE RAINFALL, BY LEVELS OF IRRIGATION (PER ACRE)

| | | | Levels of Irrigation[a] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $I_0$ | | $I_1$ | | $I_2$ | | $I_3$ | |
| Item | Unit | Price or Cost per Unit | Quantity | Value or Cost | Quantity | Value or Cost | Quantity | Value or Cost | Quantity | Value or Cost |
| Production: | | | | | | | | | | |
| Silage | ton | | 2.20 | | 7.00 | | 9.30 | | 11.00 | |
| Inputs: | | | | | | | | | | |
| Seed | lb. | 0.07 | 6.00 | 0.42 | 6.00 | 0.42 | 6.00 | 0.42 | 6.00 | 0.42 |
| Power | hr. | 1.00 | 4.69 | 4.69 | 4.60 | 4.69 | 4.69 | 4.69 | 4.69 | 4.69 |
| Other Machinery | hr. | 0.25 | 4.26 | 1.06 | 4.26 | 1.06 | 4.26 | 1.06 | 4.26 | 1.06 |
| Irrigation | | | | | | | | | | |
| Fuel and Oil | acre | 2.85 | | | | 2.85 | | 4.99 | | 7.12 |
| Fixed Cost and Maint. | acre | 8.06 | | | 1.00 | 8.06 | 1.00 | 8.06 | 1.00 | 8.06 |
| Fertilizer 32-0-0 | cwt. | 4.00 | | | 0.75 | 3.00 | 0.75 | 3.00 | 0.75 | 3.00 |
| Harvesting | ton | 4.80 | 2.20 | 10.56 | 7.00 | 33.60 | 9.30 | 44.64 | 11.00 | 52.80 |
| Hauling | ton | 2.40 | 2.20 | 5.28 | 7.00 | 16.80 | 9.30 | 22.32 | 11.00 | 26.40 |
| Interest on Operating Capital | dol. | 0.06 | 35.86 | 2.15 | 83.02 | 4.98 | 84.63 | 5.08 | 86.23 | 5.17 |
| Total Specified Costs Above Land, Labor, Risk, and Management | dol. | | | 24.16 | | 75.46 | | 94.26 | | 108.72 |

[a]See Table V of Chapter II for definition of irrigation levels.

## APPENDIX E, TABLE XX

### PRODUCTION COSTS AND RETURNS FOR FORAGE SORGHUM SILAGE ON LAND CLASS $L_1$ WITH BELOW AVERAGE RAINFALL, BY LEVELS OF IRRIGATION (PER ACRE)

| | | | Levels of Irrigation[a] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $I_0$ | | $I_1$ | | $I_2$ | | $I_3$ | |
| Item | Unit | Price or Cost per Unit | Quantity | Value or Cost | Quantity | Value or Cost | Quantity | Value or Cost | Quantity | Value or Cost |
| Production: | | | | | | | | | | |
| Silage | ton | | 1.80 | | 8.50 | | 11.80 | | 14.00 | |
| Inputs: | | | | | | | | | | |
| Seed | lb. | 0.07 | 6.00 | 0.42 | 6.00 | 0.42 | 6.00 | 0.42 | 6.00 | 0.42 |
| Power | hr. | 1.00 | 4.69 | 4.60 | 4.69 | 4.69 | 4.69 | 4.69 | 4.69 | 4.69 |
| Other Machinery | hr. | 0.25 | 4.26 | 1.06 | 4.26 | 1.06 | 4.26 | 1.06 | 4.26 | 1.06 |
| Irrigation | | | | | | | | | | |
| Fuel and Oil | acre | 2.85 | | | | 5.70 | | 7.84 | | 9.98 |
| Fixed Cost and Maint. | acre | 8.06 | | | 1.00 | 8.06 | 1.00 | 8.06 | 1.00 | 8.06 |
| Fertilizer 32-0-0 | cwt. | 4.00 | | | 0.75 | 3.00 | 0.75 | 3.00 | 0.75 | 3.00 |
| Harvesting | ton | 4.80 | 1.80 | 8.64 | 8.50 | 40.80 | 11.80 | 56.64 | 14.00 | 67.20 |
| Hauling | ton | 2.40 | 1.80 | 4.32 | 8.50 | 20.40 | 11.80 | 28.32 | 14.00 | 36.60 |
| Interest on Operating Capital | dol. | 0.06 | 35.86 | 2.15 | 84.09 | 5.05 | 85.69 | 5.14 | 87.29 | 5.24 |
| Total Specified Costs Above Land, Labor, Risk, and Management | dol. | | | 21.28 | | 89.18 | | 115.17 | | 136.25 |

[a]See Table V of Chapter II for definition of irrigation levels.

## APPENDIX E, TABLE XXI

### PRODUCTION COSTS AND RETURNS FOR FORAGE SORGHUM SILAGE ON LAND CLASS $L_2$ WITH BELOW AVERAGE RAINFALL, BY LEVELS OF IRRIGATION (PER ACRE)

| | | | Levels of Irrigation[a] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $I_0$ | | $I_1$ | | $I_2$ | | $I_3$ | |
| Item | Unit | Price or Cost per Unit | Quantity | Value or Cost | Quantity | Value or Cost | Quantity | Value or Cost | Quantity | Value or Cost |
| Production: | | | | | | | | | | |
| Silage | ton | | 1.40 | | 7.00 | | 9.30 | | 11.00 | |
| Inputs: | | | | | | | | | | |
| Seed | lb. | 0.07 | 6.00 | 0.42 | 6.00 | 0.42 | 6.00 | 0.42 | 6.00 | 0.42 |
| Power | hr. | 1.00 | 4.69 | 4.69 | 4.69 | 4.69 | 4.69 | 4.69 | 4.69 | 4.69 |
| Other Machinery | hr. | 0.25 | 4.26 | 1.06 | 4.26 | 1.06 | 4.26 | 1.06 | 4.26 | 1.06 |
| Irrigation | | | | | | | | | | |
| Fuel and Oil | acre | 2.85 | | | | 5.70 | | 7.84 | | 9.98 |
| Fixed Cost and Maint. | acre | 8.06 | | | 1.00 | 8.06 | 1.00 | 8.06 | 1.00 | 8.06 |
| Fertilizer 32-0-0 | cwt. | 4.00 | | | 0.75 | 3.00 | 0.75 | 3.00 | 0.75 | 3.00 |
| Harvesting | ton | 4.80 | 1.40 | 6.72 | 7.00 | 33.60 | 9.30 | 44.64 | 11.00 | 52.80 |
| Hauling | ton | 2.40 | 1.40 | 3.36 | 7.00 | 16.80 | 9.30 | 22.32 | 11.00 | 26.40 |
| Interest on Operating Capital | dol. | 0.06 | 35.86 | 2.15 | 84.09 | 5.05 | 85.69 | 5.14 | 87.29 | 5.24 |
| Total Specified Costs Above Land, Labor, Risk, and Management | dol. | | | 18.40 | | 78.38 | | 97.17 | | 111.65 |

[a]See Table V of Chapter II for definition of irrigation levels.

APPENDIX E, TABLE XXII

ESTIMATED GROSS INCOME, PRODUCTION COSTS, AND NET INCOME FOR SELECTED CROPS WITH AVERAGE RAINFALL AND 4-PLOW TRACTOR AND EQUIPMENT, BY LEVELS OF IRRIGATION (PER ACRE)

| Crop and Levels of Irrigation | Gross Income | | Production Costs[a] | | Net Income[b] | |
|---|---|---|---|---|---|---|
| | $L_1$ Land | $L_2$ Land | $L_1$ Land | $L_2$ Land | $L_1$ Land | $L_2$ Land |
| Cotton | | | | | | |
| $I_0$ | 99.10 | 87.82 | 49.63 | 46.29 | 49.47 | 41.53 |
| $I_1$ | 167.45 | 146.95 | 101.41 | 95.30 | 66.04 | 51.65 |
| $I_2$ | 211.88 | 188.00 | 120.15 | 113.13 | 91.23 | 74.87 |
| $I_3$ | 247.75 | 222.12 | 136.34 | 128.72 | 111.41 | 93.40 |
| Wheat | | | | | | |
| $I_0$ | 39.60 | 32.40 | 11.05 | 10.77 | 28.55 | 21.63 |
| $I_1$ | 52.20 | 43.20 | 28.75 | 28.15 | 23.45 | 15.05 |
| $I_2$ | 64.80 | 57.60 | 33.31 | 32.83 | 31.49 | 24.77 |
| $I_3$ | 73.80 | 66.60 | 37.59 | 37.16 | 36.21 | 29.44 |
| Alfalfa | | | | | | |
| $I_0$ | 52.00 | 40.00 | 30.25 | 25.87 | 21.75 | 14.13 |
| $I_1$ | 86.00 | 39.60 | 28.51 | 27.91 | 20.09 | 11.69 |
| $I_2$ | 110.00 | 84.00 | 73.91 | 64.42 | 36.09 | 19.58 |
| $I_3$ | 128.00 | 100.00 | 83.48 | 74.72 | 44.52 | 25.28 |
| Grain Sorghum | | | | | | |
| $I_0$ | 52.00 | 40.00 | 30.25 | 25.87 | 21.75 | 14.13 |
| $I_1$ | 86.00 | 64.00 | 60.92 | 52.89 | 25.08 | 11.11 |
| $I_2$ | 61.20 | 49.72 | 31.49 | 30.27 | 29.71 | 19.45 |
| $I_3$ | 170.00 | 140.00 | 86.00 | 74.78 | 84.00 | 65.22 |
| Forage Sorghum | | | | | | |
| $I_0$ | | | 27.29 | 22.64 | | |
| $I_1$ | | | 86.00 | 74.78 | | |
| $I_2$ | | | 114.16 | 95.35 | | |
| $I_3$ | | | 133.19 | 110.56 | | |
| Bermuda | | | | | | |
| $I_0$ | | | 5.83 | 5.83 | | |
| $I_1$ | | | 36.83 | 36.83 | | |

[a]Production costs include cost of seed, fertilizer, weed and insect chemicals, power and machinery, harvesting, and interest on operating capital.

[b]Net income is defined as returns to land, family labor, management, and risk.

APPENDIX E, TABLE XXIII

ESTIMATED GROSS INCOME, PRODUCTION COSTS, AND NET INCOME FOR SELECTED CROPS WITH BELOW AVERAGE RAINFALL AND 4-PLOW TRACTOR AND EQUIPMENT, BY LEVELS OF IRRIGATION (PER ACRE)

| | Gross Income | | Production Costs[a] | | Net Income[b] | |
|---|---|---|---|---|---|---|
| | $L_1$ Land | $L_2$ Land | $L_1$ Land | $L_2$ Land | $L_1$ Land | $L_2$ Land |
| Cotton | | | | | | |
| $I_0$ | 70.72 | 62.85 | 41.13 | 38.77 | 29.59 | 24.08 |
| $I_1$ | 167.95 | 146.95 | 105.93 | 99.82 | 62.02 | 47.13 |
| $I_2$ | 211.88 | 188.00 | 124.57 | 117.55 | 87.31 | 70.45 |
| $I_3$ | 247.75 | 222.12 | 140.84 | 133.22 | 106.91 | 88.90 |
| Wheat | | | | | | |
| $I_0$ | 25.20 | 19.80 | 9.99 | 9.78 | 15.21 | 10.02 |
| $I_1$ | 52.20 | 43.20 | 30.56 | 29.96 | 21.64 | 13.24 |
| $I_2$ | 64.80 | 57.60 | 35.56 | 35.08 | 29.24 | 22.52 |
| $I_3$ | 73.80 | 66.60 | 40.88 | 40.45 | 32.92 | 26.15 |
| Alfalfa | | | | | | |
| $I_0$ | 38.00 | 28.00 | 25.14 | 21.49 | 12.86 | 6.51 |
| $I_1$ | 86.00 | 64.00 | 62.69 | 54.66 | 23.31 | 9.34 |
| $I_2$ | 110.00 | 84.00 | 75.64 | 66.15 | 34.36 | 17.85 |
| $I_3$ | 128.00 | 100.00 | 85.50 | 76.70 | 42.50 | 23.30 |
| Grain Sorghum | | | | | | |
| $I_0$ | 22.61 | 17.85 | 8.84 | 8.47 | 13.77 | 9.38 |
| $I_1$ | 61.20 | 49.72 | 33.34 | 32.46 | 27.86 | 17.26 |
| $I_2$ | 67.15 | 53.98 | 36.99 | 35.63 | 30.16 | 18.35 |
| $I_3$ | 69.70 | 56.10 | 39.47 | 38.08 | 30.23 | 18.02 |
| Forage Sorghum | | | | | | |
| $I_0$ | | | 19.81 | 16.66 | | |
| $I_1$ | | | 87.03 | 76.23 | | |
| $I_2$ | | | 113.00 | 95.00 | | |
| $I_3$ | | | 134.08 | 109.48 | | |
| Bermuda | | | | | | |
| $I_0$ | | | 5.92 | 5.92 | | |
| $I_1$ | | | 41.33 | 41.33 | | |

[a]Production costs include cost of seed, fertilizer, weed and insect chemicals, power and machinery, harvesting, and interest on operating capital.

[b]Net income is defined as returns to land, family labor, management, and risk.

## APPENDIX E, TABLE XXIV

### ESTIMATED LABOR REQUIREMENTS FOR SELECTED CROPS WITH AVERAGE RAINFALL, BY LEVELS OF IRRIGATION (PER ACRE)[a]

| Crop and Levels of Irrigation | Two-Plow Equipment | | | | | Four-Plow Equipment | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Jan.-April | May-July | Aug. Sept. | Oct.-Dec. | Total | Jan.-April | May-July | Aug. Sept. | Oct.-Dec. | Total |
| Cotton | | | | | | | | | | |
| $I_0$ | 2.14 | 2.42 | 0.30 | 0.15 | 5.01 | 1.27 | 1.23 | 0.15 | 0.15 | 2.80 |
| $I_1$ | 2.14 | 5.42 | 0.35 | 0.15 | 8.06 | 1.27 | 4.23 | 0.20 | 0.15 | 5.85 |
| $I_2$ | 2.14 | 8.98 | 0.40 | 0.15 | 11.67 | 1.27 | 7.79 | 0.25 | 0.15 | 9.46 |
| $I_3$ | 2.14 | 10.08 | 2.85 | 0.35 | 15.42 | 1.27 | 8.89 | 2.70 | 0.35 | 13.21 |
| Wheat | | | | | | | | | | |
| $I_0$ | | 1.49 | 0.63 | 0.20 | 2.32 | | 0.83 | 0.42 | 0.20 | 1.45 |
| $I_1$ | 2.00 | 1.67 | 0.73 | 0.20 | 4.60 | 2.00 | 1.01 | 0.52 | 0.20 | 3.73 |
| $I_2$ | 2.00 | 1.75 | 0.73 | 2.30 | 6.78 | 2.00 | 1.09 | 0.52 | 2.30 | 5.91 |
| $I_3$ | 4.00 | 1.84 | 0.73 | 2.30 | 8.87 | 4.00 | 1.18 | 0.52 | 2.30 | 8.00 |
| Alfalfa | | | | | | | | | | |
| $I_0$ | | 3.56 | 0.80 | 0.09 | 4.45 | | 3.39 | 0.67 | 0.09 | 4.15 |
| $I_1$ | 0.15 | 5.70 | 0.85 | 0.09 | 6.79 | 0.15 | 5.53 | 0.72 | 0.09 | 6.49 |
| $I_2$ | 0.15 | 7.95 | 0.85 | 0.09 | 9.04 | 0.15 | 7.78 | 0.72 | 0.09 | 8.74 |
| $I_3$ | 0.15 | 7.95 | 3.05 | 0.09 | 11.24 | 0.15 | 7.78 | 2.92 | 0.09 | 10.94 |
| Grain Sorghum | | | | | | | | | | |
| $I_0$ | 0.84 | 1.11 | 0.83 | 0.05 | 2.83 | 0.47 | 0.61 | 0.55 | 0.03 | 1.66 |
| $I_1$ | 0.84 | 3.20 | 1.05 | 0.05 | 5.14 | 0.47 | 2.70 | 0.77 | 0.05 | 3.99 |
| $I_2$ | 0.84 | 4.71 | 1.11 | 0.05 | 6.71 | 0.47 | 4.21 | 0.83 | 0.05 | 5.56 |
| $I_3$ | 0.84 | 6.19 | 1.17 | 0.05 | 8.25 | 0.47 | 5.69 | 0.89 | 0.05 | 7.10 |
| Forage Sorghum | | | | | | | | | | |
| $I_0$ | 1.88 | 2.03 | 0.80 | | 4.71 | 1.02 | 0.72 | | | 1.74 |
| $I_1$ | 1.88 | 5.03 | 1.25 | | 8.16 | 1.02 | 3.72 | 0.45 | | 5.19 |
| $I_2$ | 1.88 | 6.89 | 2.87 | | 11.64 | 1.02 | 5.58 | 2.07 | | 8.67 |
| $I_3$ | 1.88 | 9.53 | 6.25 | | 17.66 | 1.02 | 8.22 | 3.45 | | 12.69 |
| Bermuda | | | | | | | | | | |
| $I_0$ | 1.47 | 1.09 | 0.48 | | 3.04 | 0.80 | 0.55 | 0.25 | | 1.60 |
| $I_1$ | 1.62 | 5.45 | 2.73 | | 9.80 | 0.95 | 4.94 | 2.50 | | 8.39 |

[a]Labor coefficients were based on the following sources: Larry J. Connor, William F. Lagrone, and James S. Plaxico, Resource Requirements, Costs and Expected Returns; Alternative Crop and Livestock Enterprises; Loam Soils of the Rolling Plains of Southwestern Oklahoma, Oklahoma Agricultural Experiment Station in cooperation with the U. S. Department of Agriculture, Processed Series P-368 (Stillwater, 1961), and Jay M. Bagley and Wayne O. Criddle, Evaluation of Sprinkler Irrigation Systems in Northern Utah, Utah Agricultural Experiment Station in cooperation with the U. S. Department of Agriculture, Bulletin 387 (Logan).

## APPENDIX E, TABLE XXV

### ESTIMATED LABOR REQUIREMENTS FOR SELECTED CROPS WITH BELOW AVERAGE RAINFALL, BY LEVELS OF IRRIGATION (PER ACRE)[a]

| Crop and Levels of Irrigation | Two-Plow Equipment | | | | | Four-Plow Equipment | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Jan.-April | May-July | Aug. Sept. | Oct.-Dec. | Total | Jan.-April | May-July | Aug. Sept. | Oct.-Dec. | Total |
| Cotton | | | | | | | | | | |
| $I_0$ | 2.14 | 2.42 | 0.30 | 0.15 | 5.01 | 1.27 | 1.23 | 0.15 | 0.15 | 2.80 |
| $I_1$ | 2.14 | 7.91 | 0.35 | 0.15 | 10.55 | 1.27 | 6.72 | 0.35 | 0.15 | 8.49 |
| $I_2$ | 2.14 | 9.17 | 2.55 | 0.15 | 14.01 | 1.27 | 7.98 | 2.55 | 0.15 | 11.95 |
| $I_3$ | 2.14 | 11.92 | 3.47 | 0.15 | 17.68 | 1.27 | 10.74 | 3.47 | 0.15 | 15.63 |
| Wheat | | | | | | | | | | |
| $I_0$ | | 1.32 | 0.63 | 0.20 | 2.15 | | 0.83 | 0.42 | 0.20 | 1.45 |
| $I_1$ | 3.20 | 1.42 | 0.63 | 0.20 | 5.45 | 3.20 | 0.83 | 1.26 | 1.40 | 6.69 |
| $I_2$ | 3.20 | 1.42 | 1.47 | 2.20 | 8.29 | 3.20 | 0.83 | 1.30 | 2.20 | 7.53 |
| $I_3$ | 5.20 | 1.42 | 1.47 | 2.20 | 10.29 | 5.20 | 0.83 | 1.30 | 2.20 | 9.53 |
| Alfalfa | | | | | | | | | | |
| $I_0$ | | 3.56 | 0.80 | 0.09 | 4.45 | | 3.39 | 0.67 | 0.09 | 4.15 |
| $I_1$ | 1.30 | 6.12 | 0.80 | 0.09 | 8.31 | 1.30 | 5.87 | 0.67 | 0.15 | 7.99 |
| $I_2$ | 1.30 | 7.04 | 1.96 | 0.09 | 10.39 | 1.30 | 6.79 | 1.65 | 0.15 | 9.89 |
| $I_3$ | 1.30 | 8.06 | 3.12 | 0.09 | 12.57 | 1.30 | 7.81 | 2.81 | 0.15 | 12.07 |
| Grain Sorghum | | | | | | | | | | |
| $I_0$ | 0.84 | 1.02 | 0.71 | | 2.57 | 0.47 | 0.61 | 0.55 | 0.03 | 1.66 |
| $I_1$ | 0.84 | 5.11 | 0.83 | | 6.78 | 0.47 | 4.70 | 0.53 | 0.05 | 5.75 |
| $I_2$ | 0.84 | 5.61 | 1.83 | | 8.28 | 0.47 | 5.20 | 1.53 | 0.05 | 7.25 |
| $I_3$ | 0.84 | 6.11 | 2.83 | | 9.78 | 0.47 | 5.20 | 2.53 | 0.05 | 8.25 |
| Forage Sorghum | | | | | | | | | | |
| $I_0$ | 1.88 | 2.03 | 0.80 | | 4.71 | 1.02 | 0.96 | 0.85 | | 2.83 |
| $I_1$ | 1.88 | 4.53 | 2.70 | | 9.11 | 1.02 | 3.46 | 0.85 | | 5.33 |
| $I_2$ | 1.88 | 5.53 | 3.20 | | 10.61 | 1.02 | 4.46 | 3.25 | | 8.73 |
| $I_3$ | 1.88 | 6.53 | 3.70 | | 12.11 | 1.02 | 5.46 | 3.75 | | 10.23 |
| Bermuda | | | | | | | | | | |
| $I_0$ | 1.47 | 1.09 | 0.48 | | 3.04 | 0.80 | 0.55 | 0.25 | | 1.60 |
| $I_1$ | 1.62 | 6.45 | 3.73 | | 11.80 | 1.05 | 5.94 | 3.50 | | 10.49 |

[a]Labor coefficients were based on the following sources: Larry J. Connor, William F. Lagrone, and James S. Plaxico, Resource Requirements, Costs and Expected Returns; Alternative Crop and Livestock Enterprises; Loam Soils of the Rolling Plains of Southwestern Oklahoma, Oklahoma Agricultural Experiment Station in cooperation with the U. S. Department of Agriculture, Processed Series P-368 (Stillwater, 1961), and Jay M. Bagley and Wayne O. Criddle, Evaluation of Sprinkler Irrigation Systems in Northern Utah, Utah Agricultural Experiment Station in cooperation with the U. S. Department of Agriculture, Bulletin 387 (Logan).

APPENDIX E, TABLE XXVI

PRODUCTION COSTS AND RETURNS FOR BEEF COW-CALF ENTERPRISE; SPRING CALVING WITH SALE OF FEEDER CALVES OCTOBER 1 (PER COW)[a]

| Item | Unit | Price or Cost Per Unit | Quantity | Value or Cost |
|---|---|---|---|---|
| Production: | | | | |
| Cull Cows | cwt. | 13.13 | 1.18 | 15.49 |
| Heifer Calves | cwt. | 21.42 | 1.29 | 27.63 |
| Steer Calves | cwt. | 23.42 | 2.14 | 50.12 |
| Total | dol. | | | 93.24 |
| Inputs: | | | | |
| Range | AUM | | 12.88 | |
| Hay (Alfalfa - 6 lbs./day) | ton | 20.00 | 0.44 | 8.80 |
| Salt | lbs. | 0.03 | 33.60 | 1.01 |
| Veterinary and Medicine | dol. | | 3.36 | 3.36 |
| Bull Depreciation | dol. | | 1.40 | 1.40 |
| Hauling and Marketing Cost | cwt. | 0.40 | 4.61 | 1.84 |
| Property Tax | dol. | 0.037 | 58.11 | 2.15 |
| Interest on Operating Capital | dol. | 0.06 | 198.61 | 11.92 |
| Total Specified Costs | dol. | | | 30.48 |
| Returns to Land, Labor, Risk, and Management | dol. | | | 62.76 |

Labor Requirements (Man Hours Per Cow)

| Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.73 | 2.76 | 2.95 | 2.09 | 0.20 | 0.72 | 0.20 | 0.16 | 0.20 | 0.48 | 0.50 | 0.60 | 12.59 |

[a]Wintered on alfalfa hay and range; non-creep fed, sold off native range.

## APPENDIX E, TABLE XXVII

### PRODUCTION COSTS AND RETURNS FOR BEEF COW-CALF ENTERPRISE; FALL CALVING WITH SALE OF FEEDER CALVES JULY 20 (PER COW)[a]

| Item | Unit | Price or Cost Per Unit | Quantity | Value or Cost |
|---|---|---|---|---|
| Production: | | | | |
| Cull Cows | cwt. | 13.95 | 1.18 | 16.46 |
| Heifer Calves | cwt. | 22.20 | 1.29 | 28.54 |
| Steer Calves | cwt. | 24.20 | 2.14 | 51.76 |
| Total | dol. | | | 96.76 |
| Inputs: | | | | |
| Range | AUM | | 11.40 | |
| C.S.C. (1.75 lbs./day) | cwt. | 3.80 | 2.87 | 10.90 |
| Sorghum Silage (27 lbs./day) | ton | 4.20 | 1.84 | 7.71 |
| Salt | lbs. | 0.03 | 33.60 | 1.01 |
| Veterinary and Medicine | dol. | | 3.36 | 3.36 |
| Bull Depreciation | dol. | | 1.40 | 1.40 |
| Hauling and Marketing | cwt. | 0.40 | 4.61 | 1.84 |
| Property Tax | dol. | 0.037 | 70.00 | 2.58 |
| Interest on Operating Capital | dol. | 0.06 | 206.80 | 12.41 |
| Total Specified Costs | dol. | | | 41.21 |
| Returns to Land, Labor, Risk, and Management | dol. | | | 55.55 |

Labor Requirements (Man Hours Per Cow)

| Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.77 | 1.05 | 0.87 | 0.61 | 0.10 | 0.08 | 0.34 | 0.08 | 0.42 | 0.85 | 1.10 | 1.19 | 7.46 |

[a]Wintered on sorghum silage, cotton seed cake, and range; non-creep fed.

## APPENDIX E, TABLE XXVIII

## PRODUCTION COSTS AND RETURNS FOR GOOD FEEDER CATTLE ENTERPRISE; BUY APRIL 15 AND SELL OCTOBER 15 (PER STEER)[a]

| Item | Unit | Price or Cost Per Unit | Quantity | Value or Cost |
|---|---|---|---|---|
| Production: | | | | |
| Feeder | cwt. | 20.23 | 8.25 | 166.90 |
| Less One Per Cent Death Loss | | | | 165.23 |
| Inputs: | | | | |
| Calf | cwt. | 25.26 | 5.00 | 126.30 |
| Midland Bermuda | AUM | 1.56 | 4.00 | 6.25 |
| Veterinary and Medicine | dol. | | 0.80 | 0.80 |
| Salt | lbs. | 0.01 | 8.00 | 0.08 |
| Hauling and Marketing | cwt. | 0.40 | 12.25 | 4.90 |
| Interest on Operating Capital | dol. | 0.06 | 64.37 | 3.86 |
| Total Specified Costs | | | | 142.19 |
| Returns to Land, Labor, Risk, and Management | dol. | | | 23.04 |

Labor Requirements (Man Hours Per Steer)

| Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0.55 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.55 | 0 | 0 | 3.60 |

[a]Grazed through summer and sold off Midland Bermuda pasture.

## APPENDIX E, TABLE XXIX

PRODUCTION COSTS AND RETURNS FOR GOOD FEEDER CATTLE ENTERPRISE; BUY OCTOBER 15 AND SELL MAY 15 (PER STEER)[a]

| Item | Unit | Price or Cost Per Unit | Quantity | Value or Cost |
|---|---|---|---|---|
| Production: | | | | |
| Feeder | cwt. | 22.29 | 7.15 | 159.37 |
| Less One Per Cent Death Loss | | | | 157.78 |
| Inputs: | | | | |
| Calf | cwt. | 23.42 | 4.50 | 105.39 |
| Native Range | AUM | | 0.50 | |
| Small Grain Grazing | | | | |
| Before March 1 | AUM | | 1.40 | |
| After March 1 | AUM | 1.81 | 1.40 | 2.53 |
| Forage Sorghum | ton | 8.61 | 0.45 | 3.87 |
| C.S.C. (1.5 lbs./day) | cwt. | 3.81 | 0.69 | 2.62 |
| Veterinary and Medicine | dol. | | 1.45 | 1.45 |
| Salt | lbs. | 0.01 | 16.30 | 0.16 |
| Hauling and Marketing | cwt. | 0.40 | 11.65 | 4.66 |
| Property Tax | dol. | 0.037 | 49.00 | 1.81 |
| Interest on Operating Capital | dol. | 0.06 | 65.89 | 3.95 |
| Total Specified Costs | dol. | | | 126.44 |
| Returns to Land, Labor, Risk, and Management | dol. | | | 31.34 |

Labor Requirements (Man Hours Per Steer)

| Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.45 | 0.45 | 0.30 | 0.30 | 1.02 | 0 | 0 | 0 | 0 | 0.54 | 0.30 | 0.30 | 3.66 |

[a]Wintered on small grain pasture with forage sorghum and cottonseed cake when off small grain. Sold off grazed out small grain.

## APPENDIX E, TABLE XXX

## PRODUCTION COSTS AND RETURNS FOR GRADE A DAIRY ENTERPRISE (PER COW)

| Item | Unit | Price or Cost Per Unit | Quantity | Value or Cost |
|---|---|---|---|---|
| Production: | | | | |
| Milk | cwt. | 4.60 | 2,000.0 | 368.00 |
| Cull Cows | cwt. | 12.50 | 60.0 | 30.00 |
| Cull Heifers, 2 Years | cwt. | 16.00 | 8.0 | 5.12 |
| Cull Heifers, 1 Year | cwt. | 18.00 | 4.0 | 2.88 |
| Calves | head | 15.00 | 16.0 | 9.60 |
| Total | dol. | | | 415.60 |
| Inputs: | | | | |
| Hauling Milk | cwt. | 0.30 | 2,000.0 | 24.00 |
| Hauling Cattle | cwt. | 0.40 | 85.6 | 1.37 |
| Veterinary and Medicine | dol. | | | 5.00 |
| Dairy Supplies | dol. | | | 4.00 |
| Utilities | dol. | | | 3.00 |
| DHIA Testing | cow | 5.25 | 25.0 | 5.25 |
| Spray Material | dol. | | | 0.80 |
| Raising Replacement | head | 170.00 | 5.0 | 34.00 |
| Purchased Feeds: | | | | |
| Cotton Seed Meal | cwt. | 3.90 | 126.0 | 19.66 |
| Wheat Bran | cwt. | 2.50 | 84.0 | 8.40 |
| Salt and Mineral | cwt. | 1.00 | 8.4 | 0.34 |
| Farm Grown Feeds:[a] | | | | |
| Sorghum Silage | ton | 9.50 | 161.5 | 61.37 |
| Oats | cwt. | 0.94 | 126.1 | 4.74 |
| Grain Sorghum | cwt. | 0.75 | 495.7 | 14.87 |
| Hay | ton | 22.25 | 56.3 | 50.10 |
| Grinding Feed | cwt. | 0.15 | 710.0 | 4.26 |
| Interest on Operating Capital | dol. | 0.06 | 17,925.90 | 43.02 |
| Total Specified Costs | dol. | | | 284.17 |
| Returns to Land, Labor, Risk, and Management | dol. | | | 131.43 |

Labor Requirements (Man Hours Per Cow)

| Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.46 | 7.54 | 8.46 | 8.78 | 7.68 | 7.40 | 7.68 | 7.68 | 7.40 | 8.46 | 8.15 | 8.46 | 96.15 |

[a]Charged on a cost of production basis.

## APPENDIX F, TABLE I

### A TYPICAL TABLEAU USED IN PROGRAMMING OPTIMUM FARM PLANS (FARM A-1, AVERAGE RAINFALL WITH WATER AVAILABILITY RESTRICTED TO LEVEL 2)

| Item | Row | Unit | $P_0$ | Cotton | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $P_1$ | $P_2$ | $P_3$ | $P_4$ | $P_5$ | $P_6$ | $P_7$ | $P_8$ |
| | $C_j$ | dol. | | 48.86 | 40.92 | 67.97 | 53.52 | 93.89 | 77.03 | 113.81 | 95.80 |
| Land Resources | | | | | | | | | | | |
| $L_1$ | 101 | acre | 7 | 1 | | 1 | | 1 | | 1 | |
| $L_2$ | 102 | acre | 31 | | 1 | | 1 | | 1 | | 1 |
| $L_3$ | 103 | acre | 13 | | | | | | | | |
| $L_4$ | 104 | acre | 29 | | | | | | | | |
| $L_5$ | 105 | acre | 8 | | | | | | | | |
| Wheat Allotment | 106 | acre | 10 | | | | | | | | |
| Cotton Allotment | 107 | acre | 10 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Grazing | | | | | | | | | | | |
| Oct.-Feb. | 108 | AUM | 32 | | | | | | | | |
| Mar.-May | 109 | AUM | 32 | | | | | | | | |
| June-Sept. | 110 | AUM | 32 | | | | | | | | |
| Labor | | | | | | | | | | | |
| Jan.-Apr. | 111 | hour | 726 | 2.14 | 2.14 | 2.14 | 2.14 | 2.14 | 2.14 | 2.14 | 2.14 |
| May-July | 112 | hour | 638 | 2.42 | 2.42 | 5.42 | 5.42 | 8.98 | 8.98 | 10.08 | 10.08 |
| Aug.-Sept. | 113 | hour | 440 | 0.30 | 0.30 | 0.35 | 0.35 | 0.40 | 0.40 | 2.85 | 2.85 |
| Oct.-Dec. | 114 | hour | 594 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.35 | 0.35 |
| Capital | | | | | | | | | | | |
| Total | 115 | dol. | .1 | 34.46 | 34.46 | 95.47 | 95.47 | 100.72 | 100.72 | 105.97 | 105.97 |
| Annual | 116 | dol. | .1 | 27.83 | 27.83 | 83.71 | 83.71 | 87.26 | 87.26 | 91.57 | 91.57 |
| Irrigation Water | 117 | Ac.In. | 225 | | | 6 | 6 | 13 | 13 | 20 | 20 |
| Alfalfa Hay | 118 | ton | .1 | | | | | | | | |
| Small Grain Hay | 119 | ton | .1 | | | | | | | | |
| Forage Sorghum | 120 | ton | .1 | | | | | | | | |
| Grain Sorghum | 121 | cwt. | .1 | | | | | | | | |
| Oats | 122 | cwt. | .1 | | | | | | | | |

APPENDIX F, TABLE I (continued)

| Row | Wheat | | | | | | | | | | Alfalfa | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $P_9$ | $P_{10}$ | $P_{11}$ | $P_{12}$ | $P_{13}$ | $P_{14}$ | $P_{15}$ | $P_{16}$ | $P_{17}$ | $P_{18}$ | $P_{19}$ | $P_{20}$ | $P_{21}$ | $P_{22}$ |
| $C_j$ | 28.52 | 21.59 | 14.67 | 7.75 | 25.39 | 16.99 | 33.56 | 26.87 | 38.33 | 31.70 | -26.83 | -22.45 | -56.50 | -48.47 |
| 101 | 1 | | | | 1 | | 1 | | 1 | | 1 | | 1 | |
| 102 | | 1 | | | | 1 | | 1 | | 1 | | 1 | | 1 |
| 103 | | | 1 | | | | | | | | | | | |
| 104 | | | | 1 | | | | | | | | | | |
| 105 | | | | | | | | | | | | | | |
| 106 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | |
| 107 | | | | | | | | | | | | | | |
| 108 | -0.50 | -0.40 | -0.30 | -0.20 | -0.65 | -0.50 | -0.75 | -0.65 | -0.85 | -0.70 | | | | |
| 109 | | | | | | | | | | | | | | |
| 110 | | | | | | | | | | | | | | |
| 111 | | | | | 2.00 | 2.00 | 2.00 | 2.00 | 4.00 | 4.00 | | | 0.15 | 0.15 |
| 112 | 1.49 | 1.49 | 1.49 | 1.49 | 1.67 | 1.67 | 1.75 | 1.75 | 1.84 | 1.84 | 3.56 | 3.56 | 5.70 | 5.70 |
| 113 | 0.63 | 0.63 | 0.63 | 0.63 | 0.73 | 0.73 | 0.73 | 0.73 | 0.73 | 0.73 | 0.80 | 0.80 | 0.85 | 0.85 |
| 114 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 2.30 | 2.30 | 2.30 | 2.30 | 0.09 | 0.09 | 0.09 | 0.09 |
| 115 | 14.50 | 14.50 | 14.50 | 14.50 | 62.92 | 62.92 | 66.48 | 66.48 | 67.42 | 67.42 | 42.65 | 42.65 | 92.58 | 92.58 |
| 116 | 13.10 | 13.10 | 13.10 | 13.10 | 59.84 | 59.84 | 62.51 | 62.51 | 63.21 | 63.21 | 27.74 | 27.74 | 75.61 | 75.61 |
| 117 | | | | | 5 | 5 | 10 | 10 | 15 | 15 | | | 6.00 | 6.00 |
| 118 | | | | | | | | | | | -2.60 | -2.00 | -4.3 | -3.2 |
| 119 | | | | | | | | | | | | | | |
| 120 | | | | | | | | | | | | | | |
| 121 | | | | | | | | | | | | | | |
| 122 | | | | | | | | | | | | | | |

APPENDIX F, TABLE I (continued)

| Row | Alfalfa | | | | Grain Sorghum | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $P_{23}$ | $P_{24}$ | $P_{25}$ | $P_{26}$ | $P_{27}$ | $P_{28}$ | $P_{29}$ | $P_{30}$ | $P_{31}$ | $P_{32}$ | $P_{33}$ | $P_{34}$ | $P_{35}$ | $P_{36}$ |
| $C_j$ | -69.53 | -60.04 | -78.91 | -70.15 | 25.58 | 18.52 | 10.98 | 3.60 | 31.44 | 21.18 | 34.64 | 22.83 | 34.82 | 22.61 |
| 101 | 1 | | 1 | | 1 | | | | 1 | | 1 | | 1 | |
| 102 | | 1 | | 1 | | 1 | | | | 1 | | 1 | | 1 |
| 103 | | | | | | | 1 | | | | | | | |
| 104 | | | | | | | | 1 | | | | | | |
| 105 | | | | | | | | | | | | | | |
| 106 | | | | | | | | | | | | | | |
| 107 | | | | | | | | | | | | | | |
| 108 | | | | | | | | | | | | | | |
| 109 | | | | | | | | | | | | | | |
| 110 | | | | | | | | | | | | | | |
| 111 | 0.15 | 0.15 | 0.15 | 0.15 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 |
| 112 | 7.95 | 7.95 | 7.95 | 7.95 | 1.11 | 1.11 | 1.11 | 1.11 | 3.20 | 3.20 | 4.71 | 4.71 | 6.19 | 6.19 |
| 113 | 0.85 | 0.85 | 3.05 | 3.05 | 0.83 | 0.83 | 0.83 | 0.83 | 1.05 | 1.05 | 1.11 | 1.11 | 1.17 | 1.17 |
| 114 | 0.09 | 0.09 | 0.09 | 0.09 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |
| 115 | 96.85 | 96.85 | 101.12 | 101.12 | 11.39 | 11.39 | 11.39 | 11.39 | 61.92 | 61.92 | 64.06 | 64.06 | 66.19 | 66.19 |
| 116 | 78.81 | 78.81 | 81.42 | 81.42 | 11.16 | 11.16 | 11.16 | 11.16 | 59.48 | 59.48 | 61.08 | 61.08 | 62.68 | 62.68 |
| 117 | 12.00 | 12.00 | 18.00 | 18.00 | | | | | 4 | 4 | 7 | 7 | 10 | 10 |
| 118 | -5.5 | -4.2 | -6.4 | -5.0 | | | | | | | | | | |
| 119 | | | | | | | | | | | | | | |
| 120 | | | | | | | | | | | | | | |
| 121 | | | | | | | | | | | | | | |
| 122 | | | | | | | | | | | | | | |

APPENDIX F, TABLE I (continued)

| Row | Forage Sorghum | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | $P_{37}$ | $P_{38}$ | $P_{39}$ | $P_{40}$ | $P_{41}$ | $P_{42}$ | $P_{43}$ | $P_{44}$ | $P_{45}$ |
| $C_j$ | -22.01 | -21.29 | -18.41 | -77.68 | -70.48 | -107.18 | -89.18 | -125.15 | -103.55 |
| 101 | | | | 1 | | 1 | | 1 | |
| 102 | 1 | | | | 1 | | 1 | | 1 |
| 103 | | 1 | | | | | | | |
| 104 | | | 1 | | | | | | |
| 105 | | | | | | | | | |
| 106 | | | | | | | | | |
| 107 | | | | | | | | | |
| 108 | | | | | | | | | |
| 109 | | | | | | | | | |
| 110 | | | | | | | | | |
| 111 | 1.88 | 1.88 | 1.88 | 1.88 | 1.88 | 1.88 | 1.88 | 1.88 | 1.88 |
| 112 | 2.03 | 2.03 | 2.03 | 5.03 | 5.03 | 6.89 | 6.89 | 9.53 | 9.53 |
| 113 | 0.80 | 0.80 | 0.80 | 1.25 | 1.25 | 2.87 | 2.87 | 6.25 | 6.25 |
| 114 | | | | | | | | | |
| 115 | 35.86 | 33.75 | 29.98 | 86.16 | 86.16 | 86.87 | 86.87 | 89.00 | 89.00 |
| 116 | 35.86 | 33.75 | 29.98 | 83.02 | 83.02 | 83.55 | 83.55 | 84.15 | 84.15 |
| 117 | | | | 4 | 4 | 7 | 7 | 10 | 10 |
| 118 | | | | | | | | | |
| 119 | | | | | | | | | |
| 120 | -2.20 | -2.10 | -1.70 | -8.50 | -7 | -11.80 | -9.30 | -14.00 | -11.00 |
| 121 | | | | | | | | | |
| 122 | | | | | | | | | |

APPENDIX F, TABLE I (continued)

| Row | Bermuda | | | | | Grazed Out Small Grain | | | |
|---|---|---|---|---|---|---|---|---|---|
| | $P_{46}$ | $P_{47}$ | $P_{48}$ | $P_{49}$ | $P_{50}$ | $P_{51}$ | $P_{52}$ | $P_{53}$ | $P_{54}$ |
| $C_j$ | -5.30 | -5.30 | -5.30 | -33.76 | -33.76 | -4.77 | -4.77 | -4.77 | -4.77 |
| 101 | | 1 | | 1 | | 1 | | | |
| 102 | | | 1 | | 1 | | 1 | | |
| 103 | | | | | | | | 1 | |
| 104 | | | | | | | | | 1 |
| 105 | 1 | | | | | | | | |
| 106 | | | | | | | | | |
| 107 | | | | | | | | | |
| 108 | -0.21 | -0.20 | -0.18 | -0.80 | -0.65 | -0.50 | -0.40 | -0.30 | -0.20 |
| 109 | -2.06 | -1.96 | -1.72 | -7.84 | -6.32 | -2.80 | -2.30 | -1.40 | -1.00 |
| 110 | -1.93 | -1.84 | -1.60 | -7.36 | -5.98 | | | | |
| 111 | 1.47 | 1.47 | 1.47 | 1.62 | 1.62 | | | | |
| 112 | 1.09 | 1.09 | 1.09 | 5.45 | 5.45 | 1.49 | 1.49 | 1.49 | 1.49 |
| 113 | 0.48 | 0.48 | 0.48 | 2.73 | 2.73 | 0.63 | 0.63 | 0.63 | 0.63 |
| 114 | | | | | | 0.20 | 0.20 | 0.20 | 0.20 |
| 115 | 20.32 | 20.32 | 20.32 | 81.17 | 81.17 | 13.63 | 13.63 | 13.63 | 13.63 |
| 116 | 10.16 | 10.16 | 10.16 | 65.91 | 65.91 | 12.25 | 12.25 | 12.25 | 12.25 |
| 117 | | | | 16 | 16 | | | | |
| 118 | | | | | | | | | |
| 119 | | | | | | | | | |
| 120 | | | | | | | | | |
| 121 | | | | | | | | | |
| 122 | | | | | | | | | |

APPENDIX F, TABLE I (continued)

| Row | Small Grain Hay | | Sudan Grass | | Cow-Calf | | Feeders | | | Dairy |
|---|---|---|---|---|---|---|---|---|---|---|
| | $P_{55}$ | $P_{56}$ | $P_{57}$ | $P_{58}$ | $P_{59}$ | $P_{60}$ | $P_{61}$ | $P_{62}$ | $P_{63}$ | $P_{64}$ |
| $c_j$ | -12.63 | -10.44 | -4.33 | -4.33 | 75.67 | 83.42 | 41.69 | 20.28 | 33.15 | 305.53 |
| 101 | | | | | | | | | | |
| 102 | | | | | | | | | | |
| 103 | 1 | | 1 | | | | | | | |
| 104 | | 1 | | 1 | | | | | | |
| 105 | | | | | | | | | | |
| 106 | | | | | | | | | | |
| 107 | | | | | | | | | | |
| 108 | -0.30 | -0.20 | | | 3.80 | 4.30 | 1.60 | 2.70 | 0.40 | 0.40 |
| 109 | | | | | 3.80 | 4.30 | 1.70 | | 1.20 | 2.20 |
| 110 | | | -1.00 | -0.60 | 3.80 | 4.30 | | | 3.20 | 4.00 |
| 111 | | | 1.88 | 1.88 | 3.30 | 9.53 | 1.50 | 1.92 | 0.55 | 33.24 |
| 112 | 2.69 | 2.69 | 1.43 | 1.43 | 0.52 | 1.12 | 1.02 | | 1.50 | 22.76 |
| 113 | 0.63 | 0.63 | | | 0.50 | 0.36 | | | 1.00 | 15.08 |
| 114 | 0.20 | 0.20 | | | 3.14 | 1.58 | 1.14 | 1.14 | 0.55 | 25.07 |
| 115 | 26.80 | 26.80 | 10.62 | 10.62 | 211.69 | 200.80 | 111.42 | 115.08 | 129.18 | 763.30 |
| 116 | 26.80 | 26.80 | 10.23 | 10.23 | 206.79 | 198.61 | 65.89 | 43.17 | 64.37 | 717.04 |
| 117 | | | | | | | | | | |
| 118 | | | | | | 0.437 | | 0.40 | | 1.75 |
| 119 | -1.00 | -0.70 | | | | | | | | 0.50 |
| 120 | | | | | 1.84 | | 0.45 | | | 4.00 |
| 121 | | | | | | | | | | 19.83 |
| 122 | | | | | | | | | | 5.04 |

APPENDIX F, TABLE I (continued)

| Row | Hire Labor | | | | Capital Borrow | Buy Oats | Buy Grain Sorghum | Buy Alfalfa Hay | Sell Alfalfa Hay |
|---|---|---|---|---|---|---|---|---|---|
| | $P_{65}$ | $P_{66}$ | $P_{67}$ | $P_{68}$ | $P_{69}$ | $P_{70}$ | $P_{71}$ | $P_{72}$ | $P_{73}$ |
| $C_j$ | -1.00 | -1.00 | -1.00 | -1.00 | -0.06 | -2.00 | -1.75 | -20.00 | -20.00 |
| 101 | | | | | | | | | |
| 102 | | | | | | | | | |
| 103 | | | | | | | | | |
| 104 | | | | | | | | | |
| 105 | | | | | | | | | |
| 106 | | | | | | | | | |
| 107 | | | | | | | | | |
| 108 | | | | | | | | | |
| 109 | | | | | | | | | |
| 110 | | | | | | | | | |
| 111 | -1.00 | | | | | | | | |
| 112 | | -1.00 | | | | | | | |
| 113 | | | -1.00 | | | | | | |
| 114 | | | | -1.00 | | | | | |
| 115 | 1.00 | 1.00 | 1.00 | 1.00 | -1.00 | 2.00 | 1.75 | 20.00 | |
| 116 | 0.50 | 0.50 | 0.50 | 0.50 | -1.00 | 1.00 | 0.87 | 10.00 | |
| 117 | | | | | | | | | |
| 118 | | | | | | | | -1 | 1 |
| 119 | | | | | | | | | |
| 120 | | | | | | | | | |
| 121 | | | | | | | -1 | | |
| 122 | | | | | | -1 | | | |

APPENDIX G, TABLE I

PROGRAMMED QUANTITIES OF ALFALFA PRODUCED AND SOLD BY FARM SIZE, TYPE, AND WATER LEVEL FOR AVERAGE AND BELOW AVERAGE RAINFALL CONDITIONS

| Farm Identification[a] | Average Rainfall<br>Quantity Produced | Average Rainfall<br>Quantity Sold | Below Average Rainfall<br>Quantity Produced | Below Average Rainfall<br>Quantity Sold |
|---|---|---|---|---|
| | | - Tons - | | |
| A-12 | 6 | | 2 | |
| A-13 | 38 | 32 | 2 | |
| A-14 | 100 | 94 | 100 | 98 |
| B-12 | 58 | | 38 | 33 |
| B-13 | 115 | 112 | 51 | 46 |
| B-14 | 265 | 259 | 255 | 252 |
| C-12 | 6 | | | |
| C-13 | 6 | | 5 | |
| C-14 | 101 | 95 | 86 | 79 |
| C-22 | 53 | 16 | 5 | |
| C-23 | 111 | 70 | 38 | |
| C-24 | 111 | 70 | 45 | 11 |
| D-12 | 147 | 136 | 70 | 61 |
| D-13 | 434 | 423 | 96 | 87 |
| D-14 | 544 | 516 | 544 | 522 |
| D-22 | 369 | 329 | 307 | 253 |
| D-23 | 550 | 510 | 435 | 400 |
| D-24 | 555 | 515 | 510 | 478 |
| E-12 | 226 | 50 | 19 | |
| E-13 | 83 | 52 | 83 | 67 |
| E-14 | 103 | 71 | 258 | 236 |
| E-22 | 123 | | 64 | 31 |
| E-23 | 158 | | 83 | 12 |
| E-24 | 158 | | 93 | |
| F-12 | 352 | 306 | 26 | |
| F-13 | 806 | 764 | 6 | |
| F-14 | 826 | 779 | 819 | 813 |
| F-22 | 32 | | 19 | |
| F-23 | 32 | | 19 | |
| F-24 | 582 | 557 | 589 | 571 |

[a]Refers to resource strata, farm type, and farm water level. For example, A-12 refers to resource situation A, farm type 1, and farm water level 2. These characteristics are defined in Chapter II.

## APPENDIX G, TABLE II

### MARGINAL RETURNS PER ACRE FOOT OF WATER FROM NO IRRIGATION AND PRECEDING LEVEL OF IRRIGATION BY FARM TYPE, SIZE, AND WATER LEVEL FOR AVERAGE AND BELOW AVERAGE RAINFALL[a]

| Farm Size and Type[b] | Average Rainfall | | | | | |
|---|---|---|---|---|---|---|
| | Marginal Returns Per Acre Foot of Water | | | | | |
| | From No Irrigation | | | From Preceding Irrigation Level | | |
| | Farm Water Levels[c] | | | | | |
| | 2 | 3 | 4 | 2 | 3 | 4 |
| A-1 | 36.69 | 25.15 | 20.36 | 36.69 | 13.60 | 10.77 |
| B-1 | 30.48 | 21.67 | 18.00 | 30.48 | 12.87 | 10.67 |
| C-1 | 30.76 | 21.36 | 17.73 | 30.76 | 11.96 | 10.47 |
| C-2 | 32.29 | 21.85 | 16.98 | 32.29 | 11.42 | 7.23 |
| D-1 | 20.93 | 17.38 | 14.98 | 20.93 | 13.83 | 10.18 |
| D-2 | 30.01 | 20.47 | 16.35 | 30.01 | 10.94 | 8.10 |
| E-1 | 22.58 | 16.16 | 13.72 | 22.58 | 9.75 | 8.83 |
| E-2 | 18.82 | 12.99 | 11.19 | 18.82 | 7.22 | 7.53 |
| F-1 | 20.72 | 15.61 | 13.45 | 20.72 | 10.51 | 9.11 |
| F-2 | 30.66 | 21.30 | 16.89 | 30.66 | 11.95 | 8.06 |
| | Below Average Rainfall | | | | | |
| A-1 | 34.08 | 26.48 | 19.53 | 34.08 | 18.88 | 5.62 |
| B-1 | 32.44 | 25.75 | 19.14 | 32.44 | 19.05 | 5.92 |
| C-1 | 27.42 | 21.00 | 16.62 | 27.42 | 18.65 | 7.86 |
| C-2 | 39.65 | 28.14 | 21.19 | 39.65 | 16.62 | 7.30 |
| D-1 | 26.65 | 20.41 | 16.49 | 26.65 | 14.17 | 8.65 |
| D-2 | 25.45 | 19.22 | 15.69 | 25.45 | 13.00 | 8.03 |
| E-1 | 16.83 | 17.18 | 13.50 | 16.83 | 17.53 | 6.13 |
| E-2 | 34.88 | 22.68 | 17.66 | 34.88 | 10.49 | 7.61 |
| F-1 | 25.16 | 17.97 | 14.36 | 25.16 | 10.77 | 7.14 |
| F-2 | 23.72 | 19.85 | 15.91 | 23.72 | 15.98 | 8.03 |

[a]Marginal returns to water, family labor, risk, and management associated with irrigation exclusive of fixed costs of irrigation equipment.

[b]A description of farm size and type groups is presented in Tables II and IV of Chapter II.

[c]Farm water levels are defined in Table VI of Chapter II.

# VITA

Dale O. Anderson

Candidate for the Degree of

Doctor of Philosophy

Thesis: THE VALUE OF IRRIGATION WATER IN THE WASHITA RIVER BASIN OF ROGER MILLS COUNTY, OKLAHOMA

Major Field: Agricultural Economics

Biographical:

Personal Data: Born in Dunn Center, North Dakota, April 2, 1937, the son of Odin and Erna Anderson.

Education: Attended elementary and high school in Dunn County, North Dakota; graduated from Dunn Center High School, Dunn Center, North Dakota in May, 1954; received the Bachelor of Science Degree from the North Dakota State University with a major in Mechanized Agriculture, in May, 1959; received the Master of Science Degree from the North Dakota State University, with a major in Agricultural Economics, in August, 1960; completed requirements for the Doctor of Philosophy Degree in May, 1965.

Professional Experience: Employed as a Research Assistant in the Department of Agricultural Economics, North Dakota State University, Fargo, North Dakota, from March, 1959, to September, 1960; employed as a Research Assistant in the Department of Agricultural Economics, Oklahoma State University, Stillwater, Oklahoma, from September, 1960, to June, 1961; employed as an Agricultural Economist with the United States Department of Agriculture, from June, 1961, to September, 1963; employed as an Assistant Professor in the Department of Agricultural Economics, North Dakota State University, Fargo, North Dakota, from September, 1963, to date.