EFFECTS OF UPSTREAM FLOOD PROTECTION ON LAND USE IN THE UPPER WASHITA RIVER BASIN, OKLAHOMA

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TABLES OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Background of the Study

The present small watershed program is a comparatively new phase in the development and conservation of this nation's natural resources. The installation of flood-retarding structures authorized by the Flood Control Act of 1944 (P.L. 534)[1] did not begin until 1946. Most of the watershed structures have not been completed for more than ten years. Hence, their economic impacts have not been fully realized.

Soil Conservation Service administrators at all levels are well aware of the broad spectrum of problems associated with trying to predict the probable effects of the small watershed projects. The *ex post* evaluation of the effects of the installed projects has been limited for the most part to studies of pilot watersheds.[2] The results of these studies have been somewhat inconclusive because, among other things, problems were encountered in isolating the effects of watershed programs from numerous other factors affecting yields, shifts in land use, agricultural incomes, et cetera.

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[1]Public Law 534 authorized the expenditure of $11,243,000 for land treatment and for the purchase of 328,000 acres of submarginal farm land as recommended by the Undersecretary of Agriculture in House Document No. 275 of the first session of the 78th Congress.

[2]Six Mile Creek, Arkansas; Honey Creek, Iowa; Mule Creek, Iowa; East Willow Creek, Minnesota; Kiowa Creek, Colorado; and Upper Rio Hondo, New Mexico.

The importance of analyzing the actual magnitude and incidence of the benefits and costs of the small watershed programs is emphasized in several ways. First, clarification of the differing viewpoints on the sagacity of federal expenditures for the development of agricultural resources requires knowledge of the actual results of the programs. Secondly, the dispute over the combination of large and small dams that provide the greater efficiency in flood control also demands knowledge of the effects of the small watershed projects.[3] Thirdly, the very recently renewed interest in measuring the secondary impacts of the small watershed projects requires knowledge of the primary effects, since the two effects are often functionally related.[4]

In 1961, the Soil Conservation Service and the Economic Research Service formulated a plan of study and established financial arrangements to undertake a continuing laboratory type appraisal of watershed protection. The overall study is concerned with the economic evaluation of: (1) the effects of watershed protection on flood damage reduction and land use, (2) the potential returns to irrigation, (3) the secondary effects of watershed protection on various sectors of the economy, local and national, and (4) the recreational potential of the structure sites. In addition, work was to be done on developing methodology for predicting future impacts.

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[3]See Luna B. Leopold and Thomas Maddock Jr., The Flood Control Controversy (New York, 1954); Elmer T. Peterson, Big Dam Foolishness (New York, 1954); Ben Morell, Our Nation's Water Resources - Policies and Politics (Chicago, 1956); and others.

[4]This interest was initiated by the 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 Resources, Senate Document No. 97 (Washington, 1962).

The Washita Basin of Oklahoma, one of eleven projects authorized under the 1944 Flood Control Act, was selected as the locale for this laboratory analysis. As of July, 1963, more than half of nearly one thousand structures planned on the sixty-four sub-watersheds had been installed, and eighty-three percent of the sub-watersheds had been planned.[5] Because the sub-watersheds lie in one geographic area, and because all degree of project completion exist, the Washita Basin offers a unique opportunity for comparative studies of the installed projects.

The land use study presented in this thesis is one segment of the broad program of investigation. This thesis is concerned with the effects of flood protection on the agricultural use of flood plain lands along with the related impacts on the uplands.

The Geographic Area Under Study

Nine watersheds of the Upper Washita River Basin in western Oklahoma were selected for study. Five of the watersheds have been developed.[6] The other four have been planned, but no structures have been built. The watersheds were paired in the following groups:[7]

Group I - Barnitz Creek (developed more than 5 years), Beaver Creek (undeveloped),

Group II - Cavalry Creek (developed from 1-5 years), Boggy Creek (undeveloped),

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[5]Soil Conservation Service, United States Department of Agriculture, Annual Report on Washita River Watershed, unpublished mimeographed bulletin (July, 1963).

[6]The developed watersheds were essentially completed in the time period given. However, some minor facets of the plan of development may be incompleted even at this time.

[7]These pairs were selected after consultation with Soil Conservation Service soil scientists.

Group III - Saddle Mountain Creek (developed more than 5 years), Rainy Mountain Creek (undeveloped),

Group IV - Big Kiowa Creek (developed 5 years or more), Panther Creek (developed from 1-5 years), Whiteshield Creek (undeveloped).

These watersheds were selected and paired, because, within a group, they are fairly similar in inherent soil productivity, yet they offer an opportunity for comparing the effects of flood protection.[8] The nine watersheds from which information was collected lie in a four county area in the Rolling Red Plains Resource Area.[9] Annual precipitation decreases from 30 to 26 inches from east to west across the area. Soils are about equally divided between those with tight clay subsoils and those with lighter loam subsoils. Most of the tighter subsoils are in the southeastern part of the area.

Benefit-Cost Analysis

The economic feasibility of developing natural resources is estimated by calculating a benefit-cost ratio.[10] If the ratio is greater than

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[8] Watersheds within a group lie adjacent to one another except for Panther Creek. Because Rainy Mountain Watershed is large and heterogenous, only the reaches that laid adjacent to Saddle Mountain Watershed were considered. These few reaches are hereinafter referred to as Rainy Mountain Watershed, but they do not represent the entire watershed.

[9] Roger Mills, Custer, Washita, and Kiowa Counties.

[10] Benefit-cost analysis is a term commonly used by federal agencies involved in resource development. Project benefits are the value of the goods and services produced by the project and by activities stemming from or induced by the project. Project costs are the economic cost (in essence, market values) of using goods and services for a given purpose. Project benefits and costs as used in agency accounting are explicitly defined by the Sub-committee on Evaluation Standards of the Inter-Agency Committee on Water Resources in the Proposed Practices for Economic Analysis of River Basin Projects: Report to the Inter-Agency River Basin Committee (Washington, 1958), (commonly referred to as the Green Book).

one, the project is said to be economically feasible. Two important components on the benefit side of the ratio are: (1) the reduction of damage to crops and pasture, and (2) the increased value of production arising from more intensive use of the flood plain.[11]

But increasing concern with the prediction of benefits from land use changes has come about on the national level because of the surplus of the relatively "intensive" crops such as wheat, cotton, and to a lesser extent, feed grains. The contradiction between the acreage control programs and the resource conservation and development programs has been the subject of many articles.[12] Land development and subsequent intensification of use in one area may force land retirement in another area, especially when development projects are ill-timed with respect to the

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[11]The Soil Conservation Service identifies three types of benefits arising from more intensive use of the flood plain. The definitions of the three types are:

1. The restoration of former productivity - the difference between the present net income of land that was formerly cultivated but is now abandoned or in low-producing crops because of the adverse effects of flooding and the expected income after this land is restored to its former productivity as a result of the program.

2. Changed land use - the difference between the net income of flood plain land that previously has never been cultivated and the expected income of this land after the program induced changes to cultivated or urban use.

3. More intensive land use - the difference between the net income of flood plain land now in cultivation and the expected income of this land after the program induced changes from low intensity crops to higher intensity crops or a change in the intensity of application of variable inputs to a specific crop.

Source: Soil Conservation Service, United States Department of Agriculture, Economics Guide for Watershed Protection and Flood Prevention (Washington, 1958), Chapter IV.

[12]For example see John A. Schnittker, "Appraisal of Programs and Impacts on Land Use Adjustments," Dynamics of Land Use - Needed Adjustments, Iowa State University Center for Agricultural and Economic Adjustment (Ames, 1961), pp. 229-236.

national demand for particular agricultural products.[13]

Those who defend the apparent anomaly do so on the basis of the spectre of an approaching Malthusian world of food scarcities and/or the distributive goals of equity among regions of the country or sectors of the economy. In addition small watershed proponents stress the conservation aspects of the programs more so than the resource development aspect.

This study does not deal with the broad philosophical issues of the overall worth of resource development, nor with the controversy between those who favor big dams and those who favor small dams. The viewpoint of this analysis is local.[14] Thus the interregional shifts in land use caused by resource development are not considered. However, the importance of the changes in land use in relation to these issues emphasizes the need for objective measurement of the actual effects of the programs and for more refined techniques to make future estimates of changes in land use. Hopefully, knowledge of the local benefits of the small watershed programs will contribute answers to broad questions concerning the distribution and magnitude of the overall effects.

The Significance of Land Use in Benefit-Cost Analysis

Benefits from changes in land use are not only important in

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[13] See G. S. Tolley, "Impact of Public Resource Development on Agricultural Production and Income," Proceedings of the Agricultural Economics and Rural Sociology Section, Association of Southern Agricultural Workers Convention, Memphis, Tennessee, February, 1959.

[14] The appropriate viewpoint for evaluating benefits of federally financed projects is national, but the viewpoint of this analysis, and probably most small watershed planning, is local.

themselves, but they are also important in their effect upon the magnitude of the benefits from the reduction of damages to crops and pasture over the lifetime of the project. Reduction of damage to low-valued crops such as pasture does not create large monetary benefits. If during the life of the project high valued crops are planted, then there would be increased benefits from the reduction of damage to the higher valued crops. This means that it is not only necessary to establish which changes in land use are induced by the project, but it is also necessary to determine the total land use changes that can be expected during the life of the project.

It is entirely possible that flood plain land use could become less intensive over the life of the project as the result of, for example, acreage control programs. Land use change benefits could continue to accrue, since flood plain land use might have been still less intensive without the flood protection program. The fact that there is a trend for marginal land, both bottomland and upland, to be farmed less intensively now than it was in the decades of the forties and fifties may not have as much effect on the benefits of land use changes as it would on the benefits from the reduction of damages to crops and pasture.

The significance of the benefits from changes in land use can be viewed somewhat more pragmatically. Nationally, about 22 percent[15] of all the estimated benefits of watershed protection are due to: (1) the restoration of former productivity, (2) changed land use, and (3) more intensive land use.[16] The weighted average of the percentage of benefits

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[15]This figure is for watersheds approved as of June 30, 1962, under P.L. 566 Watershed Work Plans.

[16]Defined in footnote 10. Hereinafter references to "changes in land use" shall include all of the three types of changes listed above.

of the nine watersheds of this study that came from the above three categories is 11 percent. The percentage varies from 0 to 53 percent (see Table I). Each of these nine watersheds would have had a benefit-cost ratio greater than one even if no benefits of changed land use had been assumed. However, this is not the case for every watershed project in the country.

Current Evaluation Procedures

The Soil Conservation Service evaluates the benefits from the reduction of damage to crops and pasture and the benefits of changes in land use on the basis of the effects of flood protection on flood plain land only.[17] This approach implies that the shifts in upland use associated with the flood protection induced shifts in bottomland use are not important enough to be explicitly considered. In estimating land use change benefits, a sample of farm operators are asked what changes in land use they intend to make if flood protection is provided. Although the Economics Guide for Watershed Protection and Flood Prevention states that farmers' intentions do not necessarily indicate the actual extent of flood plain development after protection is provided, these responses

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[17]A short section in the Economics Guide for Watershed Protection and Flood Prevention, Ch. IV, p. 6, is devoted to a discussion of the possibility that upland allotment crops may move to the bottomland after protection is provided. In this case, "...the net income difference between use of an acre of upland versus an acre of flood plain..." is the appropriate determination to be made, but "Also, any substitute or replacement crops on the upland should be taken into account in calculating the net income difference." The above statement is in reference to allotment crops only and does not appear in reference to any other crops. There is no evidence in the work plans of the watersheds studied that substitute or replacement crops have been taken into account.

TABLE I

SOURCES OF BENEFITS IN THE STUDIED WATERSHEDS[a]

Item	Group I				Group II			
	Barnitz Creek		Beaver Creek		Cavalry Creek		Boggy Creek	
	Dollars	Percent	Dollars	Percent	Dollars	Percent	Dollars	Percent
Flood Damage Reduction Benefits[b]								
Agricultural	159,131	74.8	29,891	50.7	51,320	61.7	41,712	55.1
Nonagricultural	2,100	1.0	6,995	11.9	250	.3	5,033	6.7
Indirect & Off-Site	33,571	15.8	15,818	26.8	12,731	15.3	18,608	24.6
Restoration of Former Productivity	0	0	6,266	10.6	0	0	10,303	13.6
Changed Land Use[c]	0	0	0	0	0	0	0	0
More Intensive Land Use	17,802	8.4	0	0	18,880	22.7	0	0
Total Benefits	212,504	100.0	58,970	100.0	83,181	100.0	75,656	100.0

TABLE I (Continued)

Item	Group III				Group IV					
	Saddle Mtn. Cr.		Rainy Mtn. Cr.		Big Kiowa Cr.		Panther Cr.		Whiteshield Cr.	
	Dollars	Percent	Dollars	Percent	Dollars	Percent	Dollars	Percent	Dollars	Percent
Flood Damage Reduction Benefits[b]										
Agricultural	21,133	72.3	158,140	61.7	3,216	31.9	18,777	82.7	9,689	53.6
Nonagricultural	113	.4	12,025	4.7	25	.2	0	0	4,530	25.1
Indirect & Off-site	5,675	19.4	63,837	24.9	1,506	14.9	2,356	10.4	3,854	21.3
Restoration of Former Productivity	0	0	22,330	8.7	0	0	0	0	0	0
Changed Land Use[c]	0	0	0	0	0	0	0	0	0	0
More Intensive Land Use	2,315	7.9	0	0	5,349	53.0	1,577	6.9	0	0
Total Benefits	29,236	100.0	256,332	100.0	10,096	100.0	22,710	100.0	18,073	100.0

[a]Source: The respective watershed work plans (more fully identified in the Bibliography).

[b]This classification of benefits arises from agency usage.

[c]Although none of the watersheds show changed land use benefits, it is because the benefits were not classified in the work plan according to the definitions of the Economics Guide.

normally serve as a basis for estimating benefits from changes in land use.[18]

The Economics Guide lists the factors to be considered in evaluating benefits of changes in land use as follows:[19]

(1) Productive capacity of the land,

(2) Type of farming,

(3) Width of flood plain,

(4) Degree of protection afforded by measures,

(5) Willingness, intentions, financial status, and the managerial ability of present and future flood plain operators to develop land,

(6) Availability of markets for any new products, and

(7) Restrictions imposed by acreage allotments and marketing quotas.

The relative weights to be put on the above considerations are left to the discretion of the economist, except that guides are given concerning the amount of benefits from changes in land use that can be claimed on certain alloted crops. The productive capacity of the various classes of land relative to one another is theoretically important in explaining land use and changes in land use. But the theoretical importance of the productive capacity of the various classes of land in actuality may be overshadowed by the willingness, intentions, financial status, and managerial ability of the present and future farm operators. Thus it is difficult for an economist using conventional budgeting techniques to take account of all the relationships that exist.

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[18] Economics Guide for Watershed Protection and Flood Prevention, Ch. IV, p. 2. Hereinafter this publication is referred to as the Economics Guide.

[19] Ch. IV, p. 2.

The Hypothetical Factors Affecting Land Use and Changes in Land Use

The list of evaluation factors in the *Economics Guide* probably is not all inclusive, but if the effects of all the listed factors could be simultaneously considered, the actual changes in land use could be explained more accurately than they are at present. An objective specification of the factors and the interrelationships among them could serve as a basis for predicting the changes in land use induced by the project. Furthermore, if such a model were used at the time that benefits were estimated, then an *ex post* evaluation of the actual changes in land use, and their causes, would be easier than if there had been no objective specification of the model.

In practice even the most sophisticated model cannot specify these few variables. But the simple linear programming tableau provides a basis for taking into account many of the interrelationships among the various factors affecting land use. Furthermore, linear programming offers a method by which the *ex ante* estimates of the degree of protection afforded by the measures can be empirically checked with the *ex post* results. Because of the uncertainty surrounding the estimates of the crop damages sustained and the degree of flood protection provided, the empirical check of the actual effect with the effect implied by the estimates is important.[20]

In this study all of the factors listed in the *Economics Guide* are considered in the explanation and prediction of land use. The manner

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[20] The estimated crop damage factors are explained in the next chapter.

in which they are specified, however, is very simple in relation to their complexity in the real world. No effort has been made to consider curvilinear relationships among the listed factors. Likewise, single-valued expectations were assumed throughout the study.

The Objectives and Content of the Study

The general objectives of the study are: (1) to determine changes made in land use attributable to a reduction in flooding, (2) to predict future changes in land use consistent with observable economic relationships, and (3) to contribute to an overall model explaining land use. More specifically, these objectives are: (1) to compare land use in protected watersheds with similar unprotected watersheds and with country trends, (2) to explain land use in watersheds already protected, (3) to find the changes in land use implied by the reduction in flood damage proposed by the Soil Conservation Service in the as yet unprotected watersheds, and (4) to explore the usefulness of linear programming as a predictive model of changes in land use.

The remainder of this thesis is divided into four chapters. The second chapter contains the concepts and procedures used to compare, explain, and project land use. The empirical comparisons among protected and unprotected watersheds are presented in the third chapter. The fourth chapter contains the programming results of the explanation and prediction of land use and changes in land use. In the final chapter the results of the analysis are summarized, and conclusions are drawn about the model, the damage factors, and the changes in land use.

CHAPTER II

CONCEPTS AND PROCEDURES

The purposes of this chapter are to present: (1) the concept of decision-making applicable to the operational procedures, and (2) the explicit model, assumptions, and procedures of this study.

Decision Making in an Empirical Framework

A discussion of adjustment to changing conditions must rest on principle. Although many alternative principles of behavior have been proposed, profit maximization is still the most consistently assumed main principle governing businessmen's actions. Exceptions to the rule cause many economists to seek and propose a more general rule of action. Unfortunately few new proposals have been sufficiently tested for universal applicability, for explanatory power, or for predictive accuracy.

The maximization of utility has much appeal as a universal principle of consumption and production behavior. However, its usefulness for empirical research is limited by difficulties of measurement and interpersonal comparisons. Yet in an analysis dealing with farm operators as a particular group of businessmen, utility maximization has special appeal because of the interdependence of firm and household decisions.

Utility and profit maximization are not inconsistent. As Papandreou has stated "...profit maximization does imply rationality of course, but rationality is consistent with other things as well as profits."[1] Two methods of incorporating both nonmonetary utilities and the utility obtained from profit into empirical models have recently been used.

One method employs "income targets" set at less than maximum potential income. The minimization of costs for this income target is consistent with the efficiency aspects of the profit motive and the "satisficing" principle proposed by Simon.[2]

A second method frequently used to take into account subjective utilities is the capital rationing model. In this procedure the marginal value product of capital is set at some predetermined level. Risk aversion is assumed important in restricting the amount of capital investment to less than that which is most profitable under perfect competition.[3]

A conceptual model illustrating the relationship between the two models discussed above is shown in Figure 1. For the sake of simplicity, two assumptions are made: (1) the market cost of capital[4] is constant and has been paid, and (2) the utility per dollar of profit is constant over the range of profits discussed.[5]

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[1]Andreas G. Papandreou, "Problems in the Theory of the Firm," <u>A Survey of Contemporary Economics</u>, Vol. II, ed. Bernard F. Haley (Homewood, 1952), pp. 205-213.

[2]Herbert A. Simon, <u>Models of Man</u> (New York, 1957), Chapters 14 and 15. Simon's concept is that decision makers have certain aspirations which they attempt to attain. Once they have attained their level of aspiration, they appear satisfied with their "status quo."

[3]One of the conditions of perfect competition is perfect knowledge, which implies no risk.

[4]Capital is used here in a general sense to include all nonland capital used in the firm.

[5]Profits are used here as returns above variable costs.

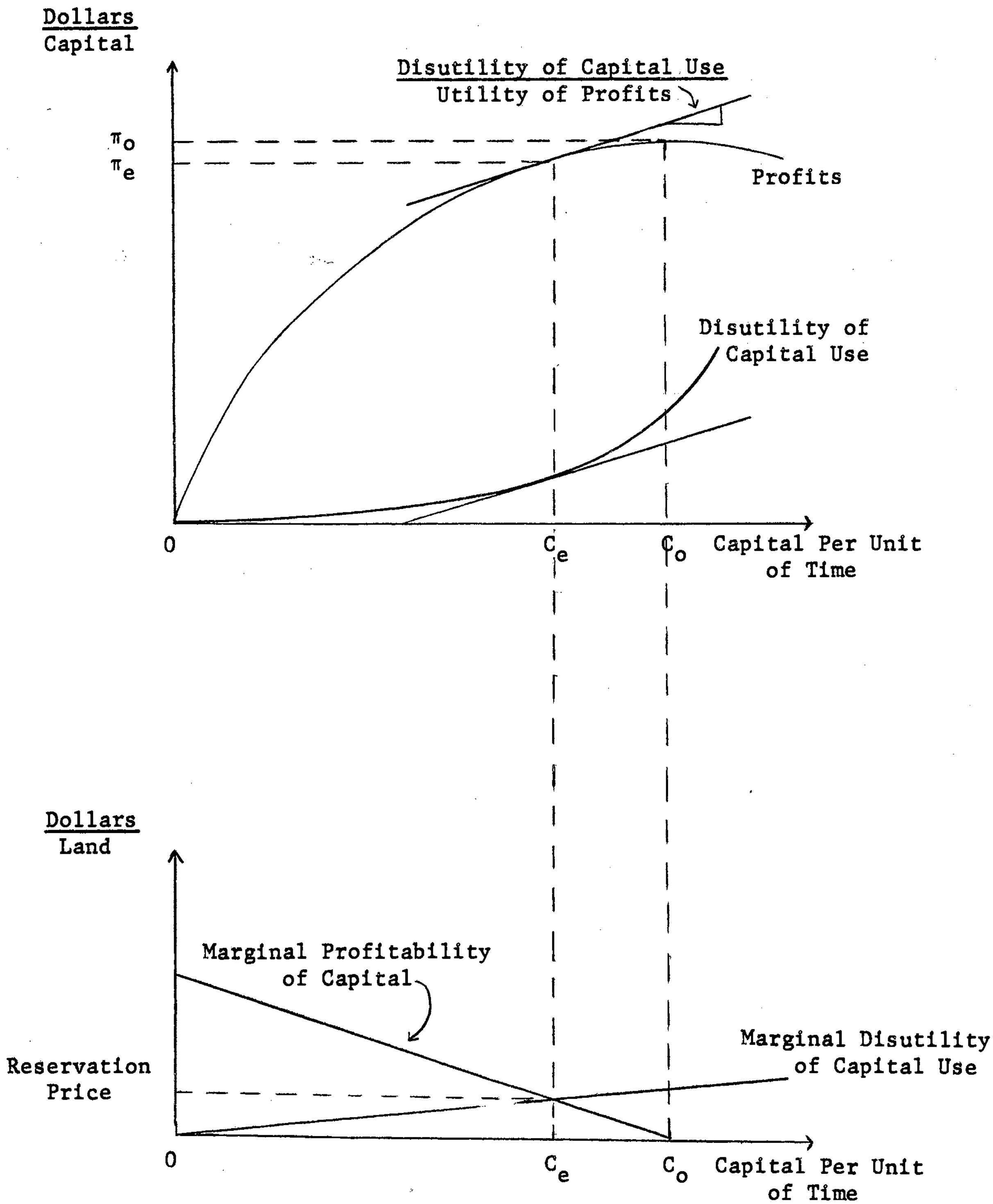

Figure 1. The Hypothetical Equilibrium Point Between the Utility of Profits Derived from Capital and the Disutility of Capital Use

Monetary profit is shown as a function of capital. Diminishing marginal returns are displayed only because of the diminishing productivity of capital added to the fixed factor, land.

The disutility of capital use is also shown in Figure 1.[6] It is measured in monetary terms since a dollar is equivalent to a unit of utility or disutility by assumption.

If there was no disutility associated with capital use, then maximum utility would be at π_o and the amount of capital used would be C_o. At π_o monetary profits are maximized.

If the disutility associated with increasing amounts of borrowed capital is considered, then maximum utility is at π_e and the amount of capital used is C_e. At C_e units of capital the marginal utility from profits is equal to the marginal disutility of capital use. (Shown in the lower part of Figure 1). The slope of the two functions at C_e units of capital is the ratio of the disutility of capital use over the utility of profits.[7]

In the lower part of Figure 1, the marginal profitability of capital and the marginal disutility[8] of capital use are graphed. Where they are equal defines the reservation price on capital. The reservation price

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[6]The shape of the function relating disutility to capital use was first postulated by M. Kalecki in "Principles of Increasing Risk," Economica, New Series (1937), pp. 440-447.

[7]The concept is to maximize net utility, $G = U_p\ [\ (c)] - [Dc(c)]\ C$, where U_p = utility per unit of profit = a constant: $\pi(c)$ = profits as a function of capital, $Dc(c)$ = disutility as a function of capital, and C = capital. Thus the equation of the tangent is $\pi = \frac{G}{U_p} + \frac{Dc}{U_p} C$.

[8]Measured in monetary terms, since a dollar is equivalent to a unit of utility or disutility.

is the profit per unit of capital required by investors to overcome the disutility associated with capital use.

In this example the market price of capital has been subtracted off before the functional relationship between profit and capital was graphed. In the remainder of this thesis, however, such an assumption will not be made. Thus the reservation price will be defined as the return required per unit of resource to induce the owner of that resource to use it for purposes of production.

The reservation price is consistent with the predetermined marginal value product of capital used in the capital rationing models. Point π_e of Figure 1 is consistent with the less than maximum income assumed in the income target model.

As pictured in Figure 1, the disutility of capital use is the only cause of less than maximum income. This, however, is not necessary. There are likely disutilities with similar effects associated with each factor of production. For example, the functional relationship between the disutility of family labor and the amount used may be very small for small amounts of labor, but much larger for large amounts.[9]

Frequently it is assumed that the reservation price on owned resources is equal to either the market price per unit of time for comparable resources or equal to zero. It is possible, however, that the reservation prices (the manifestations of the equilibrium between the utility from profits and the disutility of resource use) vary between people and

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[9]See Alfred Marshall, <u>Principles of Economics</u>, Eighth edition (London, 1961), pp. 117-119, for a discussion of the marginal disutility of labor and the resulting supply price of labor.

enterprises and thus between regions of the country and sectors of the economy. If the actual magnitude of the various reservation prices in particular regions were known, it is possible that answers to questions about the expected rate of regional development could be formulated.

Linear Programming as an Operational Model for Estimating Reservation Prices

Linear programming, as a technique for formulating optimum farm plans, has been thoroughly discussed.[10] In general it is a method of maximizing a linear criterion function subject to a relevant set of linear restraints. The essential factors are the specification of the principle that guides farmers' actions, the production relationships, the prices of products and resources, and various linear restraints imposed by society or by the farm situation. Through the iterative process of determining successively higher values of the criterion function, the farm organization implied by the specified factors is determined. That is, the farm organization is determined by the deductive logic of the programming model.

A large discrepancy between the typical programmed farm organization and actual farm organization implies that: (1) farmers do not perceive or are not able to make the necessary adjustments for profit maximization, (2) the restrictions and the price and technological relationships of the programming model are not specified correctly, or (3) farmers are not trying to maximize monetary profits.

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[10] See for instance Robert Dorfman, Paul Samuelson, and Robert Solow, Linear Programming and Economic Analysis (New York, 1958); and Earl O. Heady and Wilfred Candler, Linear Programming Methods (Ames, 1958).

If it is assumed that farmers can adjust immediately, and that the relationships of the programming model are specified correctly, then differences in the programmed organization and the actual organization could be imputed to errors in the specification of the criterion function.

It is possible that some of the discrepancies between the programmed organization and the actual organization can be removed by changing the reservation price on a key resource. A reservation price different from the market price or from zero is possible when nonmonetary utilities are associated with resource use.

But, more than one type of resource may have a nonmonetary utility associated with it. Thus some combination of reservation prices on two resources may remove more of the discrepancies between programmed and actual organization than placing a reservation price on one resource only.

Finally, it is theoretically possible that a unique set of reservation prices for all of the resources and restrictions in the program could be found. If they could, all of the differences between programmed and actual farm organization might be removed (assuming that all the restrictions were specified at the same level of preciseness as our information on farm organization).

Operational Problems

Four operational problems exist: (1) The estimation of reservation prices on more than one resource is an inefficient trial and error method. (2) If the true reservation prices of other resources are ignored, the model may impute them to the reservation price of the resource under consideration. This means that the model loses structural identity for later predictive purposes. That is, the farm organization is explained with a model whose parameters may be inaccurate. The right answer is obtained with the wrong model. The model is, therefore, inappropriate in another situation where the values of the variables differ from the original. (3) The dynamic aspects of the economy means that true reservation prices are constantly changing. The environmental conditions surrounding the entrepreneurial unit affect the reservation prices. (4) If a unique set of reservation prices could be found, the programming model would provide a description of the farm organization within the postulated framework and at a particular point in time. But again its usefulness for predictive purposes is reduced, because the entrepreneurial unit has been described with a set of static equations.

The Operational Technique Used

In this study, the price of nonland capital was varied until a programmed organization was found that was most similar to the actual organization. It was then assumed that this price on capital (the reservation price) would remain unchanged after flood protection, but that the prices of other resources "fixed" to the farm (family labor, allotments, and land) were variable. That is, their marginal value products were not predetermined. This procedure implicitly assumes that:

(1) Flood damages do not affect the risk component of the reservation price on nonland capital to any great extent, and thus flood protection will have no appreciable influence on that price either.

(2) The reservation prices on the other resources "fixed" to the farm are zero. This means that they will be used in the farm firm until they are used up or until their marginal returns

become zero.

The Procedures Employed

In this section, the sources, collection, and classification of the data are discussed, the assumptions of the programming model are stated, and the advantages and disadvantages of the analytical procedure are discussed.

The Data

Historical data on land use in the four counties were summarized from annual reports of the Oklahoma Crop Reporting Service. The use of the flood plain at the time the Soil Conservation Service originally planned the watershed was obtained from the substantiating data for the respective watershed work plans. Present land use, farm resource situations for the programming analysis, and characteristics of farms and farmers that might affect land use were collected by interviewing a sample of farmers in the area. Other data on damage factors, soil characteristics, and yields were obtained from the Soil Conservation Service.

The Farm Survey and the Sampling Procedure

Because the changes in land use on both the bottomland and upland soils were of interest, the population from which the data were collected was defined as "farms with bottomland in the specified watershed." The typical flood plain is wider at the lower end of the stream or reach than at the upper end. For any particular reach the width is very irregular. In order to make certain that a representative sample (with respect to flood plain width) was selected, the flood plain was categorized into widths of: (1) less than 1/8 mile, (2) between 1/8 and 1/4 mile, and

(3) greater than 1/4 mile.[11] An equal number of sample units were drawn randomly from each width category.

Farmers who operated land in the sample units were questioned about their entire farm unit. Since field and farm boundaries in this area are not related to flood plain boundaries, the size of the sample units (farms with flood plain land) were independent of the original stratification.

In all, 139 useable schedules were collected. These along with 25 schedules taken in Boggy Creek[12] two years earlier provided information on 164 farm units with a total of 100,181 acres of land.

Classification

The size of the sample farms varied considerably. Much of the variation, however, was in the relatively unproductive rangeland. Even though aggregation bias (as discussed later) was anticipated, the farms were classified on the basis of the acres of cultivatable land. The average resources of each class were used to construct a typical farm. Typical farms, based on the average characteristics of the sample of farms, were used so that aggregated results might be less biased than the results of aggregating some subjectively chosen representative farms. Aggregating the results made it possible to compare land use changes, as determined by programming, with historical land use changes and with the Soil

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[11]A study of flood plain width and other geographic features that affect the agricultural occupance of flood plain land is found in Ian Burton, Types of Agricultural Occupance of Flood Plains in the United States (Chicago, 1962).

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

Conservation Service predictions of land use changes.

The classification based on the acres of cultivatable land was chosen because it was hypothesized that: (1) the absolute amount of cultivatable land would have an influence on the capability and willingness of farm operators to change farm organization, and (2) the ratio of cultivatable bottomland to cultivatable upland might have an influence on the changes in land use that would occur as a result of flood protection.[13]

Resource Situations

Sample farms in each watershed group were classified first, on the basis of whether they fell in protected or unprotected watersheds and second, on the basis of their total acres of cultivatable land. The characteristics of the farms in each category were then averaged to construct a typical farm. In Chapter III land use on farms with fairly comparable resource situations was compared to determine if differences could be detected as a result of flood protection.

The same resource situations were retained, but defined more explicitly, for the programming analysis. The bottomland acreage as determined from the farm surveys was divided into two classes of land suitable for cultivation and one class of range. The upland acreage was divided into two classes of cultivatable land and two classes of range. The selection of the soils to be included in each of the productivity classes was done after consulting with soil scientists in the area studied. The yields for each productivity class were weighted

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[13]These two influences were alluded to in Burton, Ibid., pp. 10-11.

averages of the yields for soil types included in each class[14] except for minor modifications based upon judgments of agricultural workers in the area. Yields on flood plain soils were those expected under protected conditions and under the management prevailing in the area.

The bottomland soils were originally divided into flood plain and nonflood plain according to the descriptive legend of the county soil reports. Later computations showed that the flood plain delineated by the Soil Conservation Service at the time of project planning included more of the bottomland than the flood plain soils delineated in the descriptive legend of the county soils reports. The division of the bottomland soils was retained but only on the basis of the differences in their productivity. All of the bottomland on the farms surveyed was assumed to be flood plain and was subject to the average Soil Conservation Service damage factor when unprotected conditions were programmed.[15]

Labor

Farm operators of the surveyed farms were asked the hours worked by them and members of their family each month of the year. These figures were modified by assuming that 1/3 of the operator's time was spent in management and other labor not included in the program requirements. For younger boys 1/8 was subtracted from their hours worked for each year that they were younger than 16 years of age.

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[14]The yields of the various soils were taken from Soil Conservation Service field reports of representative soil types in the respective counties.

[15]The Soil Conservation Service damage factors are explained in a later section.

Hired labor was assumed available in all periods at a rate of $1 per hour.

Capital

The capital supply was restricted only by the required rates of return (the reservation prices). Capital requirements for each enterprise were divided into total and annual capital.[16] The required rate of return was charged on the total capital used. An alternative assumption would have been to charge the required rate of return against the annual capital. This might have had an effect on farm organization and the rate of return required to produce a programmed organization most like the actual organization.

Technology and Management

The intent of this study was to approximate actual management in the area. The primary manifestation of the management level is the yields assumed. Recommended fertilizer and insecticide applications are not high in this dryland area. Thus the differences in costs per acre among poor, average, and good managers are not large. Since information collected in the farm survey concerning the levels of fertilizer application was not sufficient to develop input coefficients independent of other data, the recommended levels were included in the budgets.

An analysis of the power available on each farm in the survey showed no significant difference among farms falling in the small and large categories of cultivatable land. Since larger tractors seemed

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[16]Annual capital is total capital required by an enterprise in the year multiplied by the fraction of the year that the capital is actually in use.

to be the rule rather than the exception on all farms, four-row equipment was assumed on all sizes of farms.

Allotments and Acres Idled Under Conservation Reserve, Feed Grain, and Wheat Programs

The bottomland and upland idled under the Conservation Reserve, Feed Grain, and Wheat Programs was subtracted from the total bottomland and upland resources of the typical farms. The idle upland was assumed to have occurred on the poorest quality cropland. The bottomland in conservation reserve was divided among the bottomland productivity classes in the same proportion as these exist on the farms.

The current acres of wheat, cotton, grain sorghum, and barley were considered to be the effective allotments. This means that with a change in flooding conditions, the total acres of these crops can decrease but cannot increase. There can also be a reallocation of these crops between bottomland and upland.

Enterprises Included

The crop and livestock enterprises included were those that are presently in the area. They included wheat, cotton, grain sorghum, barley, oats used for grain and pasture, alfalfa, forage sorghum, small grain for pasture only, sudan, Johnson grass, cultivatable pasture,[17] and various stocker and cow-calf enterprises. No irrigated enterprises

[17]Some of the land in the watersheds was suitable for cultivation but was in pasture. In Groups I, III, and IV an enterprise was included to allow all classes of cultivatable land to be utilized for pasture with no explicit labor or capital cost. The amortized costs of establishing pastures are negligible, and the annual maintenance costs are included in the livestock enterprise budgets.

were included since very little irrigation was reported in the farm survey. The enterprise budgets constructed were modifications of those developed for Southern Regional Research Project S-42[18] and by Dale O. Anderson and W. B. Back.[19] The major modification of the budgets, aside from the yields and the necessary adjustments in harvesting costs, was that no custom operations were assumed except for the stripping of 2/3 of the cotton crop. No custom operations were assumed because of the large amount of family and hired labor reported used in the farm survey. On some farms, however, this may result in a downward bias in the preharvest costs since some custom labor, especially in cotton, probably was used.

Four basic sets of crop enterprise budgets - one set for each watershed group - were used because yields varied among watershed groups.

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[18]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 and Experiment Station in Cooperation with the United States Department of Agriculture, Processed Series P-368 (Stillwater, 1961).

William F. Lagrone, Percy L. Strickland, Jr., and James S. Plaxico, Resource Requirements, Costs and Expected Returns; Alternative Crop and Livestock Enterprises, SANDY Soils of the Rolling Plains of Southwestern Oklahoma, Oklahoma Agricultural and Experiment Station in Cooperation with the United States Department of Agriculture, Processed Series P-369 (Stillwater, 1961).

John W. Goodwin, James S. Plaxico, and William F. Lagrone, Resource Requirements, Costs and Expected Returns; Alternative Crop and Livestock Enterprises, CLAY Soils of the Rolling Plains of Southwestern Oklahoma, Oklahoma Agricultural and Experiment Station in Cooperation with the United States Department of Agriculture, Processed Series P-357 (Stillwater, 1960).

[19]Dale O. Anderson and W. B. Back, "Budgets for Selected Irrigated and Non-Irrigated Crops Grown on Bottomland Soils of Roger Mills County, Oklahoma," publication forthcoming.

Those crops not presently grown in a particular group of watersheds were not included in that group's programs.

Product prices were basically the quantity weighted average of the monthly prices for 1961 (Appendix B, Table I). Costs were those assumed in the S-42 studies.[20]

Livestock enterprises in the area varied considerably among farms and also from year to year for any particular farm. The enterprises included are representative of several of the more stable livestock enterprises. Most of the feeder enterprises depended on some combination of wheat and other temporary pasture, and almost all required some range. The cow-calf enterprises required about nine to eleven animal unit months of range along with supplementary home produced alfalfa or forage sorghum. One cow-calf enterprise required purchasing of winter forage. Spring and fall calving and various purchasing and selling dates also were included in the analysis.

Damage Factors

The damage factors used by the Soil Conservation Service are basically the percent damage in crop yields due to flooding. The damage factors used in this study were those developed by the Soil Conservation Service planners in each watershed. However, certain modifications were made so that they could be used in the programming analysis. The final form of the damage factors accounted for the depth of inundation, frequency, and season of flooding specific to the particular watershed. In addition the degree of protection provided by the structures is accounted

[20]Cited in footnote 18, Chapter II.

for in the damage factors.[21]

It has been hypothesized that if the estimates of damage by the Soil Conservation Service were accurate, there would be more shifts in land use than have actually taken place. Thus in this study, the implications of four levels of the damage factors with respect to land use changes were determined. The levels were: (1) the estimated damage factors for each crop, (2) 2/3 of the damage factors for each crop, (3) 1/3 of the damage factors for each crop, and (4) the protection level provided or proposed by the Soil Conservation Service.

Land Use Intensity

In Chapter III, land use intensity is roughly indicated by the proportion of an area devoted to cotton, wheat, and alfalfa - three "intensive" crops in the area. In Chapter IV, the returns, net of operating costs, to land, labor, management, and capital from a composite acre serve as a measure of land use intensity. While not being strictly correct, these measures are commensurate with the definitions of benefits from changes in land use given in footnote 10, Chapter I.[22]

In calculating the intensity of an acre of bottomland before and after protection, the yields under protected conditions in the watershed

[21]The computations required to adapt the Soil Conservation Service damage factors to the programming analysis are presented in Appendix D.

[22]In land economics literature the term "land use intensity" most often refers to the ratio of nonland inputs to land. The justification for using the returns per acre rather than the inputs per acres is that: (1) the benefits from changes in land use are based on the differences in net returns of a composite acre before and after flood protection, and (2) net returns are positively correlated with the ratio of nonland inputs to land over the normal range of input use.

group under consideration were used. Protected yields were used because: (1) they were assumed equal among watersheds of a group, and (2) they were a more appropriate base measure of yields than the more highly variable yields experienced under flooding.

The following example indicates the nature of the intensity measure. Suppose the land use of a particular 25-acre field is 5 acres of cotton, 10 acres of wheat, and 10 acres of alfalfa. The hypothetical per acre return to land, labor, capital, and management under protected conditions is \$67 for cotton, \$34 for wheat, and \$32 for alfalfa. The land use intensity is:

$$\frac{(67 \times 5) + (34 \times 10) + (32 \times 10)}{25} = \$39.80.$$

This is equivalent to the income per acre to land, labor, capital, and management of this field. Suppose now that a flood occurs which reduces the yield of the three crops. The new per acre income to land, labor, capital, and management is now less, but the intensity of use is the same as long as these three crops are grown on the land in the same proportion. However, if continued flooding induces farm operators to change the use of the 25 acres of land to 15 acres of wheat and 10 acres of alfalfa, the new land use intensity is now:

$$\frac{(34 \times 15) + (32 \times 10)}{25} = \$33.20.$$

The \$33.20 is not the per acre income because yields have been reduced due to flooding. In this manner, the effects of flood protection can be separated into those due to reduction in crop and pasture damages (due to increased yields) and those due to changes in land use (induced by the protection).

Using this measure, the cropland intensity of a typical farm may decrease after flood protection. Crop and livestock enterprises are profitable in a whole farm framework. But the average values of a unit of a specific enterprise, as used in the intensity measure, do not take into account the scarcities of various classes of resources on a specific farm. An example of this situation is forage marketed through livestock. Its value in this use on a specific farm may be greater than the average value of forage assumed in the intensity measures.

The Analytical Procedure

The empirical comparisons are fully described in the next chapter. The programming procedure, however, requires further elaboration.

In general, land use was explained[23] on the protected watershed of a group by varying the reservation price on the available resources. It was then assumed that the reservation prices of the protected watershed were appropriate for the unprotected watershed.

The further assumption was made that if the unprotected watershed was indeed protected, its land use could be explained with the same model. Then it was hypothesized that if the damage factors were accurate, the actual land use of the unprotected watershed could be explained by applying these damage factors to the protected yields in the original explanatory model. But if the damage factors were inaccurate, the actual land use would be explained by some intermediate level of the damage

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[23]Explain is used in this context in the sense of demonstrating a phenomenon as determinable from known conditions. In this sense a programming model may explain land use on a typical farm.

factors. Thus the prediction concerning expected land use changes in the unprotected watershed would be those differences in land use between the programmed land use with protected yields and the programmed land use with the damage factor level explaining actual land use best.

There were two reasons for selecting the protected watershed as a basis for the other programs. First, it was hypothesized that the protected yields had less year-to-year and field-to-field variance and thus were more easily determined than the unprotected yields. Secondly, if the unprotected watershed had been used as a base, it would not have been possible to test the level of the damage factors against land use in the unprotected watershed. In other words, the prediction would have depended entirely on the damage factor level assumed by the Soil Conservation Service.

Using the same rate of return in the unprotected watershed implicitly assumes that flood protection does not appreciably influence the risk factor in the reservation price on capital. This may not be true, but determining the change in the risk factor as a result of flood protection is beyond the scope of this study.

The Advantages of the Analytical Approach Used

The basic analytical approach used in this study has been suggested by several recent articles.[24] Heady has emphasized its crudeness, but also the fact that it does not require any data that is not now being

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[24] For example see E. O. Heady, "Mathematical Analysis: Models for Quantative Application in Watershed Planning," p. 216; and George S. Tolley and Ralph A. Freund, Jr., "Does the State of the Data Suggest a Program for Modifying Planning and Evaluation Procedures?" pp. 127-144; both articles in The Economics of Watershed Planning, eds. G. S. Tolley and F. E. Riggs (Ames, 1961).

used in watershed planning. Tolley and Freund asked this question, "Taking the total farm situation, what are the economic incentives regarding flood plain use with the present degree of protection, and how are these changed with reduced flooding?" They stated that the estimate of change indicated by this method may "...help circumvent reliance..." on farmers' reflections of what they might do as a result of flood protection.

In any case, this approach emphasizes the primary beneficiary of flood protection, the flood plain farmer, but it assumes that benefits do not exist unless farmers do in fact take advantage of them. It is recognized as a simple, static, predictive model, including only an assessment of the factors endogenous to the farm as a basis for projecting land use in individual watersheds.

Aggregation Bias

Differences between the programmed optimum and the actual land use of a typical farm may be due to many other things besides the utilities associated with resource use. Other causes of such differences are: (1) errors of specification in the relationships of the model, including the damage factors, (2) the impreciseness of the technique, (3) true maladjustments in resource use with respect to farmer goals and with respect to time lags in adjustment to ever changing dynamic conditions, and (4) aggregation bias associated with using a typical farm as a unit of analysis.

The first three have been alluded to earlier but the last one deserves further elaboration. The averaging of the land resources, the available labor, the allotments, and all other inputs or restrictions to determine the "typical" farm allows aggregation bias to appear. For an example, suppose a farm with 40 acres of bottomland, 100 acres of upland, and no cotton allotment is averaged in with a farm with 10 acres of bottomland, 100 acres of upland, and 50 acres of cotton allotment. Assume that average land use for these two farms includes 5 acres of cotton on the bottomland and 20 acres of upland cotton. The average bottomland is 25 acres; the average upland is 100 acres. The profit maximizing program of the typical farm probably will have 25 acres of cotton on the 25 acres of bottomland and no cotton on the upland.

Comparisons between the programmed land use on the typical farm and the actual land use on the typical farm would lead one to believe that the program model does not explain land use very well; but the discrepancy was entirely due to aggregation bias. The obvious solution is to classify the farms more precisely so that these two farms do not fall in the same category. The same possibility, however, exists with respect to each category of resources, and also with respect to those goals which motivate people. Classification of this kind was performed up to what was considered a practical level. It can only be hoped that the bias encountered was not excessive.

CHAPTER III

AN EMPIRICAL ANALYSIS OF LAND USE IN DEVELOPED AND UNDEVELOPED WATERSHEDS

This chapter contains the empirical estimates of the differences in land use between comparable resource situations. Several types of comparisons are made because the existing differences may be explained by factors other than flood protection. Historical differences between farm situations may have existed long before watershed programs were initiated. Likewise, historical differences may have been removed by the watershed programs.

In order to reduce the number of other influences affecting land use, only watersheds that were similar with respect to their inherent soil productivity were compared. Furthermore, only farms of approximately the same size were compared. The measure of size used was the total acres of cultivatable land. In Group II watersheds, Cavalry and Boggy Creek, farms were classified first by size and then by the ratio of bottomland to upland. This classification was made because it was hypothesized that flood protection might have a greater influence on land use on farms where upland was scarce relative to bottomland.

Comparisons were of three types. First, the distribution of the crops on the bottomland and upland were compared. Chi-square tests were used to test the null hypothesis that the percentage distribution of crops on the bottomland of similar sized farms from developed and undeveloped watersheds were the same.

Secondly, the percentages of the wheat and cotton allotments that were planted on the bottomland were compared between similar developed and undeveloped farms. The hypothesis was that after protection there would be an incentive to shift wheat and cotton from the upland to the bottomland. Thus less wheat and cotton would be planted on the upland and more on the bottomland on protected farms.

Finally, data available on historical trends in land use are presented. Trends in cultivated land use in a county are indicative of the influence of exogenous changes in demand and the comparative advantage of the area in general. Changes in bottomland use since the time of planning relative to the county trends are assumed to indicate the influence of the flood protection programs.

The organization of this chapter is as follows: (1) a description of the watershed pairs and farm situations, (2) comparisons of the land use in developed and undeveloped watersheds broken down by groups of watersheds, (3) historical trends in land use in pairs of watersheds exhibiting large differences in land use, and (4) historical trends in land use in pairs of watersheds in which little or no differences in land use was ascertained.

Comparisons of Farm Resource Situations in Developed and Undeveloped Watersheds

Each of the four watershed pairs studied here are as comparable as any pair of watersheds in the Washita Basin. Yet there are some obvious differences between the watersheds of any one group and the characteristics of the farms within them (Tables II through V).

TABLE II

CHARACTERISTICS OF AVERAGE (TYPICAL) FARM SITUATIONS IN GROUP I WATERSHEDS

Item	Unit	Less Than 200 Acres Cult. Land		Greater Than 200 Acres Cult. Land	
		Barnitz (Prot.)	Beaver (Unprot.)	Barnitz (Prot.)	Beaver (Unprot.)
Sample Farms	Number	13	8	23	10
Cultivatable Land	Acres	142	140	526	375
Bottomland	Acres	77	44	194	138
Upland	Acres	48	51	269	188
Gov't. Program	Acres	17	45	63	49
Range	Acres	179	215	632	172
Total	Acres	326	355	1,158	547

TABLE III

CHARACTERISTICS OF AVERAGE (TYPICAL) FARM SITUATIONS IN GROUP II WATERSHEDS

Item	Unit	Less Than 300 Acres Cult. Land				Greater Than 300 Acres Cult. Land	
		Less Than 1:2 Bottom-Upland Ratio		Greater Than 1:2 Bottom-Upland Ratio			
		Cavalry (Prot.)	Boggy (Unprot.)	Cavalry (Prot.)	Boggy (Unprot.)	Cavalry (Prot.)	Boggy (Unprot.)
Sample Farms	Number	7	8	6	7	17	10
Cultivatable Land	Acres	162	181	170	138	537	495
Bottomland	Acres	28	45	108	93	141	159
Upland	Acres	111	133	38	38	311	311
Gov't. Program	Acres	23	3	24	7	85	25
Range	Acres	95[a]	117	84[a]	135	142[a]	239
Total	Acres	257	298	254	273	679	734

[a]Includes cultivatable pasture.

TABLE IV

CHARACTERISTICS OF AVERAGE (TYPICAL) FARM SITUATIONS IN GROUP III WATERSHEDS

Item	Unit	Less Than 300 Acres Cult. Land		Greater Than 300 Acres Cult. Land	
		Saddle (Prot.)	Rainy (Unprot.)	Saddle (Prot.)	Rainy (Unprot.)
Sample Farms	Number	8	7	6	5
Cultivatable Land	Acres	204	156	672	572
Bottomland	Acres	78	71	212	192
Upland	Acres	79	63	352	249
Gov't. Program	Acres	47	22	108	131
Range	Acres	221	213	537	716
Total	Acres	425	369	1,209	1,288

TABLE V

CHARACTERISTICS OF AVERAGE (TYPICAL) FARM SITUATION GROUP IV WATERSHEDS

Item	Unit	Big Kiowa (Prot.)	Panther (Prot.)	Whiteshield (Unprot.)
Sample Farms	Number	6	8	8
Cultivatable Land	Acres	222	237	174
Bottomland	Acres	70	81	73
Upland	Acres	77	115	83
Gov't. Program	Acres	75	41	18
Range	Acres	731	526	209
Total	Acres	953	763	383

Group I

Barnitz Creek, with a total area of 178,674 acres of which 16,203 acres are bottomland, is one of the larger watersheds in the Washita River Basin. In contrast Beaver Creek has a total area of 56,088 acres, including 2,724 acres of bottomland. Barnitz was planned in 1950 and the structures were essentially completed by 1958. Beaver Creek was planned in 1958. The major physiographic difference between the watersheds is that the flood plain of Beaver Creek is, on the average, narrower than the Barnitz Creek flood plain. Nevertheless, average farm size in Barnitz Creek is nearly twice that of Beaver Creek. The large farms in Barnitz Creek have not only considerably more cultivatable land, but also considerably more range than the comparable farm in Beaver Creek. Also, the percent of land rented in Beaver Creek is about twice that of Barnitz Creek (43 and 20 percent, respectively).

Group II

Cavalry Creek Watershed project was first planned in 1951. The plan was revised in 1955, and most of the structures were completed by the end of 1959. Boggy Creek project was planned in 1960, at which time a survey of 25 farms was made.[1] Boggy Creek resource situations were developed from this survey information. The two watersheds are very similar in soils, topography, and size (69,952 acres in Cavalry Creek Watershed and 74,043 acres in Boggy Creek Watershed). The typical farm resource situations in Cavalry and Boggy Creek are also very similar.

[1] Arnold.

The main difference between the situations of the two watersheds is the amount of land in government programs. This difference may be a function of the two years separating the collection of data from the two watersheds.

Group III

Saddle Mountain Creek is a relatively small watershed with 72,420 acres, while Rainy Mountain Creek Watershed is large (209,959 acres) with considerable variation in topography and soils. Accordingly, the sample area in Rainy Mountain Watershed was restricted to the reaches lying adjacent to Saddle Mountain Watershed. The physiographic features of this limited area are more comparable to those in Saddle Mountain. Saddle Mountain was planned in 1954, and Rainy Mountain was planned in 1960. The structures on Saddle Mountain were completed by early 1960.

The general topography of the two watersheds differs considerably from that in the two previous groups. Parts of the watersheds are very flat with little distinction between upland and bottomland. The Wichita Mountain range crosses the southern part of the watersheds and, although there are large, level, upland fields of wheat among the mountains, there also is a considerable amount of rough, stony, dry rangeland. Thus more cattle ranches are found in these two watersheds than in the preceding groups. This shows up in the large average size of farms (see Table IV). The main differences between the two watersheds are the proportion of land cultivated and the percent of acres rented.

The large percent of acres rented (69 in Saddle Mountain and 32 in Rainy Mountain) is due to the fact that much of the bottomland along the creeks is small parcels of Indian land. Most of the Indian land is not operated by the Indians but, instead, is rented under terms prescribed by the Indian agency. These terms may influence land use in the aggregate.[2] Some farmers stated that the strict enforcement of the rental provisions and the short lease arrangements tended to discourage intensive land use. Local Indian agents in charge of leases, however, believed they were not unduly restrictive, nor at variance with local custom. They reported a good demand for Indian land even though lease rates had been increasing in recent years.

The resource situations of farms in Group III are fairly comparable with respect to size, but the productivity of the reaches surveyed in Rainy Mountain Creek probably is not as high, on the average, as those of Saddle Mountain Creek Watershed. The subsoils of Rainy Mountain Creek are tighter than those of Saddle Mountain, and saline soils appear to be a greater problem in Rainy Mountain Creek.

Group IV

Watersheds in this group are much smaller than the others. Big Kiowa, Panther, and Whiteshield are 25,922 acres, 47,216 acres, and 17,384 acres, respectively, in size. Some of the original Panther Creek flood plain has been condemned and will be inundated by Foss Reservoir. Big Kiowa was planned in 1953 and was essentially completed by the end of 1953; Panther was planned in 1956 and was completed by the end of 1958; and Whiteshield was planned in 1961. Big Kiowa and Whiteshield are both narrow watersheds with relatively narrow flood plains. The group has less rainfall than the other watersheds studied (about 26

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[2]One land use provision of the lease is that 20 percent of all cropland be planted to a leguminous crop such that within a five-year period all cultivated land will be covered one time.

inches). Cattle ranching is more important in these watersheds than in Barnitz and Beaver to the east. The farms surveyed in Group IV were very heterogenous with respect to the number of cultivatable acres, the total farm size, and the type of farming; but the small number of farms precluded the possibility of classifying them.

The percentage of rented land in these watersheds is small (7, 3, and 12 in the order of the table). This may be due to the pressure put on the land market by the condemnation of land for Foss Reservoir which is close to all three watersheds. The average size of farms in Whiteshield is much smaller than it is in Big Kiowa and Panther.

Land Uses of Developed and Undeveloped Watersheds

The distribution of the cultivatable land between bottomland and upland and among crops for the developed and undeveloped resource situations is shown in Tables VI through IX. Chi-square tests were computed on the difference in the percentage distribution of crops on the bottomland between the developed and undeveloped pairs. The tests by themselves do not indicate differences in intensity. If there is no significant difference, the interpretation of the test is that, with respect to cultivatable bottomland use, the sample farms of the two watersheds are similar. If there is a significant difference, the interpretation of the test is that with respect to the use of cultivatable bottomland the sample farms are different. It is possible that the difference could be that the protected farms were farmed less intensively than the unprotected ones.

Several percentage figures implied in Tables VI through IX are of

TABLE VI

DISTRIBUTION OF CULTIVATABLE LAND ON SAMPLE FARMS
IN GROUP I WATERSHEDS
(Percentages)

	Less Than 200 Acres Cultivatable Land					
	Barnitz Creek			Beaver Creek		
Crop	Bottom.	Up.	Total	Bottom.	Up.	Total
Cotton	12.9	1.3	14.2	1.8	0.0	1.8
Wheat	22.8	5.5	28.3	15.4	10.7	26.1
Alfalfa	6.5	3.5	10.0	5.8	0.0	5.8
Feed Grain	6.2	2.5	8.7	0.0	4.8	4.8
Idle	.4	12.2	12.6	4.3	27.3	31.6
Other	5.5	20.7	26.2	8.3	21.6	29.9
Total	54.3	45.7	100.0	35.6	64.4	100.0
	Greater Than 200 Acres Cultivatable Land					
	Barnitz Creek			Beaver Creek		
	Bottom.	Up.	Total	Bottom.	Up.	Total
Cotton	9.1	1.2	10.3	4.0	.6	4.6
Wheat	16.2	21.3	37.5	10.4	13.0	23.4
Alfalfa	4.6	.5	5.1	2.1	0.0	2.1
Feed Grain	2.3	4.5	6.8	5.4	3.0	8.4
Idle	1.7	10.4	12.1	1.6	11.6	13.2
Other	4.6	23.6	28.2	15.2	33.1	48.3
Total	38.5	61.5	100.0	38.7	61.3	100.0

TABLE VII

DISTRIBUTION OF CULTIVATABLE LAND ON SAMPLE FARMS
IN GROUP II WATERSHEDS
(Percentages)

Crop	Less Than 300 Acres Cultivatable Land					
	Less Than 1:2 Bottom-Upland Ratio					
	Cavalry Creek			Boggy Creek		
	Bottom.	Up.	Total	Bottom.	Up.	Total
Cotton	9.8	7.5	17.3	5.1	6.3	11.4
Wheat	2.2	32.6	34.8	10.8	40.7	51.5
Alfalfa	7.5	.5	8.0	4.4	0.0	4.4
Feed Grain	2.6	4.4	7.0	3.0	15.1	18.1
Other	0.0	32.9	32.9	2.1	12.5	14.6
Total	22.1	77.9	100.0	25.4	74.6	100.0
	Greater Than 1:2 Bottom-Upland Ratio					
	Cavalry Creek			Boggy Creek		
	Bottom.	Up.	Total	Bottom.	Up.	Total
Cotton	11.5	0.0	11.5	2.5	1.6	4.1
Wheat	35.9	22.1	58.0	46.6	16.2	62.8
Alfalfa	10.3	0.0	10.3	6.6	0.0	6.6
Feed Grain	5.2	2.9	8.1	7.2	3.8	11.0
Other	11.0	1.1	12.1	8.1	7.4	15.5
Total	73.9	26.1	100.0	71.0	29.0	100.0
	Greater Than 300 Acres Cultivatable Land					
	Cavalry Creek			Boggy Creek		
	Bottom.	Up.	Total	Bottom.	Up.	Total
Cotton	5.4	8.6	14.0	3.7	4.9	8.6
Wheat	13.6	33.8	47.4	19.5	36.1	55.6
Alfalfa	6.6	0.0	6.6	2.0	0.0	2.0
Feed Grain	3.0	15.7	18.7	2.2	16.5	18.7
Other	3.5	9.8	13.3	6.2	8.9	15.1
Total	32.1	67.9	100.0	33.6	66.4	100.0

TABLE VIII

DISTRIBUTION OF CULTIVATABLE LAND ON SAMPLE FARMS
IN GROUP III WATERSHEDS
(Percentages)

Crop	Less Than 300 Acres Cultivatable Land					
	Saddle Mountain			Rainy Mountain		
	Bottom.	Up.	Total	Bottom.	Up.	Total
Cotton	6.7	9.1	15.8	11.0	9.0	20.0
Wheat	23.3	14.2	37.5	15.1	17.1	32.2
Alfalfa	1.7	0.0	1.7	1.0	1.7	2.7
Feed Grain	0.0	4.4	4.4	3.0	2.7	5.7
Idle	4.3	18.8	23.1	0.0	14.0	14.0
Other	6.0	11.5	16.5	15.1	10.3	25.4
Total	42.0	58.0	100.0	45.2	54.8	100.0
	Greater Than 300 Acres Cultivatable Land					
	Saddle Mountain			Rainy Mountain		
	Bottom.	Up.	Total	Bottom.	Up.	Total
Cotton	4.0	4.8	8.8	3.1	10.7	13.8
Wheat	15.4	29.4	44.8	5.4	19.3	24.7
Alfalfa	.4	0.0	.4	2.6	1.1	3.7
Feed Grain	3.6	8.8	12.4	2.6	5.7	8.3
Idle	1.1	15.0	16.1	11.8	11.3	23.1
Other	8.1	9.4	17.5	19.7	6.7	26.4
Total	32.6	67.4	100.0	45.2	54.8	100.0

TABLE IX

DISTRIBUTION OF CULTIVATABLE LAND ON SAMPLE FARMS
IN GROUP IV WATERSHEDS
(Percentages)

Crop	Big Kiowa			Panther			Whiteshield		
	Bottom.	Up.	Total	Bottom.	Up.	Total	Bottom.	Up.	Total
Cotton	5.7	.8	6.5	3.4	.3	3.7	6.8	2.7	9.5
Wheat	9.6	.5	10.1	12.0	18.5	30.5	17.1	11.1	28.2
Alfalfa	1.1	0.0	1.1	7.0	0.0	7.0	3.1	0.0	3.1
Feed Grain	3.0	4.5	7.5	0.0	.5	.5	6.3	6.0	12.3
Idle	3.7	29.6	33.3	1.1	16.9	18.0	0.0	9.9	9.9
Other	12.6	28.9	41.5	11.3	29.0	40.3	9.0	28.0	37.0
Total	35.7	64.3	100.0	34.8	65.2	100.0	42.3	57.7	100.0

interest. For example, the percentage of the total bottomland in cotton, wheat, and alfalfa indicates the intensity of bottomland use, while the percentage of the total cotton planted on the bottomland indicates the portion of the total cotton allotment that is located on the bottomland. These figures are not explicitly given in the table, but they can be computed easily and will be pointed out when they are of interest.

Group I

Chi-square tests indicate a significant difference between the bottomland crop distributions on both the small and large farm categories ($\chi^2_{5d.f.}$ = 16.4 and 11.0, respectively).[3] The percentage of cultivatable bottomland devoted to the three most intensive crops - cotton, wheat, and alfalfa - is 77.7[4] and 89.4 for the small and large category farms in Barnitz Creek and 64.6 and 42.6 for the small and large category farms in Beaver Creek. Thus the difference in the distribution of bottomland crops implied by the Chi-square test is toward greater intensity in the protected watershed. The bottomland intensity of the large farms in Barnitz Creek is greater than on the small farms, while in Beaver Creek the bottomland intensity of the small farm is greatest. This rough comparison of intensities indicates the lack of a consistent relationship between farm size and bottomland use intensity in this watershed group.

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[3]These are significant at the 99 and 90 percent level, respectively.

[4]The 77.7 is obtained by summing (from Table VI in the first column) 12.9, 22.8, and 6.5, and dividing by 54.3. Other numbers in the series are computed similarly.

Group II

The subclassification of sample farms in Cavalry and Boggy Creeks, based on the ratio of cultivatable bottomland to cultivatable upland, was made to test the hypothesis that land use intensity was affected by this ratio.

None of the three categories of farms in Cavalry Creek is more intensively used than their counterparts in Boggy Creek. Chi-square tests indicate no significant difference between the distributions of crops on the bottomland of the three categories of farms in the protected and unprotected watershed ($\chi^2_{4d.f.}$ = 9.10, 8.81, and 4.72 in the order of the tables). The percentage of bottomland devoted to the three most intensive crops is 88.2, 78.0, and 79.8 for the three size categories of Cavalry Creek Watershed (listed in the order of the tables). In Boggy Creek the respective percentages are 81.1, 78.4, and 75.0. Thus the small ratio of bottomland to upland may have a slight influence on the intensity of land use.

The percentages of the total cotton and wheat allotments planted on the bottomland in the six different farm resource situations are: in Cavalry Creek 23,[5] 68, and 33; and in Boggy Creek 25, 73, and 36 (in the order of Table VII). As would be expected the percentages of the allotments planted on the bottomland are greater on the farms with a bottom-upland ratio that is greater than 1:2. This suggests that the historically based allotments are not highly correlated with the amount of cultivatable bottomland on a farm, but that the allotments are utilized on

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[5]The 23 is obtained by summing (from Table VII, columns one and two) 9.8 and 2.2, and dividing by the sum of 17.3 and 34.8. Other numbers in the series are computed similarly.

the bottomland if it is available. Furthermore, they are utilized on the bottomland in spite of flooding in Boggy Creek.

The evidence presented here shows that there is little difference at present between the land use in the two watersheds.

Group III

Both the small and the large Saddle Mountain farms are used more intensively than their Rainy Mountain Creek counterparts. The Chi-square tests on the bottomland crop distributions indicate highly significant differences. ($\chi^2_{5d.f.}$ = 14.20 and 19.05 for the small and large size category, respectively.) The three most intensive crops - cotton, wheat, and alfalfa - account for 75.5 and 60.7 percent of the Saddle Mountain Creek farms cultivatable bottomland in the small and large farm categories, respectively, while in the Rainy Mountain Creek farms the three crops account for 59.9 and 24.6 percent, respectively, of the total bottomland. Thus the bottomland on the large farms, both protected and unprotected, is less intensively used than that of the small farms. In this watershed group the conclusion regarding the greater intensity of bottomland use on the smaller farms is strengthened by an inverse relationship that exists between the intensity of use on the upland and the intensity of use on the bottomland.

The portions of the total cotton and wheat allotments planted on the bottomland are 56 and 36 percent for the small and large size farms in Saddle Mountain, and 50 and 22 percent for the small and large size farms in Rainy Mountain. The difference, however, is largely due to the large amount of wheat in Saddle Mountain. Of the total wheat allotments, 42 percent is on the bottomland in Saddle Mountain, while in Rainy Mountain only 30 percent of the total wheat allotment is on the bottomland.

However, 50 percent of the total cotton allotment is used on the bottomland in Rainy Mountain, while only 44 percent of the cotton allotment is used on the bottomland in Saddle Mountain. Thus no consistent relationship concerning the placement of allotments on the bottomland is evident in this group.

Group IV

A Chi-square test on the distribution of the bottomland crops ($\chi^2_{10d.f.} = 19.01$) showed a significant difference at the 95 percent level, but the three most intensive crops accounted for 46.0, 64.4, and 63.8 percent of the cultivatable bottomland, respectively, in Big Kiowa, Panther, and Whiteshield Creek Watersheds. The small farms in Whiteshield Watershed alluded to earlier might explain the more intensive use of bottomland.

The portion of the total cotton and wheat allotments planted on the bottomland is 92, 45, and 63 percent (in the order of Table IX). Thus Big Kiowa Creek farms may not have large wheat and cotton allotments, but what they have is planted on the bottomland.

Summary of the Four Watershed Groups

In summary, the patterns of bottomland use do differ significantly between developed and undeveloped watersheds in Groups I, III, and IV. Intensity of bottomland use is greater in the resource situations of Groups I and III. Although there is a difference in the pattern of bottomland use in Group IV, the bottomland of the protected watersheds is not clearly more intensively used than the unprotected bottomland. In Group II, there appears to be no difference in the pattern of bottomland use and, hence, no difference in intensity between protected and unprotected watersheds.

The explanation of the differences in intensity may be due, in part or entirely, to historical differences in the watersheds. The following section presents the change in bottomland use relative to the change in use of all the cultivated land in the counties in which Group I and III mainly fall (Custer and Kiowa County, respectively) to determine if the differences in intensity can be explained by historical differences.

Historical Land Use Differences as an Explanation of Current Differences in Developed and Undeveloped Watersheds

Group I

Figure 2 illustrates the nature of the relationships among the available data on the historical trends in land use. The solid line is the percentage of cultivated land in Custer County devoted to particular crops. The broken lines connect the observed percentages of bottomland devoted to the same crops in the watersheds within the county. The observations on land use in the past were made at the time of planning by the Soil Conservation Service; the 1962 observations were those calculated from the farm interviews. Climatic conditions and allotments, among other variables, could have influenced the observations for any specific year. Thus no statistical significance is placed on the slopes of the connecting lines. They merely indicate tendencies.

The amount of cultivated land devoted to cotton has decreased because of allotments. The synthetic trend line for Beaver Creek indicated little change in the percentage of bottomland devoted to cotton since 1957. This was analogous to the overall trend. In Barnitz Creek, however, the percentage of bottomland devoted to cotton was higher in 1962

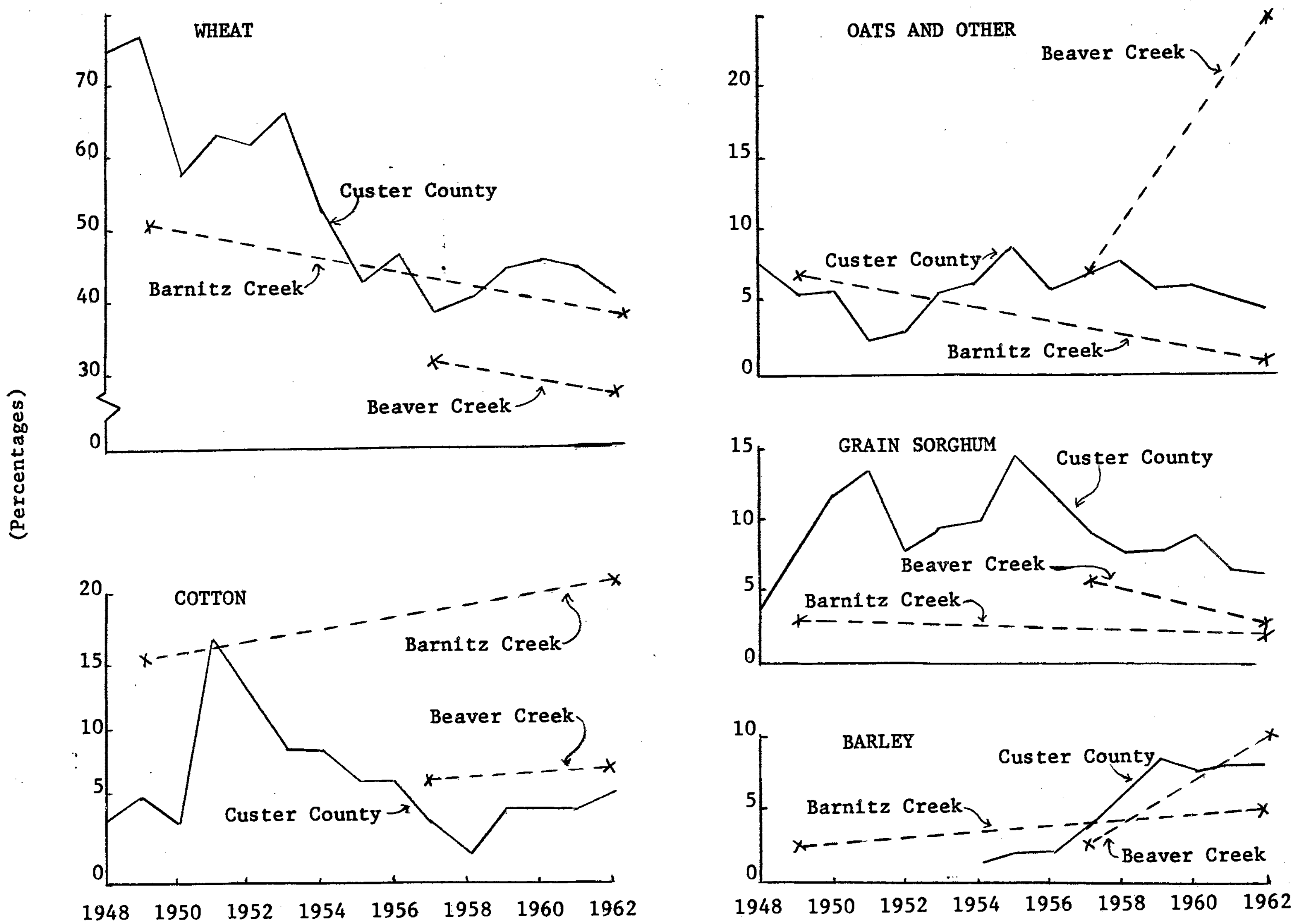

Figure 2. Selected Trends in Cropland Use for Custer County and Bottomland Use for Barnitz and Beaver Creek (Percent of Totals).

than it was in 1949. Perhaps this was the result of flood protection. If Barnitz Creek farmers were influenced by the same variables influencing Custer County farmers, then farmers in this watershed shifted much of their cotton from the upland to the bottomland. This happened while total cotton acreage decreased.

Total wheat acreage has also declined in the past decade as indicated by the solid line. It appears that the bottomland acreage devoted to wheat in each watershed declined at about the same rate as the decline in Custer County. This implies that flood protection had little influence on the relative amounts of bottomland and upland devoted to wheat production.

Some of the acreage diverted from wheat and grain sorghum by acreage allotments was used for barley. The percentage of bottomland devoted to barley has increased in both watersheds and particularly in the unprotected one. However, the increase in Beaver Creek is due to one farm with 200 acres of barley.

The amounts of bottomland devoted to grain sorghum in each watershed coincide very closely to the trend in all cultivated land in the county devoted to this crop. This, as in the case of wheat, implies that flood protection has had little influence on the acreage in sorghum.

The last category, oats and other, is a relatively extensive category of land use. It has increased considerably in the unprotected watershed and decreased somewhat in the protected one, while for the county the trend of cultivated land devoted to oats has been fairly steady.

General conclusions that can be drawn from these graphs, along with the earlier discussion of the crop distribution in 1962, are that:

(1) the unprotected watershed was farmed less intensively in the past and is farmed less intensively at present than the protected one, and (2) that the effect of flood protection has been a shift of part of the remaining cotton acreage allotment from the upland to the bottomland in the protected watershed with a corresponding decrease in bottomland devoted to the more extensive crops such as oats.

Group III

The historical trends in the percentages of cultivated land devoted to various crops in Kiowa County and the percentages of bottomland devoted to various crops on the sample farms in the Saddle Mountain Creek Watershed are shown in Figure 3. Rainy Mountain observations on land use have not been plotted, since the two observations are not in comparable areas. The trends in the use of Saddle Mountain bottomland appear to coincide very closely with the county wide trends in land use. This would imply that there have been no flood protection induced shifts in land use. Thus the only conclusion that can be drawn is that Saddle Mountain bottomland is more intensively used at present than Rainy Mountain bottomland. This, however, may be a historical fact.

Watershed Development as an Influence in Decreasing Historical Differences in Land Use

In Groups II and IV, historical differences in land use between developed and undeveloped watersheds may have been reduced by the watershed program. Historical data, however, are not available for Boggy Creek in Group II nor for Whiteshield Creek in Group IV.

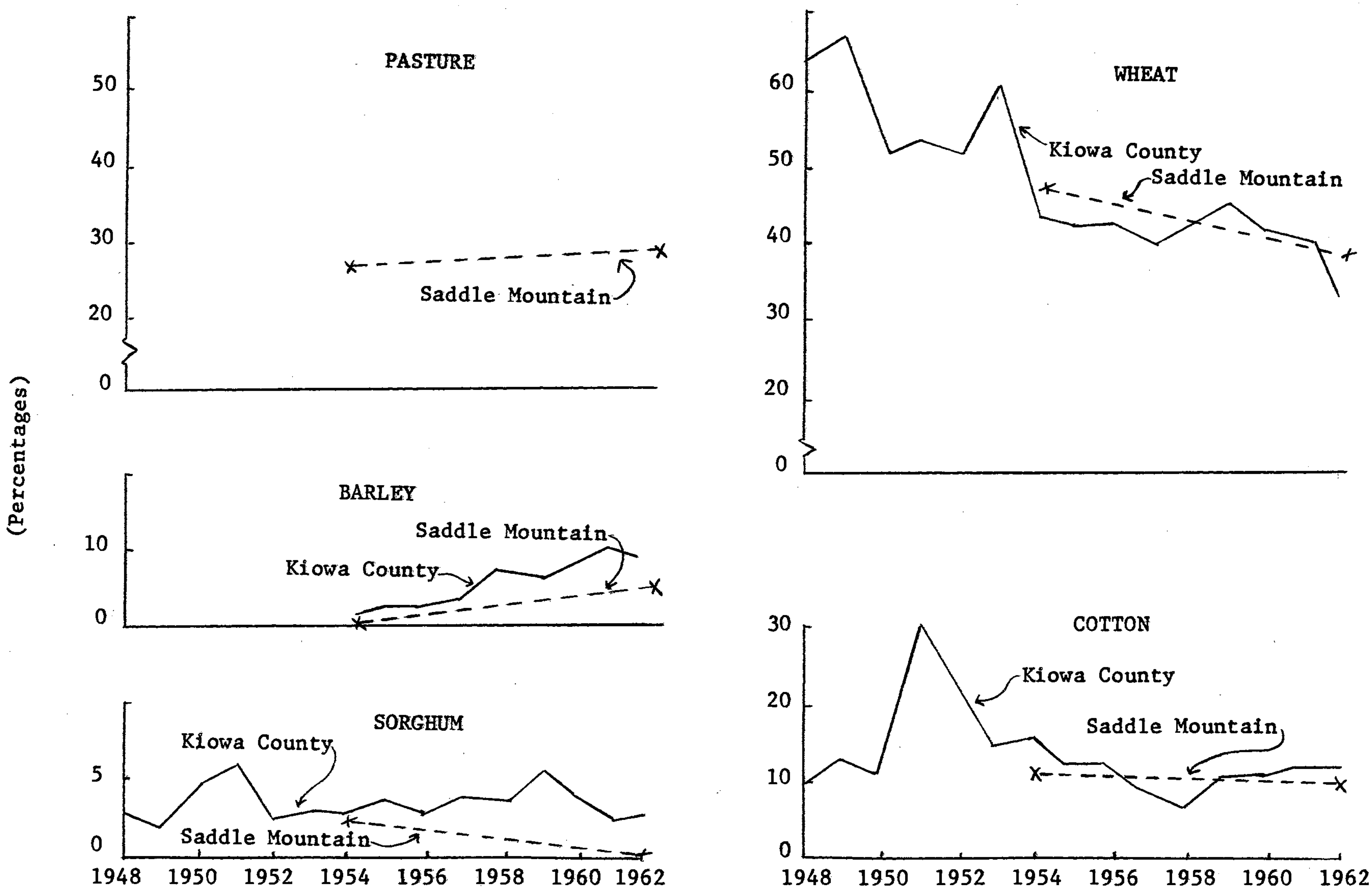

Figure 3. Selected Trends in Cropland Use for Kiowa County and Bottomland Use for Saddle Mountain Creek (Percent of Totals).

Group II

Cavalry Creek land use in 1951 and 1962 is compared with Washita County land use trends in Figure 4. The solid line represents the percent of total cultivated land devoted to specific crops in Washita County. The broken lines connect the 1951 and 1962 observations of the percentages of total bottomland devoted to specific crops. Cotton in Cavalry Creek is the only crop shown with an increase in bottomland acreage. One or two of the following conditions are hypothesized: (1) there has been an insufficient lapse of time for Cavalry Creek farmers to adjust to reduced flood risk, and/or (2) the type of adjustment to flood protection in very fertile bottomlands is one of intensified use of variable inputs on the crops already grown rather than shifts in land use. The latter hypothesis was mentioned by farmers during interviews. Thus most of the bottomland was suitable for the intensive crops before protection. That is, it was profitable to grow the intensive crops in spite of the flood risk.

Group IV

The historical trend in the use of cultivated land in Roger Mills County and the percentage of bottomland devoted to various crops in two of the watersheds is shown in Figure 5. It appears that, in Big Kiowa Creek, the percentage of bottomland planted in cotton relative to the county trend has increased. The trend in the acreage of wheat on the bottomland in Big Kiowa is nearly the same as the county. Panther Creek, the other protected watershed, appears to have had a decrease in intensity of bottomland use relative to the county trends. Bottomland use intensity in this group of watersheds apparently has been little affected by the protection programs.

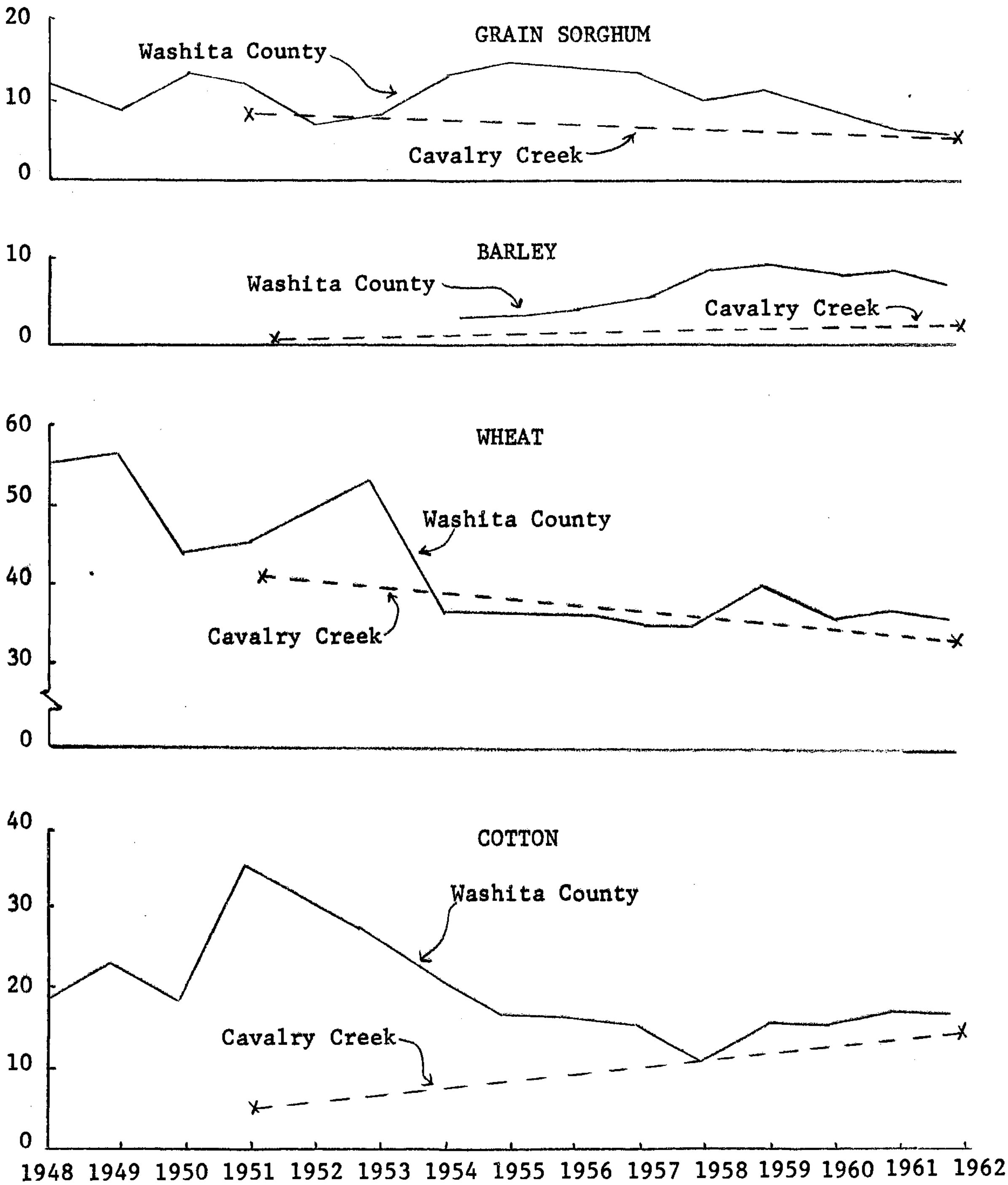

Figure 4. Selected Trends in Cropland Use for Washita County and in Bottomland Use for Cavalry Creek (Percent of Totals).

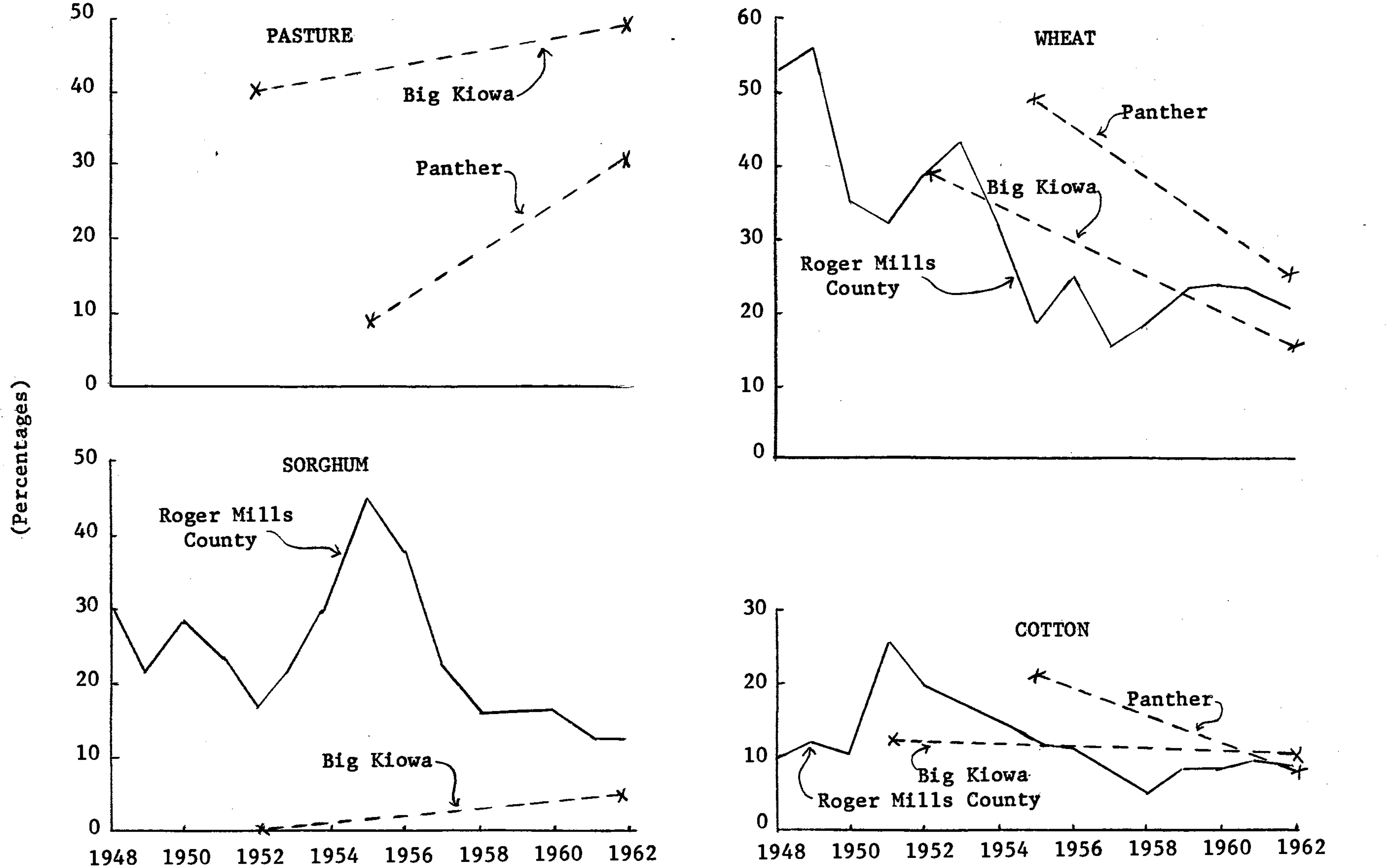

Figure 5. Selected Trends in Cropland use for Roger Mills County and Bottomland Use for Big Kiowa and Panther Creek (Percent of Totals).

Summary

The empirical evidence suggests that the bottomland use intensity of the protected watersheds is greater than that of the unprotected watersheds in two of the four groups of watersheds. Except for Kiowa Creek Watershed, the bottomland in the protected watersheds was no less intensively used than the unprotected bottomland.

In Group I watersheds the time trends in land use indicated that the difference in intensity may be partially due to flood protection.

In Group II watersheds little evidence was found that pointed to a difference in intensity between the protected and unprotected watersheds. The portion of land devoted to cotton has, however, increased in the protected watershed of Group II.

The protected bottomland in Group III watersheds is now used more intensively than the unprotected bottomland, but no empirical evidence is available to determine if the intensity differential is the result of flood protection or is entirely due to differences in inherent productivity.

The bottomland of one of the protected watersheds of Group IV is used less intensively than the unprotected bottomland. The bottomland of the other protected watershed is used equally as intensive as the unprotected bottomland. In this group no conclusions are drawn about the effect of flood protection.

Other influences could have affected land use and, thus, the conclusions drawn about the effect of flood protection. The use of land and the time lag in the adaptation of new technology may differ among particular ethnic groups. In Panther Creek where protection apparently had little effect, the establishment of Foss Reservoir may have had some effect on the statistics on land use.

The intensity measures used in this chapter are imprecise. Furthermore, little evidence of the causal nature of the differences in intensity are indicated. Questions left unanswered are:

(1) Is the similarity in land use in Group II watersheds the result of the lack of any change in Cavalry Creek following protection, or is it the result of farmers in Boggy Creek ignoring flood risk in their land use decisions?

(2) Do the Soil Conservation Service's damage factors imply the changes in land use that have occurred in the protected watersheds?

(3) Is the full level of the damage factors consistent with the differences in land use between protected and unprotected watersheds?

(4) What changes in land use can be expected in the unprotected watersheds after protection has been provided?

In Chapter IV, the more precise description of the quantity and quality of the available resources of the various watersheds - given in the programming tableau - not only makes land use comparisons more valid, but also offers an analytical vehicle to explore the influences of the damage reduction factors claimed by the Soil Conservation Service.

CHAPTER IV

PROGRAMMING RESULTS AND ANALYSIS

Introduction

The purpose of this chapter is to determine the influence of the reduction in crop and pasture damages on land use. However, other facets of the flood protection program also may influence land use. The reduction of sedimentation and scour damage over a long period of time may have an effect on land use. Also, management may be improved, and thus land use affected, because of knowledge gained by farmers during the planning and construction stages of the project. The effects of the reduction in sedimentation and scour damage and of increased knowledge, however, are not considered in this thesis.

In the empirical analysis of Chapter III, evidence of more intensive land use in the protected watersheds was found in only two of the four watershed groups. This suggests that: (1) changes in land use have not occurred in the other protected watersheds, (2) flooding has not affected land use in the unprotected watersheds, and/or (3) other factors have affected land use much more than flood protection.

One of the purposes of the programming analysis of this chapter is to determine if the damage factors assumed by the Soil Conservation Service do imply changes in land use in all the protected watersheds, or if they only imply changes in particular ones.

Another purpose is to find out if the difference between the land use in the protected watershed and the unprotected watershed of a group can be explained by the protection level estimated by the Soil Conservation Service. If some intermediate level consistently explains the difference between the protected and unprotected watersheds best, then predictions of land use changes in the unprotected watersheds should be made consistent with that level.

A third purpose of the programming analysis is to find the general pattern of changes in land use implied by the damage factors in a whole farm framework. The implied changes cannot be readily ascertained without such a tool as programming.

The analysis is broken down into four sections. The first section briefly describes the resource situations; the second section presents some programming results general for most resource situations; the third and main part of the analysis gives the program results broken down by watershed groups; and the fourth is a brief summary section.

Within a specific watershed group, two programs for each resource situation are presented in tabular form. These programs and the actual land use of the resource situation[1] form the bulk of the analysis. One of the programs assumes full protection, and the other assumes the damage level estimated by the Soil Conservation Service. In the watersheds already protected the program assuming full protection is compared with the actual land use. In the watersheds not yet protected the program assuming the full damage factor is compared with the actual land use.

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[1]Actual land use is the average of the acres devoted to each crop in the farms which make up the typical farm.

Other programs, however, were computed for each situation. A series of programs for the protected watersheds of each group were first computed to determine the appropriate reservation prices. An example of the results of various assumed reservation prices is given in Appendix E, Table I.

Another series of programs on each unprotected watershed were computed. Each of these programs assumed one of the four levels of damages described in Chapter II. These programs were used to find out if some intermediate level of the damage factor explained land use on the unprotected watersheds better than the full level of damages.

For all practical purposes, the results of varying the damage factors provided no evidence to support the hypothesis that the general level of the damage factors used by the Soil Conservation Service is too high. Thus only the results in one farm situation of Group III are presented, as an example, in Appendix E, Table II.

The Resource Situations

The land resource situations used in the programming analysis are those defined in Chapter III (Tables II through V). Cultivatable bottomland and cultivatable upland, however, were divided into two classes of land each; and rangeland was divided into three classes of land (one bottomland class and two upland classes). The classification, based on productivity, is explained in Chapter II, and the complete breakdown of each land resource situation and the assumed yields of each class of land are given in Appendix A, Table I.

Available family labor estimated from information obtained in the farm survey is presented in Table X. The large difference among watershed groups is hypothesized to be the influence of the type of farming in the area as well as other sociological factors. The 2,966 hours of family labor in Group II watersheds represent the equivalent of one man 6 days a week, 9 1/2 hours per day the year around. For purposes of this analysis family labor was assumed not to vary among watersheds within a group or among farm resource situations within a watershed.

TABLE X

ESTIMATED FAMILY LABOR PER FARM IN THE FOUR WATERSHED GROUPS BY SEASONS

	Watershed Groups			
	I	II	III	IV
	-Man-Hours-			
Dec.-April	724	821	602	707
May-June	447	715	608	318
July-Aug.	489	740	663	358
Sept.-Nov.	578	690	658	423
Annual	2,238	2,966	2,531	1,806

Allotments and capital restrictions were discussed in Chapter II. They were assumed to be the same before and after flood protection.

A typical programming tableau is presented in Appendix F, Table I. Also, the modified Soil Conservation Service damage factors and procedures used in their modifications are presented in Appendix D.

General Programming Results

Rate of Return on Nonland Capital

The first programs attempted to explain present land use on already protected watersheds. Six percent return on nonland capital was tried first. In every farm situation in which only 6 percent was required on nonland capital, cattle, mainly stockers, was a major enterprise on the farm. Although the actual number of cattle in the farm organizations was unknown,[2] the land use resulting from such large numbers of cattle was not very similar to actual land use. This indicated that farmers were requiring more than 6 percent on their nonland capital. Subsequent programs assumed rates of return gradually increasing to 30 percent. As the required rate of return on nonland capital increased, the number of stocker cattle decreased, and land use intensity[3] first increased but eventually decreased when the capital restriction became sufficiently severe to cause some land to be left idle.[4]

Rate of Return on Family Labor

A reservation price on family labor generally did not increase the explanatory power of the models. It was decided that the length of the labor periods and the potential differences in the reservation prices on labor among specific enterprises precluded the possibility of using the rate of return on labor as an instrumental variable in explaining land use. The assumption about labor most consistently yielding the best

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[2]The number of cattle was not used as a criterion to determine the appropriate reservation price because cattle enterprises were so variable in type. The criterion used was to minimize the difference between programmed and actual land use.

[3]As discussed in Chapter III, land use intensity is the return to land, labor, management, and capital from a composite acre of land.

[4]The fact that stocker cattle are not profitable when a "high" rate of return on nonland capital is required also was reported by James H. White, James S. Plaxico, and William F. Lagrone, Influence of Selected Restraints on Normative Supply Relationships for Dryland Crop Farms on Loam Soils, Southwestern Oklahoma, Technical Bulletin T-101 (Stillwater, 1963), p. 25; and by Alfred L. Barr and James S. Plaxico, Optimum Cattle System and Range Improvement Practices for Northeastern Oklahoma: Dynamic and Static Analyses, Miscellaneous Publication 62 (Stillwater, 1961), p. 12.

explanation of land use was a reservation price of zero in all labor periods.

Many farm situations did not use all available family labor. Most of the smaller farms had excess family labor in one or more periods. Less labor was used at the higher rates of return on nonland capital than at the lower rates of return. This is because, in this analysis, enterprises with high capital requirements also have relatively high labor requirements.

Actual and Programmed Farm Organizations Under Protected and Unprotected Conditions

The programmed land uses, livestock, capital use, gross income, net returns, and land use intensities for each typical resource situation along with the actual land use and land use intensity are presented in Tables XI through XXVII. The actual livestock complement, capital and labor use, gross income, and net returns are not shown.[5] For ease of comparison in the tables, the programmed land use under protected conditions is placed beside the actual land use in watersheds already protected. Similarly, in watersheds not yet protected the programmed land use under unprotected conditions is placed beside the actual land use.

In several situations, the amount of alfalfa programmed is considerably larger than is actually grown.[6] The narrow range of prices for alfalfa hay consistent with programmed acreages indicates that if the

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[5]Data on livestock numbers, capital use, gross income, and net returns were not collected in the farm survey. They are, therefore, indicated by "n. a." (not available) in the tables.

[6]Arnold, p. 57.

demand curve for alfalfa hay faced by the individual farmers was slightly inelastic, alfalfa would not be as profitable as programmed. In actuality the local market for alfalfa hay is limited; thus the net price to the farmer (after shipping charges) for large quantities of alfalfa hay may be less than the $20 per ton assumed in this study. Where the programmed acreage of alfalfa considerably exceeds the actual acreage of alfalfa, the lower limit of the relevant price range for this programmed quantity is given.

The change in the overall cropland intensity is negative in several situations because the negative change in the upland use intensity more than offsets the positive change in the bottomland use intensity. This result is possible because the intensity measure depends on the profitability of upland crops <u>relative</u> to bottomland crops after protection. But before protection, the profitability of upland crops relative to bottomland crops is greater than it is after protection. The unprotected optimum solution is based on the relative profitability of the crops before protection rather than their relative profitability after protection.

Group I

The actual and programmed land use under protected conditions are most similar for both of the typical Barnitz Creek farms when the required rate of return on nonland capital is 24 percent (Tables XI and XII). In general, the programs indicate more alfalfa than is grown, but more than 90 percent of the alfalfa grown is sold, and the lower limits of the relevant range for the price of alfalfa hay in any of the situations is $18.59 per ton.

TABLE XI

PROGRAMMED AND ACTUAL ORGANIZATION ON TYPICAL BARNITZ CREEK FARMS WITH LESS THAN 200 ACRES OF CULTIVATABLE LAND
(Protected Watershed)

Item	Unit	Actual		Programmed Protected		Programmed Unprotected		Changes from Unprot. to Prot.	
		(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)
Land Use									
Cotton	acre	19	1	20	0	0	20	+20	-20
Wheat	acre	33	8	19	22	29	12	-10	+10
Alfalfa	acre	9	5	38	0	48	0	-10	0
Barley	acre	7	0	0	0	0	0	0	0
Temp. Pasture[a]	acre	3	12	0	11	0	5	0	+6
Grain Sorghum	acre	2	4	0	0	0	4	0	-4
Forage Sorghum	acre	2	2	0	2	0	2	0	0
Cult. Pasture & Other	acre	2	16	0	13	0	5	0	+8
Total Cult. Land	acre	77	48	77	48	77	48	0	0
Cattle									
Cows	hd.	n.a.		16		15		+1	
Feeders	hd.	n.a.		0		0		0	
Capital Use	dol.	n.a.		6,430.23		6,740.74		-310.51	
Labor Use: Total	hrs.	n.a.		1,025		1,051		-26	
Family	hrs.	n.a.		1,025		1,051		-26	
Hired	hrs.	n.a.		0		0		0	
Gross Income	dol.	n.a.		7,387.12		6,184.54		+1,202.58	
Net Returns[b]	dol.	n.a.		3,458.27		2,096.66		+1,361.61	
Net Returns[c]	dol.	n.a.		4,615.71		3,309.99		+1,305.72	
Land Use Intensities									
Bottomland	dol.	38.95		41.75		33.96		+7.79	
Upland	dol.	7.78		10.05		21.29		-11.24	
Cropland	dol.	27.02		29.58		28.71		+.87	

[a]Includes small grain pasture and sudan grass.

[b]Returns to land, family labor, and management (with nonland capital paid its reservation price).

[c]Returns to land, family labor, and management (with nonland capital paid 6 percent).

TABLE XII

PROGRAMMED AND ACTUAL ORGANIZATION ON TYPICAL BARNITZ CREEK FARMS WITH GREATER THAN 200 ACRES OF CULTIVATABLE LAND (Protected Watershed)

Item	Unit	Actual		Programmed Protected		Programmed Unprotected		Changes from Unprot. to Prot.	
		(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)
Land Use									
Cotton	acre	48	6	54	0	0	54	+54	-54
Wheat	acre	86	112	107	91	137	61	-30	+30
Alfalfa	acre	24	2	33	0	25	0	+8	0
Barley	acre	9	11	0	8	0	0	0	+8
Temp. Pasture[a]	acre	7	53	0	37	15	18	-15	+19
Grain Sorghum	acre	3	13	0	16	16	0	-16	+16
Forage Sorghum	acre	1	0	0	6	0	6	0	0
Cult. Pasture & Other	acre	16	72	0	111	0	130	0	-19
Total Cult. Land	acre	194[b]	269	194[b]	269	193[b]	269	1[b]	0
Cattle									
Cows	hd.	n.a.		61		63		-2	
Feeders	hd.	n.a.		0		0		0	
Capital Use	dol.	n.a.		20,103.91		19,714.06		+389.85	
Labor Use:Total	hrs.	n.a.		2,517		2,258		+259	
Family	hrs.	n.a.		2,238		2,195		+43	
Hired	hrs.	n.a.		279		63		+216	
Gross Income	dol.	n.a.		21,647.95		17,427.86		+4,220.09	
Net Returns[c]	dol.	n.a.		10,360.15		7,043.67		+3,316.48	
Net Returns[d]	dol.	n.a.		13,978.85		10,592.20		+3,386.65	
Land Use Intensities									
Bottomland	dol.	37.41		42.93		31.59		+11.34	
Upland	dol.	10.25		8.51		12.78		-4.27	
Cropland	dol.	21.63		22.93		21.05		+1.88	

[a]Includes small grain pasture and sudan grass.

[b]Differences due to rounding.

[c]Returns to land, family labor, and management (with nonland capital paid its reservation price).

[d]Returns to land, family labor, and management (with nonland capital paid 6 percent).

TABLE XIII

PROGRAMMED AND ACTUAL ORGANIZATION ON TYPICAL BEAVER CREEK FARMS WITH LESS THAN 200 ACRES OF CULTIVATABLE LAND
(Unprotected Watershed)

Item	Unit	Actual		Programmed Unprotected		Programmed Protected		Changes from Unprot. to Prot.	
		(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)
Land Use									
Cotton	acre	3	0	3	0	3	0	0	0
Wheat	acre	22	15	2	35	14	23	+12	-12
Alfalfa	acre	8	0	39	0	27	0	-12	0
Barley	acre	0	5	0	0	0	0	0	0
Temp. Pasture[a]	acre	8	4	0	15	0	15	0	0
Grain Sorghum	acre	0	2	0	0	0	0	0	0
Forage Sorghum	acre	1	6	0	2	0	2	0	0
Cult. Pasture & Other	acre	2	19	0	0	0	12	0	+12
Total Cult. Land	acre	44	51[b]	44	52[b]	44	52[b]	0	0
Cattle									
Cows	hd.	n.a.		15		16		+1	
Feeders	hd.	n.a.		0		0		0	
Capital Use	dol.	n.a.		6,119.85		5,775.03		-344.82	
Labor Use:Total	hrs.	n.a.		765		656		-109	
Family	hrs.	n.a.		765		656		-109	
Hired	hrs.	n.a.		0		0		0	
Gross Income	dol.	n.a.		4,716.81		4,864.07		+147.26	
Net Returns[c]	dol.	n.a.		1,510.26		2,027.22		+516.96	
Net Returns[d]	dol.	n.a.		2,611.83		3,066.73		+454.90	
Land Use Intensities									
Bottomland	dol.	30.63		34.81		35.30		+ .49	
Upland	dol.	8.56		13.64		10.10		-3.54	
Cropland	dol.	18.78		23.59		21.77		-1.82	

[a]Includes small grain pasture and sudan grass.

[b]Differences due to rounding.

[c]Returns to land, family labor, and management (with nonland capital paid its reservation price).

[d]Returns to land, family labor, and management (with nonland capital paid 6 percent).

TABLE XIV

PROGRAMMED AND ACTUAL ORGANIZATION ON TYPICAL BEAVER CREEK FARMS WITH GREATER THAN 200 ACRES OF CULTIVATABLE LAND (Unprotected Watershed)

Item	Unit	Actual		Programmed Unprotected		Programmed Protected		Changes from Unprot. to Prot.	
		(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)
Land Use									
Cotton	acre	15	2	17	0	17	0	0	0
Wheat	acre	39	49	32	56	46	42	+14	-14
Alfalfa	acre	8	0	75	0	75	0	0	0
Barley	acre	20	9	0	25	0	29	0	+4
Temp. Pasture[a]	acre	44	34	12	0	0	7	-12	+7
Grain Sorghum	acre	0	2	2	0	0	2	-2	+2
Forage Sorghum	acre	5	3	0	2	0	2	0	0
Cult. Pasture & Other	acre	7	86	0	102	0	102	0	0
Total Cult. Land	acre	138	185[b]	138	185[b]	134	184[b]	0	-1[b]
Cattle									
Cows	hd.	n.a.		22		22		0	
Feeders	hd.	n.a.		0		0		0	
Capital Used	dol.	n.a.		10,637.14		10,640.52		+3.38	
Labor Used:Total	hrs.	n.a.		1,583		1,583		0	
Family	hrs.	n.a.		1,485		1,485		0	
Hired	hrs.	n.a.		98		98		0	
Gross Income	dol.	n.a.		10,505.51		12,220.17		+1,714.66	
Net Returns[c]	dol.	n.a.		3,868.83		5,575.53		+1,706.70	
Net Returns[d]	dol.	n.a.		5,783.52		7,490.82		+1,707.30	
Land Use Intensities									
Bottomland	dol.	26.14		35.14		37.21		+2.07	
Upland	dol.	6.90		7.00		6.31		- .69	
Cropland	dol.	15.11		19.13		19.54		+ .41	

[a]Includes small grain pasture and sudan grass.

[b]Differences due to rounding.

[c]Returns to land, family labor, and management (with nonland capital paid its reservation price).

[d]Returns to land, family labor, and management (with nonland capital paid 6 percent).

<u>Barnitz Creek Farms</u> - According to the programs, flood protection in Barnitz Creek could bring about a 19 to 24 percent increase in gross income which is equivalent to a 32 to 39 percent increase in net income (Tables XI and XII). The relatively large damage factors assumed by the Soil Conservation Service in this watershed imply large changes in land use as well as a large benefit from the reduction in damage to crops and pasture. In both Barnitz Creek situations, flood protection induces a shift of the entire cotton allotment and a considerable portion of the wheat allotment from the upland to the bottomland.

With respect to alfalfa, grain sorghum, barley, and cultivatable pasture, the damage factor implications differ between resource situations. Bottomland and overall cropland use intensity increased more on the large farm than it did on the small farm.

<u>Beaver Creek Farms</u> - Beaver Creek damage factors with a 24-percent required return on nonland capital do not explain land use well. As a matter of fact, the protected program explains land use on the small unprotected farm better than the unprotected program does. Assuming that all relevant variables were specified correctly, this would suggest that these farmers make their land use decisions without regard to the possible flood damages. An alternative hypothesis, however, is that there is no market for the 90 tons of alfalfa hay sold in the program at $20 per ton. If alfalfa hay went down to $19.39 per ton, the cultivatable pasture activity would be most profitable.[7]

The percentage increases in gross and net returns are less on these

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[7] The cultivatable pasture activity essentially allows the amount of land devoted to range to vary after protection.

farms than they are on the Barnitz Creek farms. This is explained by the lower damage factors employed on this watershed (Appendix D, Table I). According to this analysis, cotton would be profitable on the bottomland in spite of flooding. This is substantiated by the small amount of cotton actually grown on the upland. On the small farm, alfalfa production would be reduced to allow wheat to be produced on the bottomland, whereas on the large farm, temporary pasture and grain sorghum would be decreased to allow wheat production to be increased on the bottomland. Temporary pasture is planted on the bottomland on the large farm before protection because range is scarce relative to bottomland. The scarcity of range is corroborated by the large amount of temporary pasture actually grown on the large farm.

The increase in the overall cropland intensity is negative in the small farm and very small in the large farm.

Summary of Group I Watersheds - The actual bottomland and upland use intensities for the two Barnitz Creek farms are considerably greater than for the comparable Beaver Creek farms. However, if the influence of the differences in the total allotments is removed by comparing the bottomland use intensities relative to the upland use intensities, then there is much less difference between the protected and unprotected bottomland. The bottomland intensity of the small Barnitz Creek farm relative to its upland intensity is larger than the comparable figure in the small Beaver Creek farm (5.00 in Barnitz Creek and 3.57 in Beaver Creek).[8]

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[8]These figures are derived by dividing the actual bottomland use intensity by the actual upland use intensity. For example, $5.00 = \frac{\$38.95}{\$7.78}$, and $3.57 = \frac{\$30.63}{\$8.56}$, from Tables XI and XIII, respectively.

But, for the large farm, the bottomland use intensity relative to the upland use intensity is slightly smaller in Barnitz Creek than it is in Beaver Creek (3.64 and 3.79, respectively). This implies that the historically based allotments are larger in Barnitz Creek than they are in Beaver Creek (thus the difference in overall cropland intensity), but the portion of the Barnitz Creek allotments that is used on the bottomland is only slightly larger.

The differences in the acres of cotton and wheat allotments per acre of bottomland explain a major portion of the differences in the actual bottomland use intensities of the protected and unprotected watersheds. The programming analysis indicates, however, that if there had been no flood protection program in Barnitz Creek, the bottomland would be used less intensively in Barnitz Creek than it is in Beaver Creek. On the other hand, the overall increase in land use intensity that can be expected in Beaver Creek as a result of flood protection is very small.

Group II

Actual land use was best explained on each of the small farms in Cavalry Creek when the required rate of return on nonland capital was 24 percent. On the large farm 24 percent on nonland capital caused some cropland to become idle. Twenty-one percent explained land use best on the large farm. It is difficult to explain the difference in reservation prices amoung farm situations within one watershed logically, but the magnitude of the difference is small. Within the programming model it may be caused by the assumption of linearity. In both watersheds the greatest percentage increase in net income is, as would be expected, on the farm with the large ratio of bottomland to upland (Tables XV through XX).

TABLE XV

PROGRAMMED AND ACTUAL ORGANIZATION ON TYPICAL CAVALRY CREEK FARMS WITH LESS THAN 300 ACRES OF CULTIVATABLE LAND AND A BOTTOM-UPLAND RATIO LESS THAN 1:2
(Protected Watershed)

Item	Unit	Actual		Programmed Protected		Programmed Unprotected		Changes from Unprot. to Prot.	
		(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)
Land Use									
Cotton	acre	12	9	8	13	8	13	0	0
Wheat	acre	3	40	7	36	0	43	+7	-7
Alfalfa	acre	9	1	13	0	20	0	-7	0
Barley	acre	0	1	0	1	0	1	0	0
Temp. Pasture[a]	acre	0	41	0	54	0	47	0	+7
Grain Sorghum	acre	3	4	0	7	0	7	0	0
Forage Sorghum	acre	0	1	0	0	0	0	0	0
Other[b]	acre	1	14	0	0	0	0	0	0
Total Cult. Land	acre	28	111	28	111	28	111	0	0
Cattle									
Cows	hd.	n.a.		33		29		+4	
Feeders	hd.	n.a.		0		0		0	
Capital Use	dol.	n.a.		9,754.72		9,067.83		+686.89	
Labor Use:Total	hrs.	n.a.		1,074		1,064		+10	
Family	hrs.	n.a.		1,074		1,064		+10	
Hired	hrs.	n.a.		0		0		0	
Gross Income	dol.	n.a.		7,696.39		7,296.04		+400.35	
Net Returns[c]	dol.	n.a.		2,746.75		2,494.67		+252.08	
Net Returns[d]	dol.	n.a.		4,502.60		4,126.88		+375.72	
Land Use Intensities									
Bottomland	dol.	47.08		43.19		42.78		+.41	
Upland	dol.	14.20		17.68		18.38		-.70	
Cropland	dol.	20.81		22.82		23.30		-.48	

[a]Includes small grain pasture and sudan grass.

[b]Other cropland not accounted for in the farm survey.

[c]Returns to land, family labor, and management (with nonland capital paid its reservation price).

[d]Returns to land, family labor, and management (with nonland capital paid 6 percent).

TABLE XVI

PROGRAMMED AND ACTUAL ORGANIZATION ON TYPICAL CAVALRY CREEK FARMS WITH LESS THAN 300 ACRES OF CULTIVATABLE LAND AND A BOTTOM-UPLAND RATIO GREATER THAN 1:2
(Protected Watershed)

Item	Unit	Actual		Programmed Protected		Programmed Unprotected		Changes from Unprot. to Prot.	
		(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)
Land Use									
Cotton	acre	17	0	17	0	17	0	0	0
Wheat	acre	52	32	69	15	69	15	0	0
Alfalfa	acre	15	0	22	0	22	0	0	0
Barley	acre	3	4	0	7	0	7	0	0
Temp. Pasture[a]	acre	12	2	0	16	0	16	0	0
Grain Sorghum	acre	4	0	0	0	0	0	0	0
Forage Sorghum	acre	0	0	0	0	0	0	0	0
Other[b]	acre	5	0	0	0	0	0	0	0
Total Cult. Land	acre	108	38	108	38	108	38	0	0
Cattle									
Cows	hd.	n.a.		10		10		0	
Feeders	hd.	n.a.		0		0		0	
Capital Use	dol.	n.a.		5,232.71		5,232.71		0	
Labor Use:Total	hrs.	n.a.		795		795		0	
Family	hrs.	n.a.		795		795		0	
Hired	hrs.	n.a.		0		0		0	
Gross Income	dol.	n.a.		8,122.87		7,189.98		+932.89	
Net Returns[c]	dol.	n.a.		4,441.88		3,508.99		+932.89	
Net Returns[d]	dol.	n.a.		5,383.77		4,450.88		+932.89	
Land Use Intensities									
Bottomland	dol.	34.73		38.91		38.91		0	
Upland	dol.	18.80		14.03		14.03		0	
Cropland	dol.	30.58		32.43		32.43		0	

[a]Includes small grain pasture and sudan grass.

[b]Other cropland not accounted for in the farm survey.

[c]Returns to land, family labor, and management (with nonland capital paid its reservation price).

[d]Returns to land, family labor, and management (with nonland capital paid 6 percent).

TABLE XVII

PROGRAMMED AND ACTUAL ORGANIZATION ON TYPICAL CAVALRY CREEK FARMS WITH GREATER THAN 300 ACRES OF CULTIVATABLE LAND (Protected Watershed)

Item	Unit	Actual		Programmed Protected		Programmed Unprotected		Changes from Unprot. to Prot.	
		(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)
Land Use									
Cotton	acre	23	36	42	17	42	17	0	0
Wheat	acre	57	143	27	173	27	173	0	0
Alfalfa	acre	28	0	72	0	72	0	0	0
Barley	acre	4	53	0	57	0	57	0	0
Temp. Pasture[a]	acre	9	41	0	41	0	41	0	0
Grain Sorghum	acre	9	13	0	22	0	22	0	0
Forage Sorghum	acre	6	1	0	0	0	0	0	0
Other[b]	acre	5	24	0	0	0	0	0	0
Total Cult. Land	acre	141	311	141	311	141	311	0	0
Cattle									
Cows	hd.	n.a.		26		26		0	
Feeders	hd.	n.a.		0		0		0	
Capital Use	dol.	n.a.		15,589.79		15,589.79		0	
Labor Use: Total	hrs.	n.a.		2,479		2,479		0	
Family	hrs.	n.a.		2,335		2,335		0	
Hired	hrs.	n.a.		144		144		0	
Gross Income	dol.	n.a.		21,083.27		19,801.28		+1,281.99	
Net Returns[c]	dol.	n.a.		10,235.71		8,953.72		+1,281.99	
Net Returns[d]	dol.	n.a.		12,574.18		11,292.19		+1,281.99	
Land Use Intensities									
Bottomland	dol.	35.72		43.56		43.56		0	
Upland	dol.	17.73		18.09		18.09		0	
Cropland	dol.	23.34		26.03		26.03		0	

[a]Includes small grain pasture and sudan grass.

[b]Other cropland not accounted for in the farm survey.

[c]Returns to land, family labor, and management (with nonland capital paid its reservation price).

[d]Returns to land, family labor, and management (with nonland capital paid 6 percent).

TABLE XVIII

PROGRAMMED AND ACTUAL ORGANIZATION ON TYPICAL BOGGY CREEK FARMS WITH LESS THAN 300 ACRES OF CULTIVATABLE LAND AND A BOTTOM-UPLAND RATIO LESS THAN 1:2 (Unprotected Watershed)

Item	Unit	Actual		Programmed Unprotected		Programmed Protected		Changes from Unprot. to Prot.	
		(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)
Land Use									
Cotton	acre	9	11	14	6	14	6	0	0
Wheat	acre	19	72	0	91	30	61	+30	-30
Alfalfa	acre	8	0	24	0	1	0	-23	0
Barley	acre	4	20	0	20	0	20	0	0
Temp. Pasture[a]	acre	4	19	0	16	0	34	0	+18
Grain Sorghum	acre	1	6	7	0	0	7	-7	+7
Forage Sorghum	acre	0	15	0	0	0	0	0	0
Total Cult. Land	acre	45	133[b]	45	133[b]	45	132[b]	0	-1[b]
Cattle									
Cows	hd.	n.a.		10		22		+12	
Feeders	hd.	n.a.		0		0		0	
Capital Use	dol.	n.a.		5,710.76		7,450.45		+1,739.69	
Labor Use:Total	hrs.	n.a.		876		867		-9	
Family	hrs.	n.a.		876		867		-9	
Hired	hrs.	n.a.		0		0		0	
Gross Income	dol.	n.a.		7,072.01		7,414.03		+342.02	
Net Returns[c]	dol.	n.a.		3,373.58		3,860.97		+487.39	
Net Returns[d]	dol.	n.a.		4,401.52		5,202.05		+800.53	
Land Use Intensities									
Bottomland	dol.	37.20		43.45		44.84		+1.39	
Upland	dol.	18.49		18.75		16.62		-2.13	
Cropland	dol.	23.22		24.99		23.66		-1.33	

[a]Includes small grain pasture and sudan grass.

[b]Differences due to rounding.

[c]Returns to land, family labor, and management (with nonland capital paid its reservation price).

[d]Returns to land, family labor, and management (with nonland capital paid 6 percent).

TABLE XIX

PROGRAMMED AND ACTUAL ORGANIZATION ON TYPICAL BOGGY CREEK FARMS WITH LESS THAN 300 ACRES OF CULTIVATABLE LAND AND A BOTTOM-UPLAND RATIO GREATER THAN 1:2
(Unprotected Watershed)

Item	Unit	Actual		Programmed Unprotected		Programmed Protected		Changes from Unprot. to Prot.	
		(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)
Land Use									
Cotton	acre	3	2	5	0	5	0	0	0
Wheat	acre	61	21	61	21	67	15	+6	-6
Alfalfa	acre	9	0	26	0	20	0	-6	0
Barley	acre	8	5	0	0	0	6	0	+6
Temp. Pasture[a]	acre	8	9	0	18	0	18	0	0
Grain Sorghum	acre	2	0	1	0	1	0	0	0
Forage Sorghum	acre	2	1	0	0	0	0	0	0
Total Cult. Land	acre	93	38[b]	93	39[b]	93	39[b]	0	0
Cattle									
Cows	hd.	n.a.		11		11		0	
Feeders	hd.	n.a.		0		0		0	
Capital Use	dol.	n.a.		5,030.44		4,837.78		-192.66	
Labor Use:Total	hrs.	n.a.		656		607		-49	
Family	hrs.	n.a.		656		607		-49	
Hired	hrs.	n.a.		0		0		0	
Gross Income	dol.	n.a.		5,853.37		6,606.38		+753.01	
Net Returns[c]	dol.	n.a.		2,680.66		3,587.35		+906.69	
Net Returns[d]	dol.	n.a.		3,586.14		4,458.15		+872.01	
Land Use Intensities									
Bottomland	dol.	31.22		34.96		35.06		+ .10	
Upland	dol.	16.43		15.81		13.95		-1.86	
Cropland	dol.	26.93		29.52		29.04		- .48	

[a]Includes small grain pasture and sudan grass.

[b]Differences due to rounding.

[c]Returns to land, family labor, and management (with nonland capital paid its reservation price).

[d]Returns to land, family labor, and management (with nonland capital paid 6 percent).

TABLE XX

PROGRAMMED AND ACTUAL ORGANIZATION ON TYPICAL BOGGY CREEK FARMS WITH GREATER THAN 300 ACRES OF CULTIVATABLE LAND (Unprotected Watershed)

Item	Unit	Actual		Programmed Unprotected		Programmed Protected		Changes from Unprot. to Prot.	
		(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)
Land Use									
Cotton	acre	17	23	40	0	40	0	0	0
Wheat	acre	92	169	39	222	85	176	+46	-46
Alfalfa	acre	10	0	67	0	34	0	-33	0
Barley	acre	8	67	0	40	0	75	0	+35
Temp. Pasture[a]	acre	8	34	0	49	0	47	0	-2
Grain Sorghum	acre	3	10	13	0	0	13	-13	+13
Forage Sorghum	acre	21	8	0	0	0	0	0	0
Total Cult. Land	acre	159	311	159	311	159	311	0	0
Cattle									
Cows	hd.	n.a.		29		28		-1	
Feeders	hd.	n.a.		0		0		0	
Capital Use	dol.	n.a.		16,088.13		14,743.23		-1,344.90	
Labor Use:Total	hrs.	n.a.		2,339		2,042		-297	
Family	hrs.	n.a.		2,339		2,042		-297	
Hired	hrs.	n.a.		0		0		0	
Gross Income	dol.	n.a.		19,834.68		20,602.87		+768.19	
Net Returns[b]	dol.	n.a.		9,368.69		11,004.09		+1,635.40	
Net Returns[c]	dol.	n.a.		11,781.91		13,215.57		+1,433.66	
Land Use Intensities									
Bottomland	dol.	34.40		41.72		42.35		+ .63	
Upland	dol.	17.90		17.62		16.15		-1.47	
Cropland	dol.	23.48		25.77		25.01		- .76	

[a]Includes small grain pasture and sudan grass.

[b]Returns to land, family labor, and management (with nonland capital paid its reservation price).

[c]Returns to land, family labor, and management (with nonland capital paid 6 percent).

Cavalry Creek - The explanation of land use with the programming model was good in this watershed, especially in the two smaller farms (Tables XV and XVI). The most striking discrepancy was the large amount of programmed alfalfa in the large farm situation. The lower limit of the relevant range on the price of alfalfa hay on this farm was $19.76.

The damage factors imply no change in land use on two of the three farms and very little change on the other. The small farm with a small bottom-upland ratio has a programmed increase in wheat and a decrease in alfalfa on the bottomland with a corresponding decrease in wheat and an increase in temporary pasture on the upland. The change in intensity caused by this is small. Thus the 9 to 21 percent increase in net income on these farms is almost entirely the result of reducing damage to crops and pasture already there.

Boggy Creek - In two of the three typical farms in Boggy Creek, the programs with assumed full protection explained land use better than the programs using the damage factors. This suggests that Boggy Creek farmers are using their land as if there were no damages. Also, it may help explain why there was no observable difference in land use between the two watersheds.

No change in location of the cotton acreage is implied on the three farms, but some wheat shifts to the bottomland in each of the situations, and the amount of bottomland alfalfa is reduced after protection in each case. Changes in land use are least on the farm with the large bottom-upland ratio. But, it is this farm on which land use is explained by the program that assumes flood damages. This suggests that farmers might recognize the damages caused by flooding where they have considerable bottomland subject to flooding. It also suggests that most of the land use changes in the watershed that are implied by the damage factors already have taken place. The damage factor implications are very similar between the two other situations. The only difference is that the large farm has no increase in temporary pasture since capital to buy livestock is more scarce than land on which to grow forage for livestock.

Most of the increase in capital on the small farm with a small bottomland-upland ratio is used to increase the cow herd. The increase in bottomland intensity is small, and the change in overall cropland intensity is negative. In the other two situations capital and labor use is decreased as a result of protection

Summary of the Group II Watersheds - The actual bottomland use intensity of each of the Cavalry Creek farms is greater than the comparable resource situations in Boggy Creek. In two of the three situations, the upland use intensity of the Boggy Creek farms is greater than the comparable Cavalry Creek farms. In the same two farms (the small farm with a small bottom-upland ratio and the large farm), the Cavalry Creek bottomland is used more intensively relative to the upland than it is in Boggy Creek. Thus the more precise absolute and relative measures of land use intensity employed in this chapter indicate a small difference in intensity that was not possible to ascertain in the analysis of Chapter III.

Group III

The programs for both of the typical farms in Saddle Mountain Creek Watersheds explain actual land use best when the required rate of return on nonland capital is at 17 percent (Tables XXI and XXIII). But the required rate of return on both farms could vary between 17 and 30 percent

TABLE XXI

PROGRAMMED AND ACTUAL ORGANIZATION ON TYPICAL SADDLE MOUNTAIN FARMS WITH WITH LESS THAN 300 ACRES OF CULTIVATABLE LAND
(Protected Watershed)

Item	Unit	Actual		Programmed Protected		Programmed Unprotected		Changes from Unprot. to Prot.	
		(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)
Land Use									
Cotton	acre	14	18	32	0	32	0	0	0
Wheat	acre	48	29	43	34	33	44	+10	-10
Alfalfa	acre	3	0	3	0	3	0	0	0
Barley	acre	0	8	0	8	0	8	0	0
Temp. Pasture[a]	acre	4	23	0	33	0	0	0	+33
Grain Sorghum	acre	0	1	0	1	0	1	0	0
Bermuda	acre	0	0	0	0	10	0	-10	0
Cult. Pasture & Other	acre	9	0	0	3	0	26	0	-23
Total Cult. Land	acre	78	79	78	79	78	79	0	0
Cattle									
Cows	hd.	n.a.		15		17		-2	
Feeders	hd.	n.a.		0		0		0	
Capital Use	dol.	n.a.		5,945.07		6,083.17		-138.10	
Labor Use:Total	hrs.	n.a.		901		886		+15	
Family	hrs.	n.a.		901		886		+15	
Hired	hrs.	n.a.		0		0		0	
Gross Income	dol.	n.a.		7,544.05		7,080.80		+463.25	
Net Returns[b]	dol.	n.a.		4,115.04		3,741.78		+373.26	
Net Returns[c]	dol.	n.a.		4,769.03		4,410.93		+358.10	
Land Use Intensities									
Bottomland	dol.	31.26		41.63		39.73		+1.90	
Upland	dol.	12.92		9.89		10.53		- .64	
Cropland	dol.	22.03		25.66		25.03		+ .63	

[a]Includes small grain pasture and sudan grass.

[b]Returns to land, family labor, and management (with nonland capital paid its reservation price).

[c]Returns to land, family labor, and management (with nonland capital paid 6 percent).

TABLE XXII

PROGRAMMED AND ACTUAL ORGANIZATION ON TYPICAL SADDLE MOUNTAIN FARMS WITH GREATER THAN 300 ACRES OF CULTIVATABLE LAND (Protected Watershed)

Item	Unit	Actual		Programmed Protected		Programmed Unprotected		Changes from Unprot. to Prot.	
		(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)
Land Use									
Cotton	acre	27	33	60	0	60	0	0	0
Wheat	acre	104	197	147	154	105	196	+42	-42
Alfalfa	acre	3	0	5	0	23	0	-18	0
Barley	acre	24	56	0	80	0	80	0	0
Temp. Pasture[a]	acre	29	63	0	82	0	0	0	+82
Grain Sorghum	acre	0	3	0	3	0	3	0	0
Bermuda	acre	0	0	0	0	24	0	-24	0
Cult. Pasture & Other	acre	25	0	0	33	0	73	0	-40
Total Cult. Land	acre	212	352	212	352	212	352	0	0
Cattle									
Cows	hd.	n.a.		36		40		-4	
Feeders	hd.	n.a.		0		0		0	
Capital Use	dol.	n.a.		17,323.92		17,590.02		-266.10	
Labor Use:Total	hrs.	n.a.		2,425		2,381		+44	
Family	hrs.	n.a.		2,301		2,287		+14	
Hired	hrs.	n.a.		124		94		+30	
Gross Income	dol.	n.a.		21,158.28		20,537.67		+620.61	
Net Returns[b]	dol.	n.a.		11,316.59		10,470.24		+846.35	
Net Returns[c]	dol.	n.a.		13,222.22		12,405.14		+817.08	
Land Use Intensities									
Bottomland	dol.	26.50		38.38		36.18		+2.20	
Upland	dol.	12.98		9.98		10.96		- .98	
Cropland	dol.	18.06		20.65		20.44		+ .21	

[a]Includes small grain pasture and sudan grass.

[b]Returns to land, family labor, and management (with nonland capital paid its reservation price).

[c]Returns to land, family labor, and management (with nonland capital paid 6 percent).

TABLE XXIII

PROGRAMMED AND ACTUAL ORGANIZATION ON TYPICAL RAINY MOUNTAIN FARMS WITH LESS THAN 300 ACRES OF CULTIVATABLE LAND (Unprotected Watershed)

Item	Unit	Actual		Programmed Unprotected		Programmed Protected		Changes from Unprot. to Prot.	
		(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)
Land Use									
Cotton	acre	17	14	28	3	31	0	+3	-3
Wheat	acre	24	27	0	51	37	14	+37	-37
Alfalfa	acre	1	3	34	0	3	0	-31	0
Barley	acre	3	4	0	7	0	7	0	0
Temp. Pasture[a]	acre	17	7	0	0	0	33	0	+33
Grain Sorghum	acre	2	0	0	2	0	2	0	0
Bermuda	acre	0	0	9	0	0	0	-9	0
Cult. Pasture & Other	acre	7	8	0	0	0	7	0	+7
Total Cult. Land	acre	71	63	71	63	71	63	0	0
Cattle									
Cows	hd.	n.a.		14		15		+1	
Feeders	hd.	n.a.		0		0		0	
Capital Use	dol.	n.a.		6,525.62		5,469.39		-1,056.23	
Labor Use:Total	hrs.	n.a.		1,100		834		-266	
Family	hrs.	n.a.		1,100		834		-266	
Hired	hrs.	n.a.		0		0		0	
Gross Income	dol.	n.a.		6,064.96		6,663.91		+598.95	
Net Returns[b]	dol.	n.a.		2,251.36		3,564.03		+1,312.67	
Net Returns[c]	dol.	n.a.		3,034.43		4,220.36		+1,185.93	
Land Use Intensities									
Bottomland	dol.	27.90		36.76		42.30		+5.54	
Upland	dol.	12.75		15.29		7.41		-7.88	
Cropland	dol.	20.78		26.67		25.90		- .77	

[a]Includes small grain pasture and sudan grass.

[b]Returns to land, family labor, and management (with nonland capital paid its reservation price).

[c]Returns to land, family labor, and management (with nonland capital paid 6 percent).

TABLE XXIV

PROGRAMMED AND ACTUAL ORGANIZATION ON TYPICAL RAINY MOUNTAIN FARMS WITH GREATER THAN 300 ACRES OF CULTIVATABLE LAND (Unprotected Watershed)

Item	Unit	Actual		Programmed Unprotected		Programmed Protected		Changes from Unprot. to Prot.	
		(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)
Land Use									
Cotton	acre	18	61	29	50	79	0	+50	-50
Wheat	acre	31	111	71	71	104	38	+33	-33
Alfalfa	acre	15	6	58	0	9	0	-49	0
Barley	acre	0	28	0	28	0	28	0	0
Temp. Pasture[a]	acre	12	15	0	0	0	110	0	+110
Grain Sorghum	acre	15	5	0	20	0	20	0	0
Bermuda	acre	0	0	34	0	0	0	-34	0
Cult. Pasture & Other	acre	101	23	0	80	0	54	0	-26
Total Cult. Land	acre	192	249[b]	192	249[b]	192	250[b]	0	1[b]
Cattle									
Cows	hd.	n.a.		52		50		-2	
Feeders	hd.	n.a.		0		0		0	
Capital Use	dol.	n.a.		19,148.14		17,468.82		-1,679.32	
Labor Use:Total	hrs.	n.a.		2,609		2,349		-260	
Family	hrs.	n.a.		2,529		2,124		-405	
Hired	hrs.	n.a.		80		225		+145	
Gross Income	dol.	n.a.		16,318.35		19,156.04		+2,834.69	
Net Returns[c]	dol.	n.a.		6,382.32		9,870.59		+3,488.27	
Net Returns[d]	dol.	n.a.		8,680.10		11,792.16		+3,111.06	
Land Use Intensities									
Bottomland	dol.	16.06		30.62		41.61		+10.99	
Upland	dol.	13.72		11.15		6.58		- 4.57	
Cropland	dol.	14.74		19.63		21.85		+ 2.22	

[a]Includes small grain pasture and sudan grass.

[b]Differences due to rounding.

[c]Returns to land, family labor, and management (with nonland capital paid its reservation price).

[d]Returns to land, family labor, and management (with nonland capital paid 6 percent).

without changing land use. Seventeen percent, the lower limit of the required rate of return, is the more appropriate rate to use because the concept of a reservation price is not concerned with the maximum rate of return people are willing to take, but rather the minimum rate of return people require before they are induced to invest nonland capital.

The major difference in actual and programmed land uses for both Saddle Mountain farms was the number of acres of upland cotton. The size of this difference suggested that more than aggregation bias was involved. It was assumed that bottomland yielded 130 pounds of lint cotton per acre more than the upland did. Even if this 130-pound differential in cotton yields actually existed, the variability of yields among plots of ground could bring about the actual ratio of bottomland to upland cotton. Much of the upland may produce more cotton lint per acre than the bottomland. The true situation may be that land in Saddle Mountain Creek Watershed should not be categorized on the basis of bottomland and upland, but rather on the basis of a more precise productivity index.

Saddle Mountain Creek - Except for the cotton discrepancy mentioned earlier, the programs explain land use reasonably well in this watershed. However, the programmed solutions show more wheat and less barley and pasture than is actually grown on the bottomland of the large farm.

The relatively small damage factors imply small changes in gross and net returns. Gross income is increased by 6.5 and 3.0 percent for the small and large farms, and net income is increased by 8.1 and 6.6 percent for the small and large farms, respectively. Capital use is slightly decreased on both farms.

The implied changes in land use are similar in the two situations except that alfalfa production is reduced after flood protection on the large farm. This is because the alfalfa produced on the small farm was not produced for sale, whereas it was on the large farm. The change from cultivatable pasture to temporary pasture represents a change in intensity since the temporary pasture also produces some oats for grain. This explains the decrease in cattle even though land devoted to temporary pasture has increased.

Rainy Mountain Creek - According to the programming analysis, the net returns on the Rainy Mountain Creek farms could increase by 36 to 39 percent as a result of flood protection. The damage factors imply a shift of some of the cotton and wheat from the upland to the bottomland, where they replace alfalfa and bermuda. Temporary pasture, which includes oats for cash sale, is increased on the upland.

On the large Rainy Mountain Creek farm, the large increase in bottomland cotton requires more hired labor for cotton harvesting. Total labor, however, is less on both farms after protection because less family labor is required. Capital required also decreases on both farms after protection.

The programmed land use under assumed unprotected conditions differs considerably from their actual land use. In Appendix E, Table II, the land use of the small farm at intermediate levels of the Soil Conservation Service damage factors is presented. For some crops, intermediate levels of damage explain land use better than other levels. If the damage level was adjusted on those crops with acreages best explained by an intermediate damage level, the effect, in general, would not be a better explanation of land use within the total farm situation. The results presented in the table suggest, however, that the damage factors are not structured properly. The damage factor for wheat and temporary pasture are too high relative to the factor for alfalfa.

Summary of the Group III Watersheds - Actual bottomland use intensity is greater in both Saddle Mountain situations than it is in Rainy Mountain Creek. The intensity of bottomland use relative to upland also is greater in Saddle Mountain situations than it is in Rainy Mountain Creek (2.42 and 2.04 on the respective small and large Saddle Mountain Creek farms and 2.19 and 1.17 on the respective small and large Rainy Mountain Creek farms). The conclusion is that Saddle Mountain bottomland is farmed more intensively than Rainy Mountain bottomland probably because of flood protection. This is consistent with the analysis of these watersheds in Chapter III.

The programming analysis indicates that with flooding in both watersheds, bottomland would be most intensively used in Saddle Mountain Creek (reflecting the smaller damage reduction factors in Saddle Mountain). However, after both watersheds had been protected, the bottomland of Rainy Mountain Creek would be used more intensively than the bottomland of Saddle Mountain Creek. Before protection the intensity of bottomland use relative to the upland intensity is lower in Rainy Mountain than it is in Saddle Mountain; after protection, the intensities of bottomland use are higher in Rainy Mountain Creek.

Group IV

Less family labor per farm is available in this group of watersheds than in the others (Table X). Yet family labor was in excess at the required rate of return on nonland capital. As in Group III watersheds, 17 percent return on nonland capital gave the best explanation of actual land use in the protected watersheds (Tables XXV and XXVI).

Big Kiowa and Panther Creek Watersheds - The major differences in the explanatory programs of these two watersheds are the excess of programmed alfalfa in Big Kiowa Creek and the fact that the programmed solution used temporary pasture rather than cultivatable pasture for forage in Big Kiowa Creek.

Net returns are considerably increased as a result of flood protection in Big Kiowa Creek, but most of the 27.5 percent increase in net returns stem from the reduction in crop and pasture damage rather than changed land use. This is the only watershed having no upland use changes implied by the damage factors and having steers in the farm plan after protection. The stability range on the net returns for the steer activity was rather narrow.[9]

The structure of the Panther Creek damage factors are considerably different from those in Big Kiowa Creek (Appendix D, Table I). Cotton replaces wheat on the bottomland, and wheat replaces cotton on the upland after protection in Panther Creek. Alfalfa increases on the bottomland as a result of protection.

Whiteshield Creek - The protected program explains land use in Whiteshield Creek better than the unprotected, although neither explain the barley, grain sorghum, forage sorghum, or cultivatable pasture on the bottomland.

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[9] Steers are profitable only if their net returns are between $31.93 and $33.84.

TABLE XXV

PROGRAMMED AND ACTUAL ORGANIZATION ON TYPICAL
BIG KIOWA CREEK FARMS
(Protected Watershed)

Item	Unit	Actual		Programmed Protected		Programmed Unprotected		Changes from Unprot. to Prot.	
		(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)
Land Use									
Cotton	acre	13	2	15	0	15	0	0	0
Wheat	acre	21	1	18	4	18	4	0	0
Alfalfa	acre	2	0	19	0	8	0	+11	0
Barley	acre	0	0	0	0	0	0	0	0
Temp. Pasture[a]	acre	13	17	18	56	29	56	-11	0
Grain Sorghum	acre	7	10	0	17	0	17	0	0
Forage Sorghum	acre	0	0	0	0	0	0	0	0
Cult. Pasture & Other	acre	14	47	0	0	0	0	0	0
Total Cult. Land	acre	70	77	70	77	70	77	0	0
Cattle:Total	hd.	n.a.		48		44		+4	
Cows	hd.	n.a.		34		44		-10	
Feeders	hd.	n.a.		14		0		+14	
Capital Use	dol.	n.a.		11,222.10		11,157.82		+64.28	
Labor Use:Total	hrs.	n.a.		1,095		1,016		+79	
Family	hrs.	n.a.		1,095		1,016		+79	
Hired	hrs.	n.a.		0		0		0	
Gross Income	dol.	n.a.		8,785.83		6,667.06		+2,118.77	
Net Returns[b]	dol.	n.a.		2,212.50		2,882.89		+670.39	
Net Returns[c]	dol.	n.a.		3,222.49		4,110.25		+887.76	
Land Use Intensities									
Bottomland	dol.	24.63		30.45		29.31		+1.14	
Upland	dol.	3.69		5.46		5.46		0.00	
Cropland	dol.	13.67		17.36		16.82		+ .54	

[a]Includes small grain pasture and sudan grass.

[b]Returns to land, family labor, and management (with nonland capital paid its reservation price).

[c]Returns to land, family labor, and management (with nonland capital paid 6 percent).

TABLE XXVI

PROGRAMMED AND ACTUAL ORGANIZATION ON TYPICAL PANTHER CREEK FARMS (Protected Watershed)

Item	Unit	Actual		Programmed Protected		Programmed Unprotected		Changes from Unprot. to Prot.	
		(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)
Land Use									
Cotton	acre	8	1	9	0	0	9	+9	-9
Wheat	acre	28	44	41	31	50	22	-9	+9
Alfalfa	acre	17	0	10	0	6	0	+4	0
Barley	acre	0	1	0	0	0	0	0	0
Temp. Pasture[a]	acre	20	39	21	52	25	48	-4	+4
Grain Sorghum	acre	0	0	0	0	0	0	0	0
Forage Sorghum	acre	0	0	0	0	0	0	0	0
Cult. Pasture & Other	acre	8	30	0	32	0	36	0	-4
Total Cult. Land	acre	81	115	81	115	81	115	0	0
Cattle									
Cows	hd.	n.a.		35		35		0	
Feeders	hd.	n.a.		0		0		0	
Capital Use	dol.	n.a.		9,687.81		9,658.36		+29.45	
Labor Use:Total	hrs.	n.a.		892		875		+17	
Family	hrs.	n.a.		892		875		+17	
Hired	hrs.	n.a.		0		0		0	
Gross Income	dol.	n.a.		6,890.58		6,269.40		+621.18	
Net Returns[b]	dol.	n.a.		3,478.48		2,884.79		+593.69	
Net Returns[c]	dol.	n.a.		4,350.38		3,754.04		+596.34	
Land Use Intensities									
Bottomland	dol.	24.50		27.53		23.98		+3.55	
Upland	dol.	5.90		5.13		6.69		-1.56	
Cropland	dol.	13.58		14.39		13.84		+ .55	

[a]Includes small grain pasture and sudan grass.

[b]Returns to land, family labor, and management (with nonland capital paid its reservation price).

[c]Returns to land, family labor, and management (with nonland capital paid 6 percent).

TABLE XXVII

PROGRAMMED AND ACTUAL ORGANIZATION OF TYPICAL WHITESHIELD CREEK FARMS (Unprotected Watershed)

Item	Unit	Actual		Programmed Unprotected		Programmed Protected		Changes from Unprot. to Prot.	
		(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)	(Bot.)	(Up.)
Land Use									
Cotton	acre	12	5	0	17	17	0	+17	-17
Wheat	acre	30	19	44	5	35	14	-9	+9
Alfalfa	acre	5	0	10	0	2	0	-8	0
Barley	acre	5	6	0	0	0	0	0	0
Temp. Pasture[a]	acre	4	32	19	5	19	5	0	0
Grain Sorghum	acre	6	4	0	10	0	10	0	0
Forage Sorghum	acre	8	5	0	0	0	0	0	0
Cult. Pasture & Other	acre	3	12	0	46	0	54	0	+8
Total Cult. Land	acre	73	83	73	83	73	83	0	0
Cattle									
Cows	hd.	n.a.		17		18		+1	
Feeders	hd.	n.a.		0		0		0	
Capital Use	dol.	n.a.		5,394.27		5,173.58		-220.69	
Labor Use:Total	hrs.	n.a.		615		583		-32	
Family	hrs.	n.a.		615		583		-32	
Hired	hrs.	n.a.		0		0		0	
Gross Income	dol.	n.a.		4,945.24		5,201.83		+256.59	
Net Returns[b]	dol.	n.a.		2,519.79		2,912.92		+393.13	
Net Returns[c]	dol.	n.a.		3,005.27		3,378.54		+373.27	
Land Use Intensities									
Bottomland	dol.	27.90		25.05		31.95		+6.90	
Upland	dol.	6.67		7.35		3.79		-3.56	
Cropland	dol.	16.61		15.64		16.97		+1.33	

[a]Includes small grain pasture and sudan grass.

[b]Returns to land, family labor, and management (with nonland capital paid its reservation price).

[c]Returns to land, family labor, and management (with nonland capital paid 6 percent).

The programming analysis suggests rather large changes in land use. Programmed cotton moves from the upland to the bottomland after protection. The change in bottomland use intensity is greater in Whiteshield than the other two watersheds because of the shift in cotton acreage. Actual land use, however, is more intensive than the program model implies, so the real increase in net returns probably would not be as large as the program suggests.

Summary of Group IV Watersheds - Actual bottomland use intensity is less in the protected watersheds than it is in the unprotected watershed. However, the bottomland use intensity relative to the upland intensity is highest in Big Kiowa Creek Watershed (6.67), next in Whiteshield (4.18), and least in Panther Creek (4.15). This implies that farmers in Whiteshield historically have had more cotton and wheat allotments than Big Kiowa and Panther but plant less of them on the bottomland.

The programming analysis suggests that the percentage increase in bottomland use intensity could be greatest in Whiteshield Creek followed by Panther and then Big Kiowa. Thus it appears that protection has influenced bottomland use intensity in this group, but its influence on the as yet unprotected watershed might be less than that implied by the damage factors because of its present high degree of intensity in land use.

Summary of the Four Watershed Groups

The general pattern of land use changes implied by the damage factors are: (1) the shift of the cotton allotment from the upland to the bottomland, (2) a shift of the wheat allotment from the upland to the bottomland, (3) a reduction in the amount of alfalfa grown, (4) an increase in barley and temporary pasture on the upland formerly in wheat, and (5) a shift in grain sorghum from the bottomland to the upland. The results, however, differ among watershed groups, watersheds within a group, and among farm situations. Within watersheds of a group, the results differ because of differences in the level and structure of the damage factors and because of differences in the ratio of bottomland to upland. An example of this is given in Barnitz and Beaver Creek Watersheds.

The results differ among watershed groups because of differences in the productivity of the bottomland relative to the upland. That is, if there is a small difference in the productivity of upland relative to bottomland before protection, then, other things equal, the damage reduction factors must be larger to induce farmers to move crops from the upland to the bottomland. This is illustrated in Group II watersheds as compared with Group I.

Differences between farm situations of a particular group are least. This is because the situations assumed in this study, except in the small Group II farms, are mainly differences in scale. Thus the large farm merely represents a higher point on the homogenous production function of degree one implied by the programming model. If family labor was scarce on larger farms, diminishing returns to scale would exist (since labor would have to be hired), and the differences in the implications of the damage factors would be greater.

"Have the implied land use changes actually occurred?" A comparison of the programmed implications with the historical trends in bottomland use is only a superficial answer to the question, since many influences in addition to flood protection conceivably could have affected the historical trends in land use. An ex post comparison of the farmers' intended changes (the basis of the Soil Conservation Service estimates) and the damage factor implications is likewise superficial since the programming estimates are based on 1962 price and technological relationships, rather than the relationships that existed at the time of planning.

One major difference between the programming estimates in this thesis and those of the Soil Conservation Service deserves further attention. In most cases, increases in alfalfa as a result of flood protection do not occur as estimated in the work plans. Furthermore, they are not implied by the existing structure of the damage factors. This is because the damage reduction factor for alfalfa is generally less than damage reduction factors on other intensive crops. No increase in alfalfa after flood protection also is suggested by the difficulties that were expressed by several farmers during interviews in hiring seasonal haying labor and because of a limited market for alfalfa hay. But neither of these factors were included in the programming model.

Several other conclusions are implied by the weighted averages of the intensity measures of the various watersheds. In Table XXVIII, all of the watersheds now protected (i.e. Barnitz, Cavalry, Saddle Mountain, Big Kiowa, and Panther Creek) are considered in one category, and all of the as yet unprotected watersheds (i.e. Beaver, Boggy, Rainy Mountain, and Whiteshield Creek) are considered in another category. The following three land use intensities are discussed under each category: (1) the intensity associated with the actual bottomland use, (2) the intensity of the programmed bottomland use under protected conditions, and (3) the intensity of the programmed bottomland use under unprotected conditions.

TABLE XXVIII

ACTUAL AND PROGRAMMED BOTTOMLAND USE INTENSITIES FOR PROTECTED AND UNPROTECTED WATERSHEDS

Conditions	Protected Watersheds	Unprotected Watersheds	Differences Between Protected and Unprotected Watersheds
		-dollars-	
Actual	34.51	25.61	8.90
Programmed Under Protected Conditions	40.87	35.36	5.51
Programmed Under Unprotected Conditions	35.19	32.30	2.89
Differences Between Protected and Unprotected Programs	5.68	3.06	-

The $8.90 difference shows that there is a difference in bottomland use intensity between protected and unprotected watersheds, but the $5.51 difference shows that if all the watersheds were protected there would still be a difference between the watersheds now protected and those watersheds as yet unprotected. The $2.89 difference means that if none of the watersheds were protected the difference in bottomland use intensity would not be as large, but a difference would still exist. The $2.89 difference between the two watershed categories under programmed unprotected conditions is less than the $5.51 difference because the overall level of the damage factors is less in the unprotected category of watersheds than it is in the protected category.

The $3.06 difference is the best estimate of the increase in bottomland use intensity that could be expected from flood protection in the as yet unprotected watersheds, and the $5.68 difference is the best estimate of the increase in intensity of bottomland use that could be expected to have happened in the protected watersheds.

The difference between the $5.51 and $2.89 is $2.62; likewise the difference between $5.68 and $3.06 is $2.62. Thus the damage factors in the now protected watersheds imply $2.62 more change in bottomland use intensity as a result of flood protection than the damage factors in the as yet unprotected watersheds.

The differences in programmed protected and unprotected bottomland use intensity discussed above do not account for the difference in upland use intensity between programmed protected and unprotected. When this difference is considered, the $5.68 and $3.06 differences are reduced to a net difference in intensity per bottomland acre of $2.45 and 0.0, respectively; the weighted average of which is $1.53.

Similar intensity figures show that there is a difference in the intensity of land use between resource situations. The bottomland and upland use intensity on the small farms is $29.63 and $12.41 respectively; for the large farms the respective intensities are $32.53 and $13.63. Thus the large farms in this sample use both bottomland and upland more intensively than the smaller ones.

The programmed increase in returns as a result of flood protection and its sources are shown for each watershed in Table XXIX. The increase returns vary from $17.36 per acre to $4.10 per acre. Their variation is primarily a function of the reduction in crop and pasture damage which, in turn, depends on the acreage of allotment crops in the watershed and the size of the damage reduction factors.

TABLE XXIX

THE PROGRAMMED BENEFITS BY SOURCE AND THE TOTAL INCREASE IN RETURNS (Per Acre of Bottomland)

Watershed	Due to Changed Land Use	Due to Reduction in Crop and Pasture Damages	Total
		-dollars-	
Barnitz	9.81	12.55	17.36
Beaver	0.00	11.96	11.96
Cavalry	-.14	9.40	9.26
Boggy	-2.27	10.86	8.59
Saddle Mountain	.78	3.32	4.10
Rainy Mountain	2.86	13.49	16.35
Big Kiowa	1.13	11.55	12.68
Panther	1.33	6.03	7.36
Whiteshield	2.85	2.26	5.11

Although the returns due to changes in land use generally constitute a small portion of the total, they do contribute significantly to the variation in the overall increase in returns. The negative change in land use intensity in Group II watersheds is of special interest. In Cavalry Creek the negative change is small in amount, but the fact that there was so little change in land use implied by the damage factors is significant in view of the large land use change benefits estimated in the work plan (Table I). The rather large negative change in intensity in Boggy Creek is due to the replacement of wheat on the upland after protection with barley and temporary pasture. If alternative crops with greater intensity were available, the upland intensity would not decrease by so much. Such might be the case if controls were removed from wheat and cotton, and prices were to remain at their present level.

The returns due to the reduction in crop and pasture damages may be biased upwards. This is because the programs generally implied greater land use intensity than actually existed both before and after protection. The monetary value of reducing damages to intensive crops is greater than it is for extensive crops. Thus the programmed returns due to reducing damages to the crops may be greater than they are in actuality.

On the other hand, the returns due to changed land use can be biased either way. In Barnitz Creek, it is likely that they are biased upwards because of the shifts in the entire cotton allotment from the upland to the bottomland - a highly unlikely occurrence on all Barnitz Creek farms. Also, they may be biased downward if the program solution calls for the entire bottomland to be put into very intensive crops in spite of flooding when in truth there probably are flood channels or low depressions where the yields on bottomland crops would be very low. This may be the case in Cavalry Creek. The bias inherent in the methodology used suggests that future research along these lines should concentrate on particular farms whose precise resource complement could be ascertained.

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of this study was to evaluate and explain the *ex post* effects of the small watershed program with respect to land use changes. Specific objectives were: (1) to compare land use in protected watersheds with similar unprotected watersheds and with county trends, (2) to explain land use in watersheds already protected, (3) to find the changes in land use implied by the reduction in flood damage proposed by the Soil Conservation Service in the as yet unprotected watersheds, and (4) to explore the usefulness of linear programming as a predictive model of changes in land use.

Nine watersheds in the upper end of the Washita River Basin of Oklahoma were selected for study. The four watershed groups were: Group I, Barnitz and Beaver Creek; Group II, Cavalry and Boggy Creek; Group III, Saddle and Rainy Mountain Creek; and Group IV, Big Kiowa, Panther, and Whiteshield Creek. Data on resource situations and land use were collected from a sample of the farms in the watersheds by farmer interviews.

The Comparative Analysis

Land uses from similar protected and unprotected watershed farms were summarized, compared, and graphically presented. In addition, a more precise measure of land use intensity, based on the returns to land, labor, management, and capital from a composite acre, was employed to compare the protected and unprotected farms.

The results of statistical tests on the land use distribution, along with comparisons of the proportion of the intensive crops planted on the bottomland, indicated that in two of the watershed groups (I and III), the protected bottomland was used more intensively than the unprotected bottomland. In one watershed group (II), there was no difference in bottomland use intensity. The more refined measure of land use intensity indicated that even in Group II, the protected bottomland was used more intensively than the unprotected bottomland. The fact that the upland use intensity of the protected watersheds was less than the upland use intensity of the unprotected watersheds suggested that some of the difference was due to flood protection. There was some indication, however, that the bottomland of the protected watersheds was more intensively farmed before protection.

Historical trends in the acres of bottomland devoted to specific crops were consistent with increased bottomland use intensity following flood protection in two of the groups (I and II). The number of bottomland acres devoted to cotton increased after protection, while total acres devoted to cotton decreased.

The more intensive use of land on the large farms compared with the smaller farms is difficult to explain. Lack of allotments, and thus lower intensity, may force some farmers to seek off-farm employment. On the other hand, farmers who are closer to being true profit maximizers may be more likely to equate the marginal value product of their labor among farm and nonfarm enterprises. Thus they may recognize the low average returns on unprotected flood plain land, utilize their labor and capital on livestock oriented enterprises, and sell the rest of their labor in nonfarm pursuits.

Variables that were not accounted for in this analysis could influence the reliability of the conclusions drawn. For instance, in Group I the bottom-upland ratio differed within similar resource situations. This could mean that less of the bottomland in Barnitz Creek was subject to damaging floods, which would explain the greater intensity of bottomland use. On the other hand, the main effects of flood protection on land use intensity might not have been measured if they are truly in the form of increased inputs such as fertilizer. Or, insufficient time may have elapsed for farmers to adjust their position with respect to their physical assets in order to take advantage of flood protection. In any case, it appears at this time that the effects have been smaller than expected. Conceptually this might be expected since the type of farming in the area is becoming less intensive probably as a result of reduced allotments and changes in the competitive advantage of the area.

Programming Analysis

The programming models explained actual land use on protected watersheds best with the reservation price on nonland capital between 17 and 24 percent. The higher rates of return required were on farms in watersheds where crops were of major importance in the farm organization. This suggests that farmers restrict the use of nonland capital because of disutility associated with its use.

Differences between watersheds in the required rate of return on nonland capital probably are due to differences in the prevailing type of farming. The lower required rate of return in Group III and IV watersheds probably is associated with the greater importance of cattle in the farm organization. It has been historically true that cow-calf enterprises return less per dollar invested than cropping enterprises. In the conceptual framework of Chapter II, the disutility of using capital in beef-cow enterprises is small even at high levels of capital use.

Implications of the Programming Model

Reducing the damage to crops and pasture does not necessarily imply that cropland use intensity will be increased for two reasons. First, protection may not provide an economic potential for bottomland use intensification, especially when the characteristics of flood plain operators, as manifested by the reservation prices, are considered. This is the case in Cavalry Creek Watershed. The structure of the damage factors were such that no change in the relative profitabilities of the various crop enterprises occurred. Secondly, the decrease in upland use intensity may offset the increase in intensity of bottomland use. This second reason is illustrated in Boggy Creek where overall cropland intensity could decrease as a result of protection. Institutional restrictions, such as cotton and wheat allotments, make the second reason more important. It would become even more important when the number of possible alternative crops was less.

Inadequate specification of the available resources magnified the changes in land use implied by the damage factors in at least some cases. The shift of the entire cotton allotment from the upland to the bottomland as a result of protection illustrates this point. It is very likely some bottomland was so infrequently flooded that it was profitable to grow cotton on it. In the same way, some of the shifts not implied by the programming analysis may take place because land much more frequently flooded may be worth nothing for crops until after protection. Therefore, the magnitude of the programmed shifts is not likely to be as accurate as the direction of the shifts. Thus the decrease in overall cropland intensity may not be realistic.

Four levels of the Soil Conservation Service damage factors were assumed in an attempt to find the one level best approximating land use in the unprotected watersheds. Intermediate levels of the damage factors did no better in explaining land use than either extreme (no protection or full planned protection). In four out of eight farm situations, programs assuming full protection explained land use in unprotected watersheds better than those assuming flood damage. This suggests the possibility of farmers not placing much importance on flood damages. A possible hypothesis to explain this is that, through time, the distribution of crop yields for any tract of flood plain may be skewed to the right. That is, the modal yields are higher than the average yields. Flood plain farmers possibly make decisions based on the modal yield rather than the average yield. If flooding is the cause of yield distribution skewness, then reducing flooding may change the average yield but have little effect on the modal yield. If this case was true, land use would not change as a result of flooding, and the only positive benefits of the program would be the reduction of crop and pasture damages.[1]

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[1]This may also explain why some farmers typically overestimate average yields as compared with objective yield measurements. That is, they tend to state modal yields rather than average yields.

Linear Programming as a Land Use Predictor

Using reservation prices in a programming model is not the final solution to the problem of projecting the use of flood plain land into the future. It is possible, however, that where land use is expected to be a major source of project benefits, it may provide a means of checking the most likely changes that could be expected as a result of the program. In addition many computations needed to obtain net land use benefits might be done by machine. The technique used here required no unavailable data, nor any special handling. It does, however, demand precision in specifying the conditions of the watershed. Lack of precision is pointed out vividly in the solutions of the budgeting problem.

A possible technique requiring further investigation is outlined below. Farmer responses to their intentions about land use changes as a result of flood protection might be checked with the damage factors assumed. This could be done for the particular farms on which the greatest intended changes were indicated. In this way the resources of the particular farm could be used rather than an average set of resources for a typical farm. More detail concerning land classification, yields, asset fixity, allotments, production practices, et cetera could be collected. These farms could be selected to represent not only those farms whose managers indicated the willingness, the intent, and the ability to change, but also various resource situations found throughout the watershed.

The reservation prices for specific resources could be developed by checking the programmed results with the farmer's personal observations and his actual farm organization such that a realistic base program could be developed before the implications of the damage factors were programmed. Possibly the influence of the decreased risk also could be accounted for.

If the intentions of the farm operators were found to be feasible and likely with respect to the assumed damage factors, the programming results would serve as guide lines to make the necessary estimates for the entire watershed. If the intentions of the operators were found to be unfeasible, the programmed results, along with farmers' intentions, would serve as a basis for arriving at a reasonable estimate of the expected land use changes. It is possible that the program results could be aggregated to represent the entire watershed. The results also would serve as educational devices for the more reluctant or the less knowledgeable farmers in the watershed.

Because labor was seldom a limiting factor in any time period on any of the farms, logical implications of the damage factors possibly could be explored by conventional budgeting techniques, since the advantage of mathematical programming is diminished as the number of restrictive resources are decreased. Further work is needed to find the minimum number of restrictions to be considered when predicting changes in land use.

The Applicability of the Results

Neither the specific numerical changes in intensity nor the changes in land use implied by the damage factors are appropriate outside of the study area. Within the study area, the effects of reducing sediment and erosion damage and the treatment of upland may have as great an influence on land use as the reduction in damage to crops and pasture.

However, a greater knowledge of the influence and methods of appraising the effects of the variables listed in Chapter I has been gained. Relationships among the productive capacities of the various land classes, the damage factors, and acreage allotments have been pointed out. It is apparent that ignoring the demand facing the farmer for products, such as alfalfa hay, may have a more important influence on benefits from changes in land use in some areas than it did in this particular area where the reduction of damage implied less alfalfa grown rather than more.

This study indicates that the relationship between acreage allotments and the quality and quantity of the cultivatable upland is the most important relationship affecting benefits from changes in land use. If allotment crops are now planted on the upland, and if damage reduction on these particular crops is large enough, then a prediction that they will be moved to the bottomland probably is justified. If, however, the upland is very productive in relation to the bottomland, then it will take large damage reduction factors to induce the shifts of the crops from the upland to the bottomland, especially when the intensive crops are restricted by allotment.

Need for Further Research

Additional research into the effects of flood protection on land use could take several other alternative routes. One of them has been mentioned earlier. It is basically a refinement of the technique of this study using the particular farms in the watershed where operators indicate intentions of making changes rather than using an average farm. Its main use is to determine the effects of given damage factors. The approach does not necessarily imply programming of specific farms. Rather a more simple budgeting technique may be sufficiently precise and may lead to more practical application by economists in the field.

It appears that the physical damage factors cannot be materially improved by empirically comparing their ex post effects with their estimated size. Further work is required on: (1) the estimation of the physical damage factors, and (2) the farmer response to these physical damages. Once this work is done, accurate estimates of land use changes should follow.

Methods of determining more accurate physical damage factors could be oriented toward more objective field observation of individual flooding events. Presently farmers are asked to remember the duration and depth of inundation of floods, the velocity of the water, the stage of plant development, the reduction in yield caused by the flood, and other pertinent information about changes in production practices, substitute crops, et cetera.

Accurate estimates of the ex ante as well as the ex post effects of flood protection may require research directed toward a more precise statistical sampling technique in which data on the use of a specific plot of ground could be collected periodically. Variables with theoretic relevance associated with the specific plot of ground could also be collected so that statistical tools such as regression and/or analysis of variance could be employed to separate out the influence of specific variables. Data of this sort also could be used to: (1) determine more accurate technological coefficients for flood plain soils before and after flood protection, and (2) estimate the frequency distributions of stochastic occurrences associated with land use (yield responses, flooding events, et cetera).

A method of collecting, tabulating, and storing data that maintains georgaphic ordering has been proposed.[2] In this method, point samples are selected systematically from predetermined strata that correspond to political subdivisions such as sections or townships. The samples are selected in such a manner that many of the advantages of randomization also exist. Economic and geographic data for each point can then be collected and coded so that they can be stored and tabulated on machine punched cards. An efficient geographic coding system which maintains spatial ordering with a small number of cards also is proposed. Further work is required to find the statistical properties of economic data, such as farm units, that may be coincidental with several sample points in any one time period and with several more or different points in another time period. The method, however, offers a way to place statistical reliability on estimates of changes in land use and estimates of damage reduction as a result of flood protection.

It is conceivable that the budgeting technique of this study and the point sampling technique described above could be complementary. That is, relevant associated variables for the statistical analysis could be further delineated by continuing the budgeting technique of this study a step further. On the other hand, data from the statistical sampling would be very useful in developing more accurate budgets for flood plains, and more accurate damage factors for specific crops.

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[2] Brian J. L. Berry, Sampling, Coding, and Storage of Flood Plain Data, Agriculture Handbook No. 237 (Washington, 1962).

A possible method of studying farmers' response to flood damages and subsequent protection is the use of game theoretic models. Probabilities could be attached to various states of nature in accordance with past records of flooding events. Payoffs for alternative actions could be determined by budgeting various farm organizations under different degrees of flooding. With repeated application of the model it is possible that a pessimism-optimisim index for farm operators with respect to flood damages could be established.[3] Once an index number was found that was appropriate for the average of the farmers in the area, predictions about the effects of flood protection on land use might be made.

The Problem of Dynamics

Estimating land use and damage reduction for fifty years or more into the future is difficult because of the rapidly changing structure of the agricultural industry as well as our entire economic structure. Extrapolation from static mathematical models as used and discussed here is a crude approximation. Over a fifty-year period, demand shifters such as changes in population, tastes and preferences, and international trade agreements may explain more changes in land use in a particular watershed than price and technological relationships appropriate for a single time period. Methods of projecting prices, which are the manifestation of the demand shifters, and of incorporating them into production models also require further investigation. However, the

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[3]This index is conceived to be of the type proposed by Leonid Hurwicz. The player is trying to maximize $\alpha a + (1-\alpha)A$, where α measures the players' optimism, a denotes the smallest payoff of any state of nature for a given action, $1-\alpha$ measures the players' pessimism, and A denotes the largest payoff of any state of nature for the same given action.

development of truly dynamic models, for the purpose of predicting land use, awaits the estimation of more accurate technical coefficients on flood plain land, including the physical damage factors, and more knowledge about farmers' response to flood damages and flood protection.

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APPENDIXES

APPENDIX A

LAND CLASSIFICATION AND THE ASSUMED YIELDS

The acres of bottomland and upland for each farm were obtained in the farm survey. Legal descriptions of all the sample farms were obtained from the records of the County Agricultural Stabilization and Conservation offices. The acres of each soil type mapped were obtained for 82 of the 164 farms in the survey.

Bottomland soils were divided on the basis of their suitability for cultivation. Those suitable for cultivation were further divided into those frequently flooded and those infrequently flooded. Ther percentages of these three types of soils were applied to the survey reported bottomland acreage to obtain the acres of each of the three kinds of soil on the typical farms.

Upland soils were divided into those suitable for cultivation and those not suitable for cultivation. The soils suitable for cultivation were then divided into good and poor cropland soils on the basis of the yields for each soil type. Yields were those estimated by soil scientists and other agricultural workers in the area. Soils not suitable for cultivation were divided into good and rough, broken range. The percentage of all the upland soils falling in each of these four categories were then applied to the survey reported upland to obtain the acres of the four kinds of soil on the typical farms. The distribution of the soils for each of the watershed groups is shown in Table I of this Appendix.

Yields for each soil type were assumed to be those yields midway between yields expected under customary and improved management as determined by agricultural workers in the area. This level of yields appeared to be most consistent with those reported in the farm survey. Yields for each of the four classes of soils suitable for cultivation were basically the quantity weighted average of the yields of each soil type included in the class. Minor modifications of the yields were made after discussions with county agricultural workers. The assumed yield levels are presented in Tables II, III, IV, and V of this Appendix.

APPENDIX A, TABLE I

DISTRIBUTION OF LAND BY PRODUCTIVITY CLASSES AND BY WATERSHED GROUPS

Productivity Class	Group I				Group II					
	Barnitz		Beaver		Cavalry			Boggy		
					<300			<300		
	<200	>200	<200	>200	<1:2	>1:2	>300	<1:2	>1:2	>300
					- acres -					
Cultivatable Land	142	526	140	375	187	191	576	181	138	495
Bottomland (frequently flooded)	29	77	19	55	9	34	46	14	29	48
Bottomland (infrequently flooded)	48	126	31	89	21	78	107	34	68	111
Upland (good)	29	146	41	104	63	32	169	53	16	134
Upland (fair)	36	177	49	127	94	47	254	80	25	202
Range	179	632	215	172	70	63	103	117	135	239
Bottomland	2	20	14	5	5	25	11	16	7	46
Upland (good)	177	612	201	167	58	34	81	90	114	172
Upland (rough & broken)	0	0	0	0	7	4	10	11	14	21
Total Bottomland	79	223	64	149	35	137	164	64	104	205
Cultivatable	77	203	50	144	30	112	153	48	97	159
Range	2	20	14	5	5	25	11	16	7	46
Total Upland	242	935	291	398	222	117	515	234	169	529
Cultivatable	65	323	90	231	157	79	423	133	41	336
Range	177	612	201	167	65	38	92	101	128	193
Total Acres	321	1,158	355	547	257	254	679	298	273	734

APPENDIX A, TABLE I - CONTINUED

Productivity Class	Group III				Group IV		
	Saddle Mtn.		Rainy Mtn.		Big Kiowa	Panther	Whiteshield
	<300	>300	<300	>300			
	- acres -						
Cultivatable Land	204	672	156	572	222	237	174
Bottomland (frequently flooded)	34	86	28	101	58	61	55
Bottomland (infrequently flooded)	52	134	43	158	21	21	19
Upland (good)	18	68	13	47	39	42	27
Upland (fair)	100	384	72	266	104	113	73
Range	221	537	213	716	731	526	209
Bottomland	17	69	27	29	51	26	3
Upland (good)	112	257	102	378	571	420	173
Upland (rough & broken)	92	211	84	309	109	80	33
Total Bottomland	103	289	98	288	130	108	77
Cultivatable	86	220	71	259	79	82	74
Range	17	69	27	29	51	26	3
Total Upland	322	920	271	1,000	823	655	306
Cultivatable	118	452	85	313	143	155	100
Range	204	468	186	687	680	500	206
Total Acres	425	1,209	369	1,288	953	763	383

APPENDIX A, TABLE II

ASSUMED YIELDS UNDER PROTECTED CONDITIONS FOR GROUP I FARMS BY LAND PRODUCTIVITY CLASSES[a]

		Land Productivity Class						
Crop	Unit	1	2	3	4	5	6	7
Wheat								
Grain	bu.	27.50	22.50	18.00	12.00	-	-	-
Pasture	AUM	.50	.40	.30	.20	-	-	-
Cotton	cwt.	3.40	2.80	2.20	1.80	-	-	-
Grain Sorghum	cwt.	23.52	19.04	15.12	11.20	-	-	-
Barley	bu.	32.00	26.00	21.00	14.00	-	-	-
Oats	bu.	40.00	17.50	12.50	7.50	-	-	-
Alfalfa	ton	3.25	2.75	-	-	-	-	-
Forage Sorghum	ton	4.00	3.20	2.40	1.60	-	-	-
Small Grain Pasture	AUM	3.75	3.25	3.00	2.00	-	-	-
Sudan	AUM	3.20	2.80	2.20	1.60	-	-	-
Johnson Grass	AUM	3.20	2.80	2.00	.80	-	-	-
Cultivatable Past.	AUM	1.00	1.00	.80	.80	-	-	-
Native Range	AUM	-	-	-	-	1.00	.80	-

[a]Land productivity classes:
1. Cultivatable bottomland frequently flooded
2. " " infrequently flooded
3. " upland, good
4. " " , fair
5. Bottomland range
6. Upland range, good
7. Upland range, rough and broken.

APPENDIX A, TABLE III

ASSUMED YIELDS UNDER PROTECTED CONDITIONS FOR GROUP II FARMS BY LAND PRODUCTIVITY CLASSES[a]

Crop	Unit	Land Productivity Class						
		1	2	3	4	5	6	7
Wheat								
Grain	bu.	28.50	22.80	20.00	16.00	-	-	-
Pasture	AUM	.50	.40	.30	.20	-	-	-
Cotton	cwt.	3.50	3.00	2.40	2.00	-	-	-
Grain Sorghum	cwt.	26.60	20.44	16.24	12.32	-	-	-
Barley	bu.	33.00	26.00	23.00	18.00	-	-	-
Oats	bu.	40.00	35.00	25.00	15.00	-	-	-
Alfalfa	ton	3.25	2.75	-	-	-	-	-
Forage Sorghum	ton	4.00	3.20	2.00	1.20	-	-	-
Small Grain Pasture	AUM	3.75	3.25	3.00	2.00	-	-	-
Sudan	AUM	3.20	2.80	2.20	1.60	-	-	-
Johnson Grass	AUM	3.20	2.80	2.00	.80	-	-	-
Native Range	AUM	-	-	-	-	1.25	.80	.43

[a]Land productivity classes:

1. Cultivatable bottomland frequently flooded
2. " " infrequently flooded
3. " upland, good
4. " " , fair
5. Bottomland range
6. Upland range, good
7. Upland range, rough and broken.

APPENDIX A, TABLE IV

ASSUMED YIELDS UNDER PROTECTED CONDITIONS FOR GROUP III FARMS BY LAND PRODUCTIVITY CLASSES[a]

Crop	Unit	Land Productivity Class 1	2	3	4	5	6	7
Wheat								
Grain	bu.	25.00	21.50	18.00	14.00	-	-	-
Pasture	AUM	.50	.40	.30	.20	-	-	-
Cotton	cwt.	3.00	2.50	1.75	1.35	-	-	-
Grain Sorghum	cwt.	16.80	15.68	12.32	10.08	-	-	-
Barley	bu.	29.00	25.00	21.00	16.00	-	-	-
Oats	bu.	35.00	28.00	20.00	7.50	-	-	-
Alfalfa	ton	2.75	2.25	-	-	-	-	-
Sudan	AUM	2.80	2.20	1.60	1.00	-	-	-
Bermuda	AUM	4.00	3.50	-	-	-	-	-
Small Grain Pasture	AUM	3.50	3.00	2.50	1.80	-	-	-
Cultivatable Past.	AUM	1.25	1.25	.80	.80	-	-	-
Native Range	AUM	-	-	-	-	1.25	.80	.34

[a]Land productivity classes:
1. Cultivatable bottomland frequently flooded
2. " " infrequently flooded
3. " upland, good
4. " " , fair
5. Bottomland range
6. Upland range, good
7. Upland range, rough and broken.

APPENDIX A, TABLE V

ASSUMED YIELDS UNDER PROTECTED CONDITIONS FOR GROUP IV FARMS BY LAND PRODUCTIVITY CLASSES[a]

Crop	Unit	Land Productivity Class 1	2	3	4	5	6	7
Wheat								
Grain	bu.	22.00	17.00	16.00	9.00	-	-	-
Pasture	AUM	.50	.40	.30	.20	-	-	-
Cotton	cwt.	2.86	2.43	2.14	1.48	-	-	-
Grain Sorghum	cwt.	17.36	12.88	12.32	7.28	-	-	-
Barley	bu.	25.00	19.00	18.00	10.00	-	-	-
Oats	bu.	30.00	25.00	20.00	15.00	-	-	-
Alfalfa	ton	2.60	1.70	-	-	-	-	-
Forage Sorghum	ton	2.80	2.20	1.80	1.10	-	-	-
Small Grain Pasture	AUM	3.30	2.70	1.70	1.20	-	-	-
Sudan	AUM	2.50	1.90	1.00	.60	-	-	-
Cultivatable Past.	AUM	1.00	1.00	.80	.80	-	-	-
Native Range	AUM	-	-	-	-	1.00	.80	.34

[a]Land productivity classes:
1. Cultivatable bottomland frequently flooded
2. " " infrequently flooded
3. " upland, good
4. " " , fair
5. Bottomland range
6. Upland range, good
7. Upland range, rough and broken.

APPENDIX B, TABLE I

ASSUMED PRODUCT PRICES FOR PROGRAMMING ANALYSIS

Item	Unit	Dollars
Crops		
Cotton		
Lint	cwt.	30.00
Seed	cwt.	2.50
Wheat	bu.	1.80
Grain Sorghum	cwt.	1.75
Barley	bu.	.83
Oats	bu.	.64
Alfalfa Hay	ton	20.00
Cattle		
Good Feeders (Oct.)	cwt.	20.23
Good Feeders (May)	cwt.	22.29
Good Feeders (March)	cwt.	22.12
Calves		
Steers (Oct.)	cwt.	23.42
Steers (July)	cwt.	24.20
Heifers (Oct.)	cwt.	21.42
Heifers (July)	cwt.	22.20
Cull Cows (Oct.)	cwt.	13.13
Cull Cows (July)	cwt.	13.95

APPENDIX C, TABLE I

ESTIMATED LAND USE INTENSITIES FOR SPECIFIED CROPS ON BOTTOMLAND AND UPLAND BY WATERSHED GROUPS

	Group I		Group II		Group III		Group IV	
Crop	Bot.	Up.	Bot.	Up.	Bot.	Up.	Bot.	Up.
				-dollars-				
Cotton	66.71	37.50	70.11	42.52	57.43	21.37	58.91	28.53
Wheat	34.18	17.19	33.48	20.93	31.02	16.34	26.89	9.92
Alfalfa	32.39	0.00	31.85	0.00	25.19	0.00	24.07	0.00
Barley	15.09	6.63	14.96	8.80	13.79	6.33	11.41	2.85
Grain Sorghum	27.39	14.79	29.90	16.61	19.90	10.66	20.47	7.52
Oats & Other	13.34	4.66	14.66	4.68	12.90	4.80	13.60	3.84
Small Grain Past.	10.36	6.06	16.53	10.32	-	-	16.82	4.52
Sudan	9.53	4.70	16.57	9.09	4.51	.01	17.01	2.60
Forage Sorghum	26.45	12.48	25.87	9.06	-	-	18.69	5.31
Bermuda	-	-	-	-	16.20	-	-	-

APPENDIX D

PROCEDURE USED TO MODIFY SOIL CONSERVATION SERVICE DAMAGE FACTORS

The following steps were taken in order to modify the Soil Conservation Service damage factors such that they could be employed in the linear programming analysis:

1. The basic physical damage factors for each crop by depth increment and by the season of the year are given in the substantiating data for the individual watershed work plans.
2. The total acres inundated before and after the planned level of protection by depth increment and by the season of the year are given in the hydrologist's report and are included in the substantiating data for the individual watershed work plans. These figures are a manifestation of the frequency and intensity of flooding during the study period (usually 20 years) for the specific watershed.
3. The sum of the products of the acres inundated before protection and the percent damage factors for each crop, both of which are classified by depth increment and season of the year, yields the acre-equivalents damaged completely before protection.
4. The sum of the products of the acres inundated after protection and the percent damage factors for each crop, both of which are classified by depth increment and season of

the year, give the acre-equivalents damaged completely after protection.

5. The difference between the figures derived in step 4 and step 5 gives the reduction in acre-equivalents completely damaged as a result of flood protection.

6. Dividing the figure obtained in 5 by the product of the total flood plain acres and the years in the study period gives the uncorrected percentage reduction in damage to an acre of a particular crop.

7. Multiplying the factors which express uncorrected percentage reduction in damage to crops by the Soil Conservation Service recurrence factor gives the corrected percentage damage reduction to an acre of a particular crop. The recurrence factor corrects the damage factor for double-counting of damage that arises from floods that occur within very short time periods.

The modified damage factor is a net damage factor because the original Soil Conservation Service damage factors are net. This means that the physical damage factor takes into consideration the differences in harvesting costs due to decreased yields. The modified percentage factor can be and was applied directly to the yields assumed under protected conditions.

In some watersheds the Soil Conservation Service did not estimate damages to some of the minor crops. In these cases the damage factors employed in the programming analysis were estimated from the known damage factor information of the watershed group.

APPENDIX D, TABLE I

DAMAGE FACTORS USED IN THE PROGRAMMING ANALYSIS

Crop	Barnitz	Beaver	Cavalry	Boggy	Saddle Mtn.	Rainy Mtn.	Big Kiowa	Panther	Whiteshield
Wheat	.3218	.3029	.1592	.2176	.0782	.2718	.0753	.2030	.1014
Alfalfa	.2133	.1618	.1061	.1153	.0725	.1750	.0736	.1241	.0575
Cotton	.4154	.2422	.1379	.1386	.0437	.3210	.0445	.2487	.1306
Oats	.3231	.3493	.1899	.2413	.0725	.2718	.0828	.2230	.1235
Barley	.3231	.3493	.1899	.2413	.0725	.2718	.0828	.2230	.1235
Meadow	-	-	.0961	.0984	.0539	.2071	-	-	-
Pasture	.1297	.0978	.0567	.0755	.0315	.1199	.0303	.0885	.0209
Grain Sorghum	.3130	.2487	.1232	.1227	.0661	.2690	.0857	.1126	.0857
Small Grain Pasture	.2264	.2235	.1233	.1584	.0520	.1959	.0722	.1558	.0722
Sudan	.1662	.1438	.0765	.1019	.0661	.1260	.0483	.1085	.0483
Forage Sorghum	-	-	.1230	.1226	.0661	-	.1126	.1126	.1126
Johnson Grass	.2113	.1520	.0881	.1173	-	-	-	-	-
Corn	.4277	.2260	-	-	-	-	-	-	-
Rye	-	.3029	-	-	-	-	-	-	-

APPENDIX E, TABLE I

PROGRAMMED AND ACTUAL ORGANIZATION ON THE CAVALRY CREEK FARM WITH LESS THAN 300 ACRES CULTIVATABLE LAND AND A BOTTOM-UPLAND RATIO LESS THAN 1:2 BY SELECTED RATES OF INTEREST ON CAPITAL

		.06		.09		.12		.15		.18		.21		.24		Actual	
Item	Unit	Bot.	Up.	Bot.	Up.	Bot.	Up.	Bot.	Up.	Bot.	Up.	Bot.	Up.	Bot.	Up.	Bot.	Up.
Crop																	
Cotton	acre	8	13	8	13	8	13	8	13	8	13	8	13	8	13	12	9
Wheat	acre	0	0	5	0	20	15	20	15	20	23	19	24	7	36	3	40
Alfalfa	acre	0	0	0	0	0	0	0	0	0	0	1	0	13	0	9	1
Barley	acre	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Grain Sorghum	acre	0	0	0	0	0	0	0	0	0	0	0	7	0	7	3	4
Temp. Pasture	acre	20	98	15	98	0	83	0	83	0	75	0	67	0	54	0	41
Forage Sorghum	acre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Other	acre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	14
Cattle																	
Cows	hd.	99		93		65		64		58		52		33		n.a.	
Feeders	hd.	11		11		11		11		11		0		0		n.a.	
Capital Use	dol.	25,166.79		23,821.89		17,507.00		17,415.96		16,149.21		13,417.68		9,754.72		n.a.	
Labor Use																	
Family	hrs.	1,846		1,835		1,579		1,575		1,480		1,279		1,074		n.a.	
Hired	hrs.	273		189		3		0		0		0		0		n.a.	
Gross Income	dol.	13,157.80		12,817.82		11,312.99		11,290.15		10,960.14		8,805.58		7,696.39		n.a.	
Net Returns	dol.	5,969.67		5,241.96		4,585.20		4,062.57		3,563.84		3,105.96		2,746.74		n.a.	
Land Use Intensity																	
Bottomland	dol.	31.86		34.89		43.94		43.94		43.94		43.89		43.19		47.08	
Upland	dol.	13.79		11.20		15.08		15.08		15.89		16.43		17.68		14.20	
Cropland	dol.	17.43		15.97		22.82		22.82		21.54		21.96		22.82		20.81	

APPENDIX E, TABLE II

PROGRAMMED AND ACTUAL LAND USE OF THE TYPICAL RAINY MOUNTAIN FARM WITH LESS THAN 300 ACRES OF CULTIVATABLE LAND AT FOUR SELECTED LEVELS OF THE DAMAGE FACTORS

Crop	Actual		Unprotected		2/3 Damages		1/3 Damages		Protected	
	Bot.	Up.	Bot.	Up.	Bot.	Up.	Bot.	Up.	Bot.	Up.
Cotton	17	14	28	3	31	0	31	0	31	0
Wheat	24	27	0	51	0	51	27	24	37	14
Alfalfa	1	3	34	0	31	0	3	0	3	0
Barley	3	4	0	7	0	7	0	7	0	7
Grain Sorghum	2	0	0	2	0	2	0	2	0	2
Temporary Pasture	17	7	0	0	0	0	0	0	0	33
Bermuda	0	0	9	0	9	0	10	0	0	0
Cultivatable Pasture	6	7	0	0	0	3	0	30	0	7
Other	1	1	0	0	0	0	0	0	0	0
Total	71	63	71	63	71	63	71	63	71	63
Net Returns[a]	n.a.		$2,251.36		$2,662.75		$3,102.62		$3,564.03	
Capital Use	n.a.		$6,525.62		$6,443.72		$5,608.42		$5,469.39	

[a]Returns to land, family labor, and management (with nonland capital paid its reservation price).

APPENDIX F, TABLE I

A TYPICAL TABLEAU USED IN PROGRAMMING WATERSHED SITUATIONS (THE BARNITZ CREEK FARM WITH GREATER THAN 200 ACRES CULTIVATABLE LAND)

Item	Unit	Row	P_0	Wheat				Cotton			
				P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8
	dol.	C_j		-10.85	-10.50	-10.18	-9.76	-39.10	-35.32	-31.54	-29.02
Land Resources											
Bottomland 1	acre	101	74	1				1			
Bottomland 2	acre	102	120		1				1		
Upland 1	acre	103	121			1				1	
Upland 2	acre	104	148				1				1
Wheat Allotment	acre	105	198	1	1	1	1				
Cotton Allotment	acre	106	54					1	1	1	1
Grain Sorghum Allotment	acre	107	16								
Barley Allotment	acre	108	20								
Range	AUM	109	504								
Temporary Grazing											
Nov.-Feb.	AUM	110	0	-.5	-.4	-.3	-.2				
Mar.-June	AUM	111	0								
July-Oct.	AUM	112	0								
Labor											
Dec.-April.	hrs.	113	724					2.45	1.94	1.80	1.63
May-June	hrs.	114	447	.88	.88	.88	.88	.91	.91	.91	.91
July-Aug.	hrs.	115	489	.55	.55	.55	.55	3.14	3.14	3.14	3.14
Sept.-Nov.	hrs.	116	578	.46	.46	.46	.46	9.84	8.51	7.23	6.05
Total Capital	dol.	117	0	16.36	16.36	16.36	16.36	31.38	31.38	31.38	31.38
Annual Capital	dol.	118	0	15.04	15.04	15.04	15.04	25.63	25.63	25.63	25.63
Wheat Sell	bu.	119	0	-27.50	-22.50	-18.00	-12.00				
Cotton Sell	cwt.	120	0					-3.40	-2.80	-2.20	-1.80
Grain Sorghum Sell	cwt.	121	0								
Barley Sell	bu.	122	0								
Oats Sell	bu.	123	0								
Alfalfa	ton	124	0								
Forage Sorghum	ton	125	0								

APPENDIX F, TABLE I (Continued)

Row	Grain Sorghum				Barley				Oats & Other				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}
	-9.26	-8.69	-8.18	-7.67	-8.64	-8.22	-7.87	-7.38	-6.76	-6.59	-6.24	-5.89	-26.99	-24.04
101	1				1				1				1	
102		1				1				1				1
103			1				1				1			
104				1				1				1		
105														
106														
107	1	1	1	1										
108					1	1	1	1						
109														
110									-.9375	-.8125	-.7500	-.7500		
111									-.9375	-.8125	-.7500	-.7500		
112														
113	.46	.46	.46	.46									.04	.04
114	.51	.51	.51	.51	.88	.88	.88	.88	.66	.66	.66	.66	5.35	5.35
115	.36	.36	.36	.36	.55	.55	.55	.55	.55	.55	.55	.55	4.80	4.80
116	.65	.65	.65	.65	.46	.46	.46	.46	.46	.46	.46	.46	.19	.19
117	11.70	11.70	11.70	11.70	14.02	14.02	14.02	14.02	12.76	12.76	12.76	12.76	46.75	46.75
118	11.51	11.51	11.51	11.51	13.29	13.29	13.29	13.29	11.84	11.84	11.84	11.84	31.31	31.31
119														
120														
121	-23.52	-19.04	-15.12	-11.20										
122					-32.00	-26.00	-21.00	-14.00						
123									-20.00	-17.50	-12.50	-7.50		
124													-3.25	-2.75
125														

APPENDIX F, TABLE I (Continued)

Row	Johnson Grass P_{35}	P_{36}	P_{37}	P_{38}	Cultivatable Pasture P_{39}	P_{40}	P_{41}	P_{42}	Feeders P_{43}	P_{44}	P_{45}	P_{46}	P_{47}	P_{48}
	-.96	-.96	-.96	-.96					32.05	41.69	16.08	23.13	38.20	32.27
101	1				1									
102		1				1								
103			1				1							
104				1				1						
105														
106														
107														
108														
109					-1.00	-1.00	-.80	-.80	6.70	.50		3.30	.83	4.90
110										1.40	2.70		1.40	
111	-1.60	-1.40	-1.00	-.40						1.40		.60	2.00	
112	-1.60	-1.40	-1.00	-.40								.60	2.50	
113	.51	.51	.51	.51					3.50	1.80	1.92	.55	4.40	4.40
114	.56	.56	.56	.56					1.00	1.02		1.00	1.00	1.00
115									1.00			1.00	1.00	1.00
116									2.10	.84	.84	1.05	2.10	2.10
117	3.06	3.06	3.06	3.06					118.10	111.42	111.13	129.18	113.91	118.10
118	3.06	3.06	3.06	3.06					114.78	65.89	43.62	64.37	110.49	114.78
119														
120														
121														
122														
123														
124														
125										.45	.40			.375

APPENDIX F, TABLE I (Continued)

Row	Forage Sorghum				Small Grain Pasture				Sudan			
	P_{23}	P_{24}	P_{25}	P_{26}	P_{27}	P_{28}	P_{29}	P_{30}	P_{31}	P_{32}	P_{33}	P_{34}
	-28.86	-24.14	-19.42	-14.70	-4.57	-4.57	-4.57	-4.57	-3.64	-3.64	-3.64	-3.64
101	1				1				1			
102		1				1				1		
103			1				1				1	
104				1				1				1
105												
106												
107												
108												
109												
110					-1.875	-1.625	-1.500	-1.000				
111					-1.875	-1.625	-1.500	-1.000				
112									-3.20	-2.80	-2.20	-1.60
113	1.02	1.02	1.02	1.02					1.02	1.02	1.02	1.02
114	.82	.82	.82	.82	.44	.44	.44	.44	.59	.59	.59	.59
115	.60	.60	.60	.60	.55	.55	.55	.55	.13	.13	.13	.13
116	6.40	5.28	4.16	3.04	.46	.46	.46	.46				
117	45.34	40.62	35.90	31.18	11.25	11.25	11.25	11.25	8.65	8.65	8.65	8.65
118	45.34	40.62	35.90	31.18	10.11	10.11	10.11	10.11	8.33	8.33	8.33	8.33
119												
120												
121												
122												
123												
124												
125	-4.00	-3.20	-2.40	-1.60								

APPENDIX F, TABLE I (Continued)

	Cow - Calf			Selling Activities					
				Wheat	Cotton	Grain Sorghum	Barley	Oats	Alfalfa
Row	P_{49}	P_{50}	P_{51}	P_{52}	P_{53}	P_{54}	P_{55}	P_{56}	P_{57}
	83.42	79.31	68.07	1.80	34.17	1.75	.83	.64	20.00
101									
102									
103									
104									
105									
106									
107									
108									
109	9.50	9.80	9.40						
110		2.50							
111	1.00		1.00						
112	1.00		1.00						
113	10.13	10.13	7.44						
114	.92	.92	.54						
115	.36	.36	1.26						
116	1.18	1.18	7.11						
117	200.80	204.90	218.77						
118	198.61	201.86	212.26						
119				1					
120					1				
121						1			
122							1		
123								1	
124									1
125									

APPENDIX F, TABLE I (Continued)

Row	Capital Borrow	Labor Hire Dec.-Apr.	May-June	July-Aug.	Sept.-Nov.
	P_{59}	P_{60}	P_{61}	P_{62}	P_{63}
	-.06	-1.00	-1.00	-1.00	-1.00
101					
102					
103					
104					
105					
106					
107					
108					
109					
110					
112					
113		-1			
114			-1		
115				-1	
116					-1
117	-1	1.00	1.00	1.00	1.00
118	-1	.42	.17	.17	.24
119					
120					
121					
122					
123					
124					
125					

VITA

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Doctor of Philosophy

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