EFFECTS OF UPSTREAM WATERSHED DEVELOPMENT UPON PRICES AND VALUES OF AFFECTED FARMLAND IN SELECTED AREAS OF OKLAHOMA

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in partial fulfillment of the requirements
for the degree of
DOCTOR OF PHILOSOPHY
May 23, 1965

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ACKNOWLEDGMENTS

Sincere appreciation is extended to Dr. E. J. R. Booth, Graduate Committee Chairman, for his counsel, encouragement, and donation of time and effort during the latter portion of this research. Thanks are due Dr. W. B. Back for his guidance in the earlier phase of the study.

Appreciation is extended to Drs. J. S. Plaxico, John Franzmann, Rudolph W. Trenton, and Robert A. Hultquist, members of my graduate committee, for their comments during the preparation of this thesis. Thanks are also due Dr. Dan Badger and Dr. Leo V. Blakley for their helpful comments.

I am indebted to the Agricultural Economics Department for providing me the opportunity to continue graduate work and for making this study possible.

Many thanks are due Miss Pat Cundiff and other members of the statistical section for their help with the many computations.

Thanks are extended to Mrs. Juanita Marshall for typing the final draft, and to Mrs. Karen Konstas who typed the earlier drafts.

I am also indebted to Dr. Neil R. Cook, Economic Research Service, U. S. Department of Agriculture, for his assistance in several phases of this study.

Finally, special gratitude is due my wife, Margie, for her encouragement and patience throughout my graduate program.

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CHAPTER I

PROBLEM AND OBJECTIVES

Introduction

Federal expenditures for conservation and development of land and water resources, both agricultural and nonagricultural, have continued to grow in recent years. Total expenditures grew from about $1.2 billion in 1955 to about $2 billion in 1962, and averaged $1.5 billion annually. Federal expenditures on agricultural land and water resources averaged roughly $356 million, or 24 percent of the total, over the eight year period. During the same period (1955-1962), federal expenditures for "research and other agricultural services" averaged $267 million annually.[1] In short, investment of public funds in agricultural land and water development is substantial, both in absolute level and relative to other expenditures.

Investment in land and water resources in Oklahoma has been large. As of July, 1963, about $34 million of federal funds has been invested in upstream watershed development in the Washita River Basin in Southwestern

[1]U. S. Department of Commerce, Bureau of the Census, Statistical Abstract of the United States, 1962 edition, p. 369.

Oklahoma, the area selected for study. Expenditures in the Washita Basin are continuing at the rate of about $5 million per year.[2]

Federal expenditures for watershed development are justified on the basis of "benefit-cost analysis." The benefit-cost ratio is a ratio of average annual benefits to average annual equivalent costs. A ratio of benefits to cost greater than unity is usually regarded as an indication that the proposed work should be undertaken.[3] Benefits and costs of upstream watershed flood control projects are estimated by methods set forth in the Economics Guide.[4] In general, benefits and costs are estimated for the life of the project or 50 years, whichever is less. Both benefits and costs are computed as an annual average for the period. Benefits are discounted for any lag in occurrence and costs are amortized over the life of the project.

Table I gives the annual on-site agricultural benefits estimated by the Soil Conservation Service as reported in work plans for six upstream watersheds in Southwestern Oklahoma. These benefits result from reduction in crop and pasture damage, reduction in other agricultural damage, reduction in flood plain scour, restoration of former productivity, and more intensive land use. Direct agricultural benefits make up a large proportion of total direct benefits, accounting for 74 percent of such benefits in the six watersheds included in Table I.

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[2] U. S. Department of Agriculture, Soil Conservation Service, Annual Report on Washita River Watershed (Mimeograph, 1963), p. 2.

[3] U. S. Department of Agriculture, Soil Conservation Service, Economics Guide for Watershed Protection and Flood Prevention (Washington, 1958), Chapter 1, p. 2.

[4] Ibid., Chapters 2-6.

TABLE I

ANNUAL BENEFITS FROM WATERFLOW RETARDATION IN SIX WATERSHEDS, SOUTHWESTERN OKLAHOMA

Watershed	Direct Benefits			
	Total	Nonagri-cultural	Agricul-tural	Agricultural as a Percent of Total
		- Dollars -		(Percent)
Barnitz	212,504	35,671	176,833	83
Beaver	58,970	23,271	35,699	61
Cavalry	83,181	19,231	63,950	77
Boggy	75,656	23,641	52,015	69
Saddle	29,236	5,788	23,448	80
Rainy	256,342	75,872	180,470	70
Six Water-sheds	715,889	183,474	532,415	74

Source: Soil Conservation Service work plans for the respective watersheds.

Direct agricultural benefits arise as a result of increased productivity of flood plain land, or of nonland factors used in conjunction with flood plain land, or an increase in the productivity of both. This study attempts to determine the effects of watershed development for flood protection upon the productivity of and the returns to land and specified nonland resources in selected watersheds in Southwestern Oklahoma.

General Problem

Whether estimated benefits closely approximate actual benefits is a question about which there has been much speculation.[5] However, there is little published research on actual benefits from watershed development in an ex post sense. A procedure for estimating benefits, using actual and expected increases in land value, has been suggested by Renshaw.[6] Concerning the advantages of such a procedure, Renshaw has stated:

> A benefit estimation procedure based upon actual and expected increases in land values has three important advantages over other procedures for estimating watershed protection benefits. The first advantage is realism. The public has the advantage of knowing ex ante whether their monies can reasonably be expected to generate a return comparable to the return obtainable on the same funds invested elsewhere in the economy and ex post whether in fact expectations were realized. A second advantage of the land value approach is that most beneficiaries are clearly identified in terms of property ownership. Local assessment for watershed protection costs incurred can be made a direct function of benefits received...A third advantage of the land value approach is efficiency and the possibility for independent appraisals.[7]

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[5]For example, see Edward F. Renshaw, Toward Responsible Government: An Economic Appraisal of Federal Investment in Water Resource Programs (Chicago, 1957), Chapter VI; and Harry A. Steele, "Economics of Small Watershed Development," Agricultural Economics Research (January, 1956), pp. 17-23.

[6]Ibid., p. 78.

[7]Ibid., pp. 78-79.

Renshaw's suggested approach apparently assumes that all benefits are capitalized into the value of affected land. Studies have been made on the effects of other exogenous changes such as tobacco and peanut allotments on the value of land but none have yet treated individual upstream watersheds.[8] Geographical impacts of watershed development have been investigated especially with respect to land use.[9] A companion study on land use in the same watersheds included in this study is presently in process.[10]

The effects of watershed development upon land values and the values of other resources is central to any benefit estimation procedure. Lack

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[8]Frank H. Maier, James L. Hedrick, and W. L. Gibson, Jr., The Sale Value of Flue-Cured Tobacco Allotments, Agricultural Experiment Station, Virginia Polytechnic Institute in cooperation with Agricultural Experiment Station, North Carolina State College, Raleigh, North Carolina, and Farm Economics Research Division, Agricultural Research Service, U. S. Department of Agriculture (Blacksburg, 1960) Technical Bulletin No. 148; and Robert F. Boxley, Jr., and W. L. Gibson, Jr., Peanut Acreage Allotments and Farm Land Values, Agricultural Experiment Station, Virginia Polytechnic Institute, in cooperation with Resource Development Economics Division, Economic Research Service, U. S. Department of Agriculture (bulletin in process of being published). For effects of irrigation water on land values, see L. M. Hartman and R. L. Anderson, Estimating Irrigation Water Values: A Regression Analysis of Farm Sales Data from Northeastern Colorado, Agricultural Experiment Station, Colorado State University in cooperation with the Resource Development Economics Division, Economic Research Service, U. S. Department of Agriculture (Fort Collins, 1963) Technical Bulletin No. 81.

[9]See George S. Tolley, "Impacts of Public Resource Development Projects Upon Agricultural Production and Income," Proceedings: Agricultural Economics and Rural Sociology Section, Annual Convention (Memphis, 1959); and 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.

[10]Neil R. Cook, "Effects of Upstream Flood Protection on Land Use in the Upper Washita River Basin of Oklahoma" (unpub. Ph.D. thesis, Oklahoma State University, 1964).

of knowledge at the national level concerning such effects is apparent upon examination of records of hearings before the House Committee on Agriculture.[11] The following statements by the Honorable W. R. Poage, Vice Chairman of the Committee on Agriculture and others attending the hearings, point up the uncertainty as well as the interest in this problem.

> Mr. Poage: Well, as I see it, the problem here is about that cost per acre at $153, seems to me we would notice some other benefit there to justify it, what would that land be worth?
>
> Mr. Stubblefield: It is right valuable land down in the bottom down there--$250 or $300.
>
> Mr. Poage: What is it worth now?
>
> Mr. Stubblefield: $250 or $300.
>
> Mr. Poage: Without flood control?
>
> Mr. Stubblefield: I would say somewhere between $100 and $200. But it is very fine land down there without the flood control menace.
>
> Mr. Poage: I know, but if the land increases in value $150 as a result of this activity, the Federal Government pays $150, is there any justification for the Federal Government going in and spending $150 per acre simply to increase the land value of the present owners by $150?
>
> In other words, if all we do is for the Federal Government to go in there and add $150 to the value of the land, and I don't question but what it will add to it, is it a sound investment from the Government's standpoint simply to raise the value of my land or your land by $150 unless we are going to do something else? If we could spend $150 doing it, should we spend $150 of the taxpayers' money to raise the value of my land $150?[12]

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[11] House of Representatives, Subcommittee on Conservation and Credit of the Committee on Agriculture, "Watershed Projects," Hearings Before the Committee on Agriculture House of Representatives (Eighty-sixth Congress, Second Session, Washington, 1960).

[12] Ibid., p. 187.

The land value question also came up in hearings on other projects. For example, the following is an excerpt from records of the committee hearings concerning the Caney Creek Watershed located in Kentucky.

> Mr. Carl Brown: Mr. Chairman, I point out again that we do not consider that the benefit to land is related to the present market price of the land. If you take the increased net income over a 50-year period, with appropriate discounting to a present worth, the future increased net income will always exceed by a very substantial margin the market place value of the land today.
>
> Now, this is standard practice in the evaluation of benefits from projects and that is to capitalize the increased net return that will accrue from land, the difference between what you would get after the project is installed and what it is now, and...
>
> Mr. Poage: I recognize that that is one of the factors you take into consideration. I am just trying to take into consideration to try to apply to the Government's business the same formula that I would apply to my own and if I were buying the land and had a proposition put up to me to spend $600 an acre on some land that was worth $100 an acre, I would not go very far toward considering making the investment. If it were my own land, the cost per acre and the value per acre are certainly some of the factors I would take into consideration.
>
> Of course, I would agree that was not the only factor to take into consideration but I certainly would want to know something about it...
>
> ...Now, I just want to see where the Government goes on these things, and will say if we are going to spend $600 an acre on 3,000 acres there, what is the land going to be worth when we get the project finished seems to me to be quite important.[13]

It seems that the Committee on Agriculture required that land values be expected to increase by more than the federal investment per acre for a project to be approved. No evaluation of the relevance of the investment figures or of the expected increases in land values which were brought

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[13] Ibid., p. 180.

out in the hearings will be made here. What is important is that decisions to allocate or not allocate federal expenditures to watershed development projects are perhaps being made on the basis of expected increases in land values when the actual effect of watershed development on the values of the affected land is not known, or at least has had little empirical investigation.

Direct agricultural benefits per acre of flood plain estimated by the Soil Conservation Service are shown in Table II. These estimated benefits are net of costs other than project cost and, therefore, represent a substantial increase in annual returns to resources in the respective watersheds. If these benefits actually occur, prices and/or quantities of resources employed in the areas will be significantly affected.

As discussed earlier, benefits are estimated for a 50-year period or for the life of the project, whichever is less. Therefore, estimated benefits depend upon future prices, yields, technology, institutions, goals of farmers, degree of knowledge, and other uncertain factors that affect monetary income. In view of such problems associated with benefit estimation, many questions logically arise. Some of these questions are: (1) are the estimates of benefits predictive, (2) do these estimates closely correspond to farmers' expectations of the benefits of flood protection, (3) are the benefits attributable entirely to land, that is, do all benefits accrue to flood plain land owners, and (4) are the capitalized values of benefits reflected in the land market?

If benefits of flood protection are capitalized into the value of land resources, current land owners receive all of the benefits for the

TABLE II

SOIL CONSERVATION ESTIMATES OF ANNUAL DIRECT AGRICULTURAL FLOOD DAMAGE REDUCTION BENEFITS, SIX WATERSHEDS

Watershed	Direct Agricultural Benefits (Dollars)	Acres of Flood Plain Land (Acres)	Direct Agricultural Benefits Per Acre (Dollars)
Barnitz	176,833	7,905	22.37
Cavalry	63,950	3,777	16.93
Saddle	23,448	4,798	4.89
Beaver[a]	35,699	2,724	13.11
Boggy[a]	52,015	4,836	10.76
Rainy[a]	180,470	18,513	9.75

[a]These watersheds are, as yet, unprotected.

life of the project due to the fact that land prices reflect present values of all future incomes expected therefrom. In addition, if benefits should occur as income to land, benefits of flood prevention projects could be measured by changes in land values. In any case, benefits to farmers from watershed development would accrue to one or more of the factors of production, and a basic question of this study will be to what extent they accrue to flood plain land.

Objectives

The general objective of the study is to determine the distribution of benefits from watershed development for flood prevention among factors of production. More specifically the objectives are:

1. To estimate the actual effects of watershed development on the price of farm real estate;
2. To assess the effects of the level of benefits estimated by the Soil Conservation Service in specified watersheds on the productivity value of land; and
3. To evaluate the procedures used in this study as methods for estimating expected benefits from watershed development projects.

Area of Study

Three pairs of watersheds are included in the analysis of this study. The pairs of watersheds are Barnitz and Beaver Creeks, Cavalry and Boggy Creeks, and Saddle Mountain and Rainy Mountain Creeks, all of which are within the Washita River Basin of Oklahoma. Each pair of watersheds was selected by the following criteria:

1. Paired watersheds are similar with respect to general location and type of agriculture;
2. One watershed of each pair has been developed for flood protection for three or more years, the other is unprotected;
3. The required soils information is available; and
4. Advantage may be taken of concurrent research in these watersheds.

Barnitz, Cavalry, and Saddle Mountain Watersheds were essentially protected from flooding in 1954, 1956, and 1958, respectively. Although Beaver, Boggy, and Rainy Mountain Watersheds have been planned, project construction had not begun at the time data were collected. The six watersheds are located, for the most part, in three counties. Barnitz and Beaver are located in Custer County, Cavalry and Boggy in Washita County, and Saddle and Rainy Mountain are located in Kiowa County. Location of the three counties within Oklahoma and with respect to the Washita River Basin is shown in Figure 1.

Content of Study

The remainder of this thesis is divided into four major sections. Concepts and procedures used to accomplish the general objective of the study are presented in Chapter II, along with sources of data used for empirical estimates.

The results of the regression analyses of farm sales data are presented in Chapter III. The major purpose of the chapter is to estimate the effects of flood protection upon sales price of farm real estate.

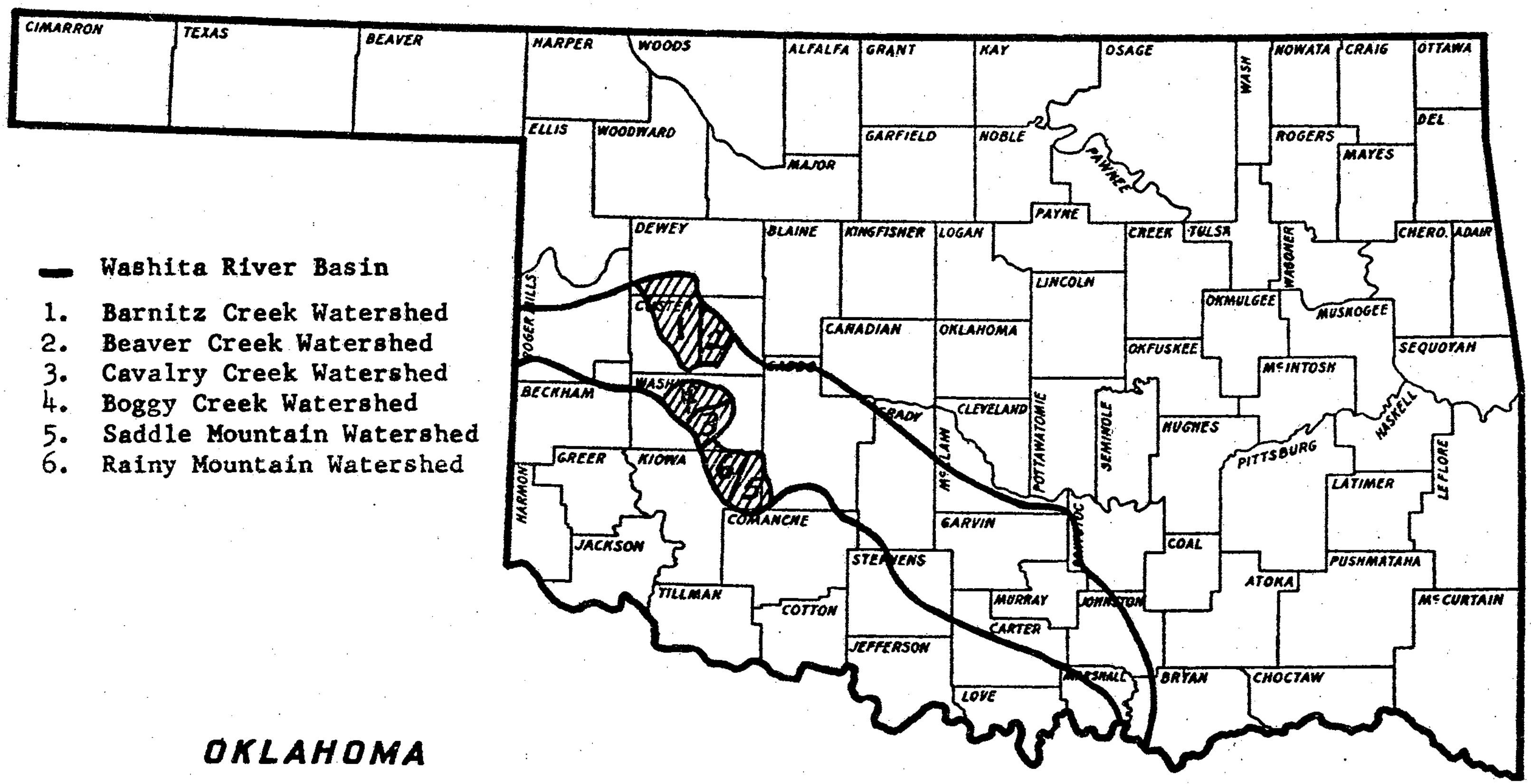

Figure 1. Location of Watersheds Included in Study.

Linear programming analysis of typical resource situations was performed to accomplish the second objective. Results of the programming analysis are presented in Chapter IV.

Finally, Chapter V includes a summary of the study, the conclusions reached, and an evaluation of the procedures used to estimate benefits of watershed development projects.

CHAPTER II

THEORETICAL CONCEPTS AND PROCEDURES

The purpose of this chapter is to discuss theoretical concepts underlying the procedures used to reach the stated objectives. The two major techniques in the study are regression and linear programming. Regression analyses of farm sales data were used to obtain empirical estimates of the effects of watershed development upon the value of affected land. Linear programming analyses of typical resource situations provide estimates of the effects of watershed development for flood protection upon the productivity of land and other nonland resources.

Factor Pricing Under Pure Competition

Assuming that production takes place under conditions of pure competition and that the goal motivating production is to maximize profits, factor pricing and product distribution are one and the same. That is, when productive factors are combined so as to maximize profit, then each of the productive factors will be paid the marginal value product of the last unit employed. Stigler sums up the theory of pricing productive factors according to their marginal value productivities as follows:

> ...The return to each productive service is at equilibrium equal to the marginal product of a unit of that productive service, under "pure" competition. The marginal product of a service is measured, of course, by the effect on the total product of the addition or withdrawal of a unit of the productive service in question, the amounts of the other productive

> services in the combination being held constant. Competition among entrepreneurs will insure that the value of the marginal product will be paid to the owner of the service, and competition among the owners of the service will insure that the remuneration does not exceed the marginal product (which would entail unemployment).[1]

Pricing factors of production according to their marginal productivity will be feasible only if certain conditions are met. If the production function of the firm is linearly homogeneous, Euler's theorem applies and there will be exactly enough product to pay each factor its marginal product share. But such an assumption may make industry equilibrium indeterminate since one firm could produce any quantity at fixed unit cost. Alternatively, it can be assumed that, for given factor price ratios which are unaffected by industry demand, the average productivity of the least cost combination is maximized for all firms. Once again, distribution by marginal product shares can be accomplished exactly. The aggregate production function of an atomistic industry of such firms will be linearly homogeneous, and the distribution will be feasible for all factor combinations and for all industry output levels which vary in the long-run through changes in the number of firms. Pricing factors by their marginal value productivity is thus not only profit maximizing but also distributionally feasible.[2]

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[1]George J. Stigler, Production and Distribution Theories: The Formative Period (New York, 1941), p. 302.

[2]Another restriction is that the marginal value product of labor be at least sufficient to provide subsistence. Since, in the factual situation examined here, the entrepreneur receives nearly all of the product through ownership of most factors, this restriction may be assumed to be met.

Returns to Fixed Factors

Marginal analysis is applicable to the problem of factor pricing when all factors are variable, and, given the efficiency assumptions outlined above, can be used to impute the value product and the price of a fixed factor. This imputation procedure insures that the total product forthcoming from combining the factors of production is distributed to those factors. It is assumed that intra-firm competition for the factor fixed to the firm will insure that its imputed price will not exceed its marginal value product.

Figure 2 illustrates the necessary conditions for obtaining maximum profit and the corresponding factor returns, according to marginal productivity theory of factor pricing. The illustration assumes that product Q is produced by combining variable nonland factors with a given quantity of land, and that production takes place under conditions of pure competition in the product and factor market. At point A, the slope of the iso-profit function is equal to the slope of the production function, or the marginal product of nonland factors is equal to the ratio of factor-product prices, which is the necessary condition for maximum profit. The quantity, NL_o, of nonland factors will be combined with the given quantities of land to yield Q_o quantity of product. The quantity of product $Q_o - K$ is the product attributable to nonland factors and K is the residual product to be imputed to land.[3]

[3]Ibid., pp. 79-80. K is equal to the residual return to land divided by the output price.

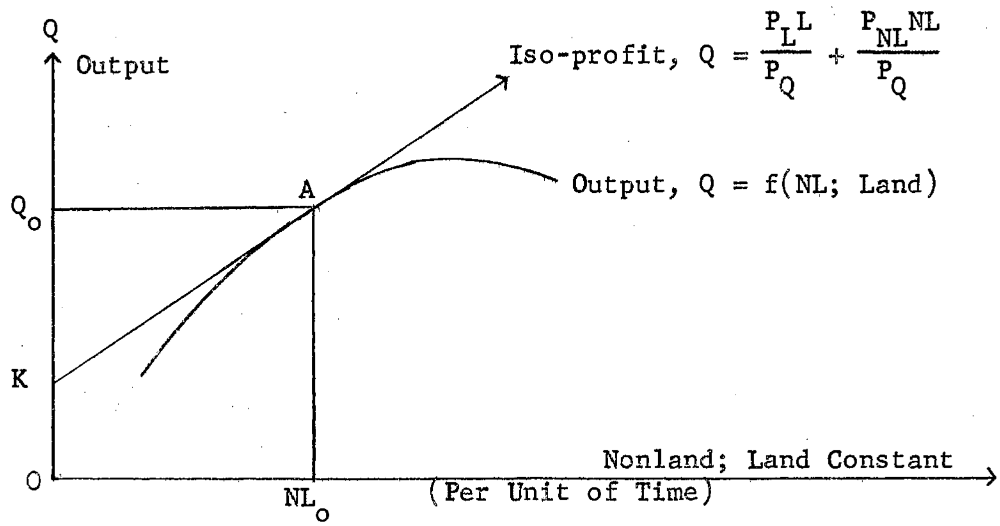

Figure 2. Illustration of Production Relations and Variable Factor Pricing.

Effects of an Exogenous Change in the Fixed Resource

Watershed development for flood protection represents an exogenous change in the productivity of resources. The question of interest is the effects of such a change on the prices of, or returns to, production factors. Watershed development may affect the productivity of land only, nonland only, or it may affect the productivity of both. The effects of an increase or decrease in efficiency of the fixed factor of production upon output and marginal productivity of variable resources has been discussed by Carlson:

> ...when it is a fixed service that has increased or decreased in efficiency the result will be very much the same. A more efficient plant will cause the output of the variable services to rise, which for a given volume of production means a lower total cost and an increased rate of return. It will also--at least for a certain range of outputs--cause the marginal productivity of the variable services to increase...[4]

[4]Sune Carlson, A Study on the Pure Theory of Production (New York, 1956), p. 70.

Carlson was concerned primarily with the effects of an increase in efficiency of the fixed factor for a given level of output. In the following illustrations of the possible effects of an increase in efficiency of a fixed factor (land), the volume of production is allowed to change.

Effects of exogenous changes in productivity of a fixed factor can best be illustrated by marginal value product curves for the varible factor. For example, the information in Figure 2 can be illustrated by a graph of the marginal value product of the nonland factors. The marginal value product graph has the advantage of simplicity when a change in the productivity of land is introduced. The relationship of the two methods can be seen by comparing Figure 3 with Figure 2. The necessary conditions for maximum profit are again that the marginal value product of the nonland factor is equal to its price, point A, Figure 3. The areas β and b, Figure 3, are the value equivalents of quantities K and $Q_o - K$, Figure 2, respectively.

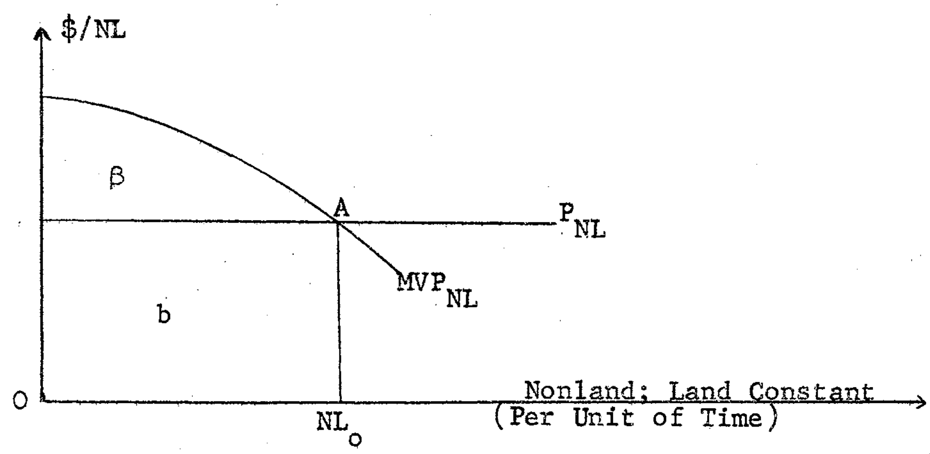

Figure 3. Illustration of the Marginal Value Product of Nonland Factors.

Effects of exogenous changes in the productivity of land on returns to resources will depend upon changes in the marginal productivity of nonland resources as well as any changes in price of the nonland factor that might result from changes in its productivity. Pure competition assumes that nonland factors are available at a constant price. The realism of such an assumption for a given watershed will depend upon how much nonland resources change. If nonland factor use increases or decreases by a significant amount, its price may increase or decrease. On the other hand, if the nonland resource is underemployed, its use may increase without significantly affecting its price. Figure 4 demonstrates the possible effects of an increase in the productivity of land on the price of the nonland factor. Point A denotes the equilibrium condition before the change in land productivity occurs. It is assumed that the increase in productivity of land causes the marginal value product of the nonland factor to shift to MVP'_{NL}. Point C is consistent with the assumption that nonland resources were underemployed prior to the change in land productivity.[5] The new level of nonland factor use does not affect its price and both land and nonland factors share the increased returns. Point B is consistent with the assumption that the nonland factor was fully employed prior to the exogenous change in land productivity. In this case, the price of the nonland factors may increase to P'_{NL} if their supply were perfectly inelastic. The prices P_{NL} and P'_{NL} represent the two extremes that can be expected, given that nonland factor use in the area above determines local nonland prices. But, in fact, with the exception of family labor these prices are established in a market far wider than the study area. Results that will be presented in a succeeding

[5]Nonland factors could be underemployed in the sense that more than were needed were available at the current price established outside the watershed. This is equivalent to assuming the supply was perfectly elastic at this price which was sufficient to cover subsistence or costs at employment levels not much less than NL_o.

chapter show that there is no appreciable change in the level of nonland factor use following watershed development. It can therefore be assumed that the price of nonland factors was unchanged by watershed development for flood protection.

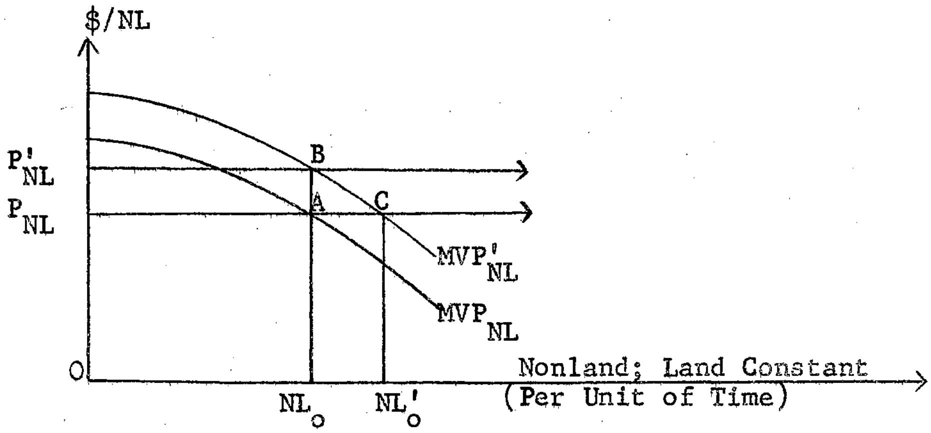

Figure 4. Possible Changes in the Price of the Nonland Factor, Given an Increase in Land Productivity.

Having assumed that nonland factor price remains constant, the effects of increased land productivity on the imputed returns to land still depend on the derived demand (MVP) of the variable factor. Examples are presented for three kinds of changes in the marginal value product curve for the variable factor. The first example represents a situation where increased returns from increased land productivity are shared proportionally by land and the nonland factor. This kind of change is illustrated in Figure 5A. Effects on factor shares of an increase in land productivity that shifts the marginal value product curve as in Figure 5A, can be summarized by:

$$0 < \frac{a}{b} = \frac{\alpha}{\beta}$$

where b is returns to the nonland factor before protection, a is the increase in returns to the nonland factor after protection, β is returns to land before protection and α is the change in returns to land after protection with the prime on variables in the figures denoting levels after protection.

Figure 5B depicts a change in the derived demand such that land receives a greater proportion of the increased returns than the nonland factor. Factor shares of the increase in returns can be summarized as:

$$0 < \frac{a}{b} < \frac{\alpha}{\beta}$$

An increase in productivity of land that results in all increased returns being imputed to land is illustrated in Figure 5C. Changes in factor shares after protection can be summarized by:

$$0 = \frac{a}{b} < \frac{\alpha}{\beta}$$

The theoretical models illustrated in Figures 4 and 5 suggest hypotheses about the effects of flood protection on returns to factors of production that range from proportional shares, to all increased returns being imputed to either factor. Operational models must now be employed in order to obtain empirical evidence that will support one of the suggested hypotheses.

Multiple regression analysis is appropriate for hypotheses about the effects of flood protection on returns to land. A model that estimates the derived demand for land before and after protection was developed and is discussed in the next section of this chapter.

Linear programming is appropriate for providing empirical evidence about hypotheses implied by the theoretical models illustrated in Figure 5. The programming model and a discussion of its relation to the theoretical models is presented in the last section of this chapter.

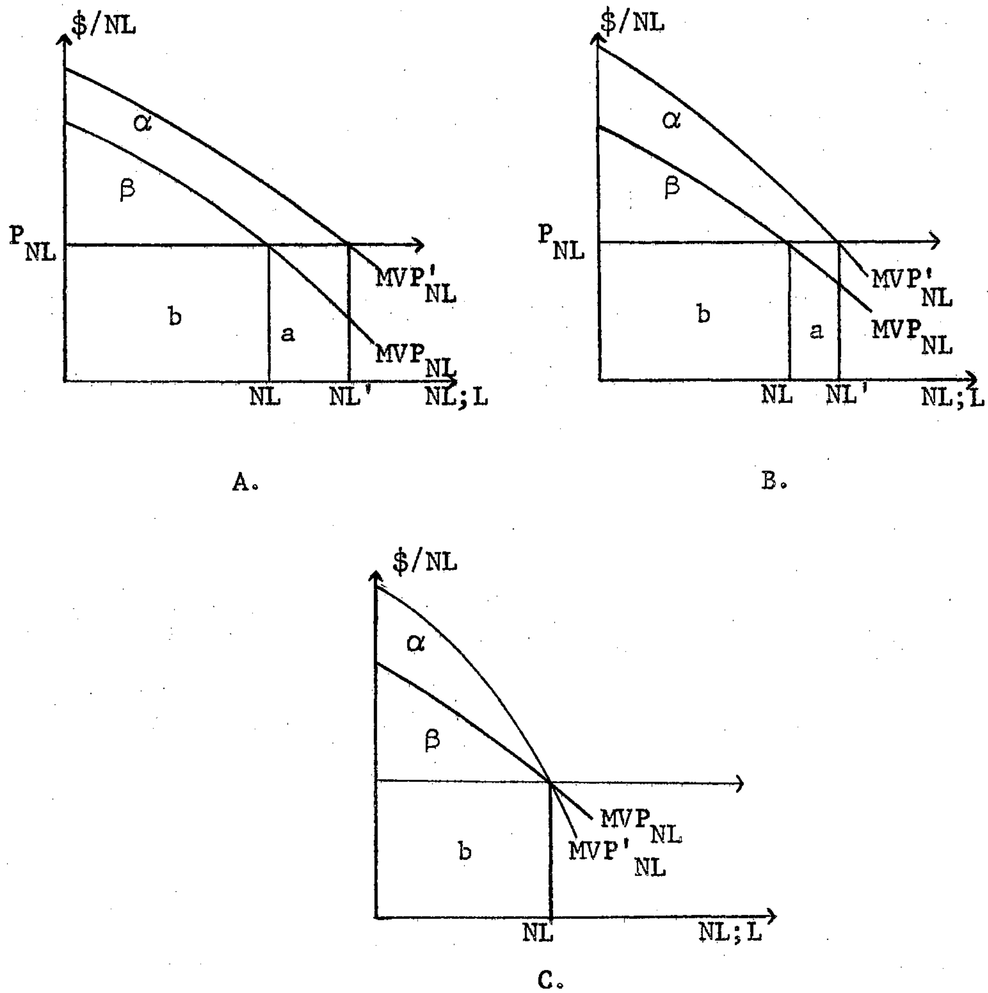

Figure 5. Illustration of Three Kinds of Changes in the Marginal Value Product of the Nonland Factor Caused by an Increase in Land Productivity after Flood Protection.

Derived Demand for Land

Since land area in the six watersheds is fixed, the effects of increased land productivity on the imputed returns to land was examined in the previous section in relation to the derived demand for the variable inputs. The observed variation in land sales jointly with land price must now be explained directly with a model suitable for empirical estimation.

Two factual considerations must, therefore, be presented to modify the results of a more general theory of derived demand for land. These are that the level of use of nonland factors did not change appreciably after flood protection in protected watersheds, and that, only in one of the protected watersheds did acres sold per unit of time increase; an expected result for all watersheds, had sufficient information been available. These results are noted in succeeding chapters.

For the aggregate of all farmers in a watershed, the demand for land is postulated in the usual manner from considerations of the marginal value product of farm size from the point of view of a manager planning a farm. Figure 6 illustrates this aggregate derived demand before protection occurs (D_b in Figure 6).

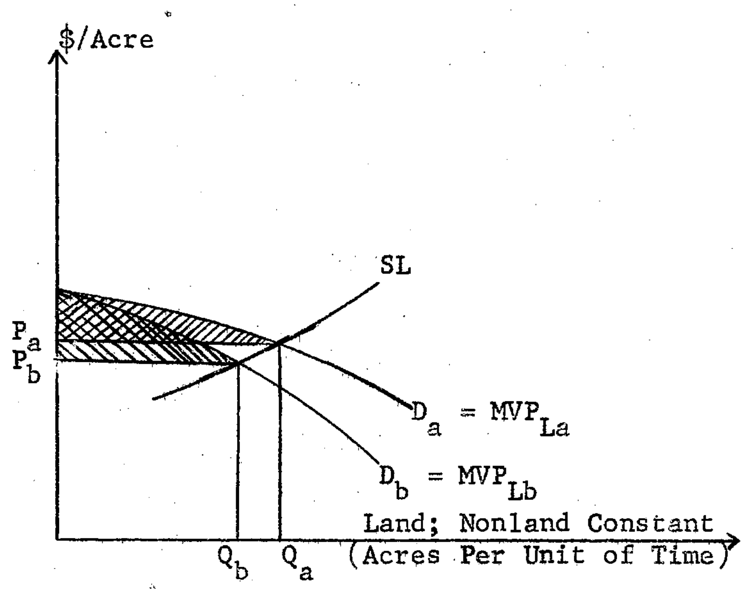

Figure 6. Illustration of the Watershed Land Market.

The supply of land is assumed to be based on the willingness of land owners to offer land for sale according to its price for the following two major reasons. Some owners may be considering retirement or changing employment and the rate of offer of land for these reasons would be expected to increase with its price. Other owners holding land speculatively would respond similarly to increased price which might lower their expected discounted gain from holding land against future price rises. In the land market as a whole, the equilibrium price and quantity is established in the neo-classical manner (Q_b, P_b).

The effects of protection are assumed to operate only on derived demand through increases in the marginal productivity of land throughout the observed farm sizes. The determinants of land supply are assumed not to include its productivity in farming. The new demand and equilibrium for the whole watershed is illustrated as before, but with the subscript "a."

Nonland factors were observed to remain essentially constant, and their marginal value products were assumed unchanged. For this reason, the hatched areas in Figure 6 are drawn equal. The two equilibrium quantities and prices are assumed to reflect the average sale before and after flood protection in the whole watershed.

The actual data to be observed and used to estimate these relations are data from farm firms. Only the average price and the total sales per unit of time can be thought of as belonging to the equilibria sketched in Figure 6. Two sorts of problems arise in adapting theory to observations in this model. The first is that there is a lack of homogeneity to be expected in the sizes of land tracts actually sold due to the small percentage of total land sold per unit of time. Figure 7 illustrates this problem for actual sales data in a watershed which essentially reflects firm rather than industry behavior. The line segment D illustrates a locus of points along which sales occur before protection. With farm size distributed about a mean, it will not be surprising to find land sales distributed widely about an average such as Q_2 rather than the small variation in size illustrated by equilibria in Figure 6.

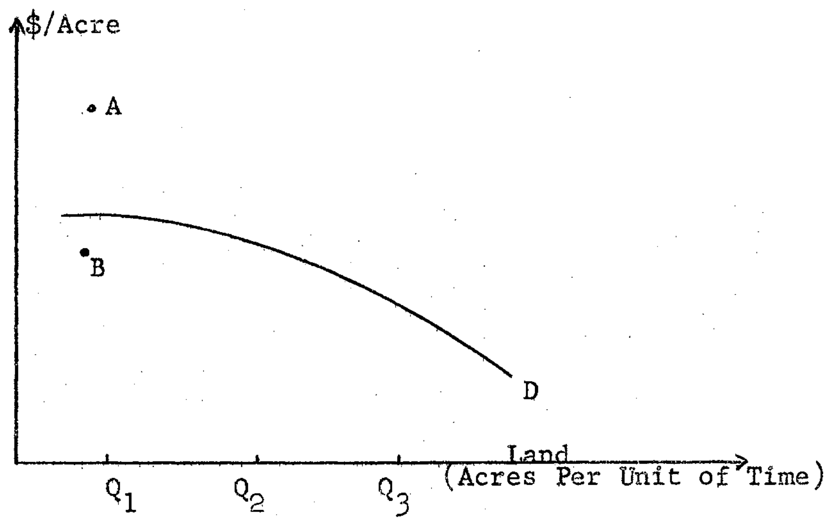

Figure 7. Illustration of Sales Observations in a Watershed.

The second disparity between theory and the more complex reality is that actual sales of land will occur for two different reasons even at the same size of tract. Point A, Figure 7, illustrates the price a purchaser might be willing to pay for a small tract of land which he is able to add to his existing farm in a close geographical location. He can afford to pay more per acre for the tract than the average relationship to the extent that he can spread existing nonland factors over the larger farm size. On the other hand, point B illustrates the purchase price of a small tract to be used as a complete farm. The farm size would be smaller than the watershed optimum due presumably to lack of availability of funds or risk aversion.

The fact that owners in the watershed would be willing to supply more than Q_1 in the aggregate at a price of A or B is not crucial. First, only a few tracts will be geographically located to satisfy the needs of the buyer at point A. Secondly, it is not in conflict with market theory that some suppliers realize a higher price than theoretical equilibrium, if there is lack of knowledge about the final equilibrium price in the process of its establishment.

Unfortunately, sales at sizes above the average, such as at Q_3, will not have the same degree of variability since the larger the tract, the less likely will the sale occur for the purpose of adding to present farm size. Even when this is the purpose, the availability of sufficient excess capacity of other factors is itself unlikely for the larger tracts. These considerations tend to reject the usual assumption of homoscedasticity in a statistical model of price regressed on quantity. Since the amount of heteroscedasticity cannot be estimated in this case, the problem, having been pointed out, will have to be ignored. Otherwise, with independent data on the relation between variance of price with size, a weighted regression might have been attempted.

The Regression Model

There remains the problem of what algebraic form to assume for the sales relationship which must be based on an acceptable underlying production function, but must be reasonably simple and statistically quantifiable. The form chosen for the regression was, in its simplest representation:

(2.1) $$R = \alpha + \beta L + u$$

where

R = revenue from the sale,

L = acres sold,

α, β = parameters of the linear relation, and

u = a random error term due to lack of complete specification, or due to basically unpredictable entrepreneurial behavior as discussed above.

In order that the sampling distribution of the needed statistical estimates can be derived, the error is hypothesized to be normal with zero mean and constant variance for each observation with no covariance between observations. In addition, the land sizes in sales are assumed to occur only at the observed levels.

For reasons discussed later, the regression was performed between revenue or per acre price times acres (i.e., $R = P_L L$) and acres. To show first that this model is consistent with the derived demand theory assumed above, consider a well-behaved production slice for nonland factors held constant as follows:

(2.2) $$Q = a \ln L + bL + c; \ a \text{ and } b > 0$$

where Q = output, and "ln" is the natural logarithmic transformation. After flood protection, it is assumed that "a" increases but that "b," the asymptotic marginal productivity, is constant. The "c" term can be thought of as a function of nonland factors. Now the marginal value product is:

(2.3) $$P_Q Q_L = P_Q(\frac{a}{L} + b)$$

where P_Q is the constant output price and A_L is the marginal physical product of land. So that, if it is assumed that land price is set according to the marginal value productivity, the revenue function is derived as in equation (2.1) with:

$$\alpha = aP_Q, \text{ and } \beta = bP_Q$$

Next, a method of assessing the effects of flood protection on the sales function and, implicitly, on marginal productivity is needed. For this, a method of dummy variables was used.[6] A dummy variable was added to the revenue model so that:

$$R = \alpha + \beta L + \gamma X + u \quad (2.4)$$

where

$$X \begin{cases} = 0 \text{ for unprotected conditions,} \\ = 1 \text{ for protected conditions.} \end{cases}$$

Then,

$$R(X = 0) = \alpha + \beta L + u \quad (2.5)$$

$$R(X = 1) = \alpha + \gamma + \beta L + u \quad (2.6)$$

and the change in the constant term γ reflects the increased productivity due to flood protection. From equation (2.3) the marginal product of land is:

$$Q_L = \frac{a}{L} + b \quad (2.7)$$

before protection occurs. It was assumed that flood protection increases "a" and if the increase is "γ," the marginal value product of land in the regression model after flood protection is

$$P_Q Q_L = \frac{\alpha + \gamma}{L} + \beta \quad (2.8)$$

Finally, to adjust the model for differences in the types of land observed in a given sale, the land variable was broken down into such

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[6]A discussion of dummy variables and their application can be found in J. Johnston, Econometric Methods (New York, 1960), pp. 221-228; and D. B. Suits, "Use of Dummy Variables in Regression Analysis," Journal of the American Statistical Association, LII (1957), pp. 548-551.

variables as flood plain land and upland suitable for crops, in addition to total acres in the sale.[7] As an illustration, let:

$$R = \alpha + pL + qF + rU + u \qquad (2.9)$$

where F = flood plain acres in the sale,

U = acres of upland suitable for cropland,

O = other land not included in regression except within total acres in sale, and

L = F + U + O.

With this model, it is possible to estimate the effect of an additional acre of, say, flood plain land in a sale

$$R_F = p + q \qquad (2.10)$$

and by inference, the effect of other land as

$$R_O = p \qquad (2.11)$$

[7]Flood plain land is defined as all land subject to flooding according to soils surveys of the counties in which the pairs of watersheds Cavalry and Boggy, Saddle and Rainy Mountain, are located. The soils survey for Custer County, the location of Barnitz and Beaver watersheds, is incomplete and flood plain land was identified from detailed soils maps of the watersheds. Upland suitable for crops was identified from the same sources as the flood plain land. Thus classification in fact includes all land suitable for crops since insignificant amounts of terrace and nonflooding bottomland are found in the area.

where the subscript indicates the variable in respect to which partial differentiation has been performed.[8]

The effect of an increase in land by one acre on sales revenue will depend on the distribution of land qualities in a particular sale. If, for example, land was divided equally among the three classes

$$R_L = p + q + r \tag{2.12}$$

equals β in equation (2.5). Otherwise, a weighted average of p, q, and r must be taken to arrive at β, the value of an additional acre of land in the sale.

Other variables which can conceptually affect sales price, such as mineral rights and improvements were also included in the actual regression to complete the specification.

The revenue model was preferred to the price model because no severe multicollinearity problem was observed among the independent variables so specified thereby removing a major reason for dividing through by acres in sale. The price model requires an additional variable or variables to account for the effects of other land on price per acre, and should also include acres in sale as a variable in order to account for the effects of

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[8]In addition to accounting for the effect of other land which can be expected to increase more than proportionally as size of tract sold increases, p accounts for the effects of size of tract sold independent of land types. For example, a small tract purchased for purposes of increasing the size of an existing farm can be expected to sell for a higher price per acre than a larger tract purchased as a complete unit even though the proportion of the various land types are the same for both tracts. Some reasons are: (1) a buyer can afford to pay more per acre for a small tract to the extent that he can spread existing nonland factors over the larger farm size; and (2) there will likely be greater risk associated with purchases of large tracts, especially if a debt must be incurred to make the purchase.

size of tract sold irrespective of land quality. In addition, ratio estimations involve problems concerning the variance to be explained.[9]

The Linear Programming Model

Empirical estimates of the effects of flood protection on the productivity of resources can be obtained from a linear programming model. Linear programming is a technique that maximizes (minimizes) a criterion function subject to linear restraints. The criterion in this case is to maximize returns from a specified set of linear processes subject to the resource restrictions specified in the model, and subject to nonnegative levels of output and resource use.

In addition to returns to nonpriced factors, the linear programming procedure computes the marginal value products of factors that are restrictive in the optimum solution. Thus, if the assumed constant prices of all nonland factors were known and entered as a cost, the marginal value product of land could be obtained directly from the program. Unfortunately, the price of family labor and the rate of return required for capital are not known. By assuming charges for the nonland factors, the residual returns are returns to land. Of course, the returns to land depend directly on the assumptions with respect to nonland factor prices. However, changes in returns to land due to flood protection will be independent of the nonland price assumptions if nonland factor use remains unchanged after protection. The programming analysis indicates that there was no appreciable change in labor and capital used following

[9]Morris H. Hansen, William N. Hurwitz, and William G. Madow, Sample Survey Methods and Theory, Vol. 1 (New York, 1960), pp. 158-175.

flood protection due to changes in land use. These results are presented in a later chapter.

Restrictions

The programming model assumes a given level of management and perfect knowledge. The level of management is implicit in the input-output coefficients assumed for the activity processes included in the model.

Land enters the model as a nonpriced factor. Therefore, the restriction on its use is the number of acres of various qualities available as specified in the various resource situations programmed.

Family labor was also considered as a nonpriced factor. The amount assumed to be available was based on information obtained from a survey of farms in the area. In addition to family labor, it was assumed that hired labor was available at a cost of $1.00 per hour.

Nonland capital was not restricted with respect to the amount available, but it was restricted in the sense that returns from its use must cover its assumed cost. The capital cost assumed varied among resource situations as well as among watersheds. For each resource situation, a capital charge was assumed that resulted in programmed farm organizations that closely approximated existing farm organization in the protected watersheds. In essence, the model with the above restrictions assumes that present farm organization in protected watersheds is optimum.

Returns to resources for unprotected conditions, assuming that flood damage factors estimated by the Soil Conservation Service are accurate, can be estimated by imposing these damage factors on the model as a further restriction. The damage factors are in terms of percentage reduction in yields due to flooding.[10]

Since both land and family labor entered the model as nonpriced factors, the change in programmed returns is attributable to both factors. Estimating the change in returns to land requires knowledge of the returns attributable to family labor. The models that have been presented estimate the change in marginal productivity of land following flood protection. The marginal productivity of labor and nonland capital were assumed to be unchanged after protection. Empirical observations support such an assumption in that the quantities of these resources used, change very little after protection.

Comparison of Regression and Programming Models

The regression model assumed that nonland factors remained fixed following flood protection so that the derived demand for land was a function of land and product price only. The programming model involves stronger assumptions about the underlying production function. The production function is assumed to consist of a set of linear processes and is, therefore, linear and homogeneous. The marginal value product of land estimated from this model is a function of the optimum processes which are, in turn, functions of land, and nonland, as well as product and factor prices. Thus, this model relaxes the assumption that nonland factors remain constant which was assumed in the revenue regression model.

Damage factors for the six watersheds under study are given in Appendix F, Table I.

Another major difference in the two models is in relation to flood protection, the critical variable in the analysis. The regression model is independent of any estimates of flood damages in that it estimates the change in actual sales price following protection. The programming model, on the other hand, estimates marginal value products of resources before and after protection on the basis of damage factors that have been estimated by the Soil Conservation Service. The increase in returns projected through damage factor estimates will be compared to the actual increases in land values obtained in the revenue regression analysis. Similarities or discrepancies between the projected and actual effects of flood protection will allow the evaluation of these methods of benefit analysis listed as the third objective of this study.

CHAPTER III

REGRESSION ANALYSIS AND RESULTS

The purpose of this chapter is to present the empirical estimates of the effects of flood protection on the sale price of farm real estate. The estimates were obtained by regression analysis of farm sales data. The revenue regression model exhibited in Chapter II, equations (2.1)-(2.11), was used for the analysis.

The chapter is divided into four major sections. The first section is a description of the farm sales data used. Analysis of farm sales data, aggregated across watersheds, is presented in the second section. One regression equation, to which dummy variables were added to account for differences in watersheds, was fitted to data for the six watersheds included in this study. The coefficients of this equation are estimates of the average relationships existing in the six watershed area. Tests of significance of thess coefficients serve as indicators of the importance of the respective independent variables in accounting for the observed variation in revenue from farm sales. The next step in this section is an analysis of protected watersheds. Sales data for the protected watersheds are divided into sales that occurred before protection, and those that occurred after protection. A regression was fitted to each group of data, and the regressions tested for a significant difference. The logic of this test is that if flood protection has significantly affected land values, it would be expected that the coefficients of a regression using data after protection would be significantly different from those using data before protection.

The third section separates the analysis into the individual protected watersheds. Two procedures for estimating the effects of flood protection are used in this section. First, the revenue regression model given by equation (2.4), Chapter II, was fitted to sales data for each of the protected watersheds. A dummy variable was used to account directly for the effect of flood protection. In cases where the revenue regression model did not yield satisfactory answers due to problems encountered when the model was fitted to the relatively small numbers of sales occurring within a particular watershed, an alternative procedure was used. The alternative procedure is discussed in detail later in this chapter. The final section is a summary of the results of the regression analysis.

Farm Sales Data

Procedure for Obtaining Data

A list of sections of land that contained some flood plain land was compiled from maps made by the Soil Conservation Service in their work plans for the six watersheds included in the study. Courthouse records were examined and information recorded about each bona fide sale that transferred title to land included within these sections during the period 1947-1962, inclusive. Bona fide sales have been defined as those sales that transfer property by warranty deeds, between a willing buyer and a willing seller.[1]

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[1]National Association of Tax Administrators, Guide for Assessment-Sales Ratio Studies (Chicago, 1954), pp. 6-8.

Information contained in courthouse records is insufficient for determining whether the above definition is met. Therefore, bona fide sales, for purposes of this study, are sales that transfer title by warranty deed, Indian deed, or contract for warranty deed. Further exclusions, made in order to obtain a useable sample, are listed in Appendix A. Useable information obtained from courthouse records, soils maps, and professional agricultural workers in the area, included (1) legal description, (2) acres in sale, (3) assessed value of land and improvements, (4) percent of mineral rights transferred, (5) sale price, (6) value of Internal Revenue Stamps affixed to the deed, (7) acres of flood plain land, and (8) acres of upland suitable for cropland.

In cases where the sale price did not appear on the deed, it was computed from the value of the Internal Revenue Stamps affixed to the deed. Regulations regarding the use of Internal Revenue Stamps, and the procedure used to estimate the sales price of land and improvements from them are discussed in Appendix B.

Data consistent with the above requirements were collected for a total of 184 sales in Barnitz, Beaver, Cavalry, Boggy, Saddle Mountain, and Rainy Mountain Watersheds. Of the 184 total sales, 95 occurred in protected watersheds, and 89 in unprotected watersheds. In all the sales in six watersheds transferred title to 29,322 acres of land during the period 1947-1962, inclusive; 16,274 acres in protected watersheds, and 13,048 acres in unprotected watersheds, as detailed in Table III. The mean values of the more important variables are tabulated in Appendix B, Table I.

TABLE III

NUMBER OF BONA FIDE SALES AND ACRES TRANSFERRED, SIX WATERSHEDS

Watershed	Number of Sales	Acres in Sales
Barnitz[a]	27	6,785
Beaver	20	4,246
Cavalry[a]	39	5,153
Boggy	12	2,100
Saddle[a]	29	4,336
Rainy	57	6,702
Protected Watersheds	95	16,274
Unprotected Watersheds	89	13,048
All Watersheds	184	29,322

[a]These watersheds have been developed for purposes of flood protection.

List of Variables

The regression analysis of this chapter used variables from the following list:

Y_T = Revenue from the sale of land and improvements where the subscript T indicates that all sales in the six watersheds were used as observations,

Y_P = Revenue from sales in protected watersheds,

Y_u = Revenue from sales in unprotected watersheds and $Y_P + Y_u = Y_T$,

Y_1 = Revenue from sales in Barnitz Creek Watershed,

Y_2 = Revenue from sales in Cavalry Creek Watershed,

Y_3 = Revenue from sales in Saddle Mountain Watershed.

Z = $Y - \hat{Y}$ where Y takes on the subscripts of the particular Y being analyzed and $\hat{Y}$ is the respective regression estimate,

B,A = Subscripts applied to protected watersheds for before and after protection. Since $Y_1 + Y_2 + Y_3 = Y_P$, these subscripts can be used for the aggregate of protected watersheds as well as for individual ones,

X_1 = Acres of land in sale,

X_2 = Percent of mineral rights transferred with sale,

X_3 = Assessed value of improvements at time of sale,

X_4 = Acres of upland suitable for crops, $X_4 \leq X_1$,

X_5 = Year in which sale occurred (1947 = 1),

X_6 = Acres of flood plain land, $X_6 \leq X_1$,

X_7 = 1 if the tract sold was in Barnitz Creek, $X_7 = 0$, otherwise,

X_8 = 1 if the tract sold was in Cavalry Creek $X_8 = 0$, otherwise,

X_9 = 1 if the tract sold was in Saddle Mountain, $X_9 = 0$, otherwise,

X_{10} = 1 if the tract sold was in Rainy Mountain, X_{10} = 0, otherwise.

X_{11} = 1 if the tract sold was in Beaver Creek, X_{11} = 0, otherwise, and

X_{12} = 1 if the sale occurred after flood protection, X_{12} = 0, otherwise.

Analysis of Aggregated Farm Sales Data

The first question to be answered is whether the revenue regression model postulated in Chapter II yields estimates that are: (1) consistent with economic theory, (2) statistically significant, and (3) sufficiently explanatory to render the model useful for testing the effects of flood protection.[2] In order to answer these questions, sales data for the six watersheds were included in one regression. More specifically, the regression is of the form:

$$\hat{Y}_T = b_o + b_1X_1 + b_2X_2 + ,\ldots, + b_{11}X_{11}$$

The coefficients for variables $X_1,\ldots,X_6$ can be considered as average relationships for all watersheds. On the other hand, coefficients for variables $X_7,\ldots,X_{11}$ allow the regression surface to shift to account for any differences in the mean revenue from land sales that may exist among watersheds. Such differences might be due to differences in the mean levels of the observed independent variables among watersheds or due to differences in variables not included in the equations. For example, Barnitz, Saddle Mountain, and Cavalry Creek Watersheds have been protected from flooding, but the other watersheds are unprotected over the period of the data. Variables $X_7,\ldots,X_{11}$ take on a value of zero for farm sales

[2]The model is statistical in that it represents a universe of all sales from such watersheds, and it is assumed that there are errors of measurement of revenue, the dependent variable in the model.

in Boggy Creek Watershed. Thus, the "b_o" coefficient in the equation is the intercept of the regression for Boggy Creek sales.

Application of the least squares technique yielded the following regression for the combined data for all six watersheds:[3]

$$(3.1) \quad \hat{Y}_T = -2,156.37 + \underline{52.67}X_1 + \underline{73.41}X_2 + \underline{6.86}X_3 + \underline{58.33}X_4 + \underline{727.54}X_5 + \underline{83.14}X_6 - \underline{11,727.25}X_7 - \underline{7,110.51}X_8 - \underline{10,372.33}X_9 - \underline{12,315.95}X_{10} - \underline{8,864.22}X_{11}; \quad R^2 = .80.$$

All coefficients of the independent variables in the equation test significantly different from zero at the 10 percent probability level,[4] and consistent with economic theory. Eighty percent of the variation in revenue from land sales is accounted for by the revenue equation, which seems sufficient to justify proceeding with the present specification of the model.

An estimate of the value of an acre of upland suitable for cropland is given by $b_1 + b_4$ = \$111.00, for an acre of flood plain land $b_1 + b_6$ = \$135.81, and \$52.67 for an acre of other land (see Chapter II).

The coefficient for the value of mineral rights is probably the most questionable coefficient in the equation. Interpretation of this coefficient is that a one percent increase in mineral rights transferred with the sale increases the revenue from that sale by \$73.41, given fixed values of all other variables. Since the mean acres in sale were 159.39, a one percent increase transfers mineral rights to approximately 1.59 acres

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[3]Coefficients that are significantly different from zero at the 10 percent probability level are underlined in each equation presented in the chapters.

[4]In fact, these coefficient estimates also would have been significantly different from zero at the one percent level.

of land. At a capitalization rate of five percent, \$3.67 capitalized in perpetuity equals \$73.41. On a per acre basis, this represents the somewhat high average annual rental value of approximately \$2.31 for mineral rights.

A problem associated with estimating the value of mineral rights from the observed data is the fact that there was little variation in the observed percentages of mineral rights transferred with land sales. For the most part, mineral rights were transferred in discrete amounts of 0, 50, or 100 percent. For example, 100 percent of the mineral rights were transferred in 79 of the 184 sales, and 50 percent were transferred in 74 of the 184 sales. In effect, rather discrete levels were observed rather than observations assumed continuous over the range of 0 to 100.

The coefficient for assessed value of improvements indicates that the ratio of sales value of improvements to assessed value of improvements is 6.86 to 1. Based on this estimate, improvements are assessed by buyers at approximately 15 percent of their market value in the six watershed areas.

Year of sale (X_5) was included as an independent variable to account for variables that can be expected to affect revenue from the sale of land, but whose levels could not be observed in the area included in the study. Some examples are the expectations of land buyers and sellers with respect to future product prices, expectations about institutional changes such as acreage allotments and marketing quotas, expectations about off-farm employment opportunities, etc. Including year of sale in the equation also accounts for changes in the general price level. The coefficient for year of sale divided by the mean acres in sale indicates that revenue from land sales increased by \$4.56 per acre per year.

Analysis of Sales Data for All Protected Watersheds

Barnitz, Cavalry, and Saddle Mountain Watersheds were developed for flood protection in 1954, 1956, and 1958, respectively.[5] The farm sales data for these watersheds were divided into two groups: (1) sales that occurred before flood protection, and (2) sales that occurred after flood protection. An equation of the form:

$$Y = b_o + b_1X_1 + ,\ldots, + b_8X_8$$

was fitted to each group of data. Variables X_7 and X_8 take on a value of zero for sales that occurred in Saddle Mountain Watershed. The regression for all three protected watersheds before protection is:

$$(3.2) \qquad \hat{Y}_{PB} = -5,823.03 + \underline{38.95}X_1 + 19.38X_2 + \underline{5.41}X_3 + \underline{65.67}X_4 + \underline{486.97}X_5 + \underline{89.04}X_6 + 334.95X_7 + \underline{3,039.62}X_8; \quad R^2 = .79.$$

Coefficients for variables X_2 and X_7 are not significant at the 10 percent probability level.

The regression for all three protected watersheds after protection is given in equation (3.3).

$$(3.3) \qquad \hat{Y}_{PA} = -41,843.23 + \underline{42.96}X_1 + 53.14X_2 + 2.50X_3 + \underline{59.75}X_4 + \underline{2,812.71}X_5 + \underline{194.16}X_6 + 883.12X_7 + \underline{6,003.24}X_8; \quad R^2 = .91.$$

The coefficients for variables X_2, X_3, and X_7 are not significant at the 10 percent probability level. The coefficients for X_2 and X_7 are not significant in either equation. On the other hand, b_3, the coefficient for value of improvements, was significant before protection, but was not significant after protection. A possible explanation is that most of the

[5]Watersheds were assumed to be developed for flood protection the year that construction of flood detention structures began.

land purchases after protection may have been made for the purpose of increasing farm size. If this is the case, buildings for residence are likely to be less valuable to the purchaser. The simple correlation coefficients for equations (3.2) and (3.3) are given in Appendix D, Tables III and IV, respectively, but do not indicate multicollinearity.

The coefficients for year of sale (X_5) and flood plain land (X_6) have increased in size after flood protection. This is consistent with the hypothesis that land values have increased in developed watersheds following flood protection. However, such differences could arise due to chance variation which possibility must now be examined.

Analysis of variance provides a basis for testing whether the coefficients for after protection differ significantly from the coefficients for before protection. The specific form of the procedure used to accomplish the test has been published by Foote[6] and an example of its use in research can be found in U. S. Department of Agriculture Technical Bulletin No. 1080.[7]

In general, the procedure is to fit one equation to all data in the protected watersheds. A statistical test is then made to determine whether or not a regression fit to the data for after protection differs significantly from the regression for before protection. If regressions are the same, or not significantly different for before and after protection, then

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[6]Richard J. Foote, Analytical Tools for Studying Demand and Price Structures, U. S. Department of Agriculture Handbook No. 146 (Washington, 1958), pp. 180-182.

[7]Kenneth W. Meinken, The Demand and Price Structure for Oats, Barley, and Sorghum Grains, U. S. Department of Agriculture Technical Bulletin No. 1080 (Washington, 1953).

all data can be used to estimate a single coefficient for each independent variable in the model and it could be concluded that flood protection has not increased land value significantly. A formal statement of the hypothesis to be tested is that:

$a_B = a_A = a_T$ and $b_{jB} = b_{jA} = b_{jT}$ for all $j = 1, \ldots, k$ in the equation.

Analysis of variance for testing the hypothesis that regression coefficients are the same for before and after protection is given in Table IV. The computed value of F is greater than the tabular value at the five percent probability level, with the appropriate degrees of freedom, and the hypothesis is rejected. An error of type I would be less than five percent of the time when rejection is based on similar evidence. Rejecting the hypothesis under test implies that land values in the watersheds have changed after these watersheds were protected from flooding. Further analysis to estimate the effects of flood protection on land values in individual watersheds is indicated. Analysis of each of the three protected watersheds is presented in the next section.

Regression Analysis of Barnitz, Cavalry, and Saddle Mountain Watersheds

Analysis of Barnitz Creek Watershed

A total of 27 sales that fit the definition of bona fide sales was tabulated in Barnitz Creek Watershed. Of these 27 sales, only five occurred after the watershed had been protected from flooding in 1954. The regression for Barnitz Creek Watershed is:

$$(3.4) \quad \hat{Y}_1 = -10{,}829.87 + \underline{43.35}X_1 + 50.76X_2 + .71X_3 + \underline{80.10}X_4 + 886.04X_5 + \underline{106.25}X_6 - 1{,}209.40X_{12}; \qquad R^2 = .84.$$

TABLE IV

ANALYSIS OF VARIANCE FOR TESTING THE HYPOTHESIS THAT THERE IS NO SIGNIFICANT DIFFERENCE IN REGRESSION EQUATIONS BEFORE AND AFTER FLOOD PROTECTION IN BARNITZ, CAVALRY, AND SADDLE MOUNTAIN WATERSHEDS

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Squares
Total	8,922,847,310	94	
SSR_T	7,394,631,251	8	
SSD_T	1,528,216,059	86	
SSD_B	730,573,134	57	
SSD_A	455,375,067	20	
$SSD_B + SSD_A$	1,185,938,201	77	15,401,795
$SSD_T - (SSD_B + SSD_A)$	342,277,858	9	38,030,873
$F = \frac{38,030,873}{15,401,795} = 2.469$		$F_{(.05)} = 2.01$	

The regression for all sales that occurred in the three protected watersheds is:

$$\hat{Y}_P = -9,423.66 + \underline{45.52}X_1 + \underline{40.22}X_2 + \underline{5.66}X_3 + \underline{69.55}X_4 + \underline{675.11}X_5 + 93.97X_6 - 447.19X_7 + 2,890.68X_8; \qquad R^2 = .83.$$

The coefficient for flood protection (b_{12}) is not significantly different from zero at the 10 percent probability level. This results in failure to reject the hypothesis that flood protection has had no effects on land values. However, there is a strong linear relationship between X_5 and X_{12} ($r_{5,12} = .91$, Appendix D, Table V) which could cause the coefficients for these variables to be inaccurate. Also, the coefficient for X_5 is not significantly different from zero at the 10 percent probability level. Evidence that year of sale as an independent variable does not significantly affect the selling price of land in Barnitz Creek for the period covered by the data is supported by an analysis of data for Beaver Creek Watershed which has not been protected from flooding. Beaver Creek lies adjacent to and to the east of Barnitz Creek. The two watersheds are comparable with respect to general land resources, climatic conditions, and type of agriculture. It seems reasonable to assume that forces, reflected by time, that affect land values would be operating similarly in both Barnitz Creek and Beaver Creek Watersheds. Analysis of the data (20 sales) for Beaver Creek results in a nonsignificant coefficient for year of sale (Appendix C). Variable X_5 was dropped from the model along with variables X_2 and X_3 since coefficients for neither X_2 or X_3 are significant and since there is no correlation problems involving these variables. The resulting equation is:

$$(3.5) \qquad \hat{Y}_1 = -3,124.79 + \underline{43.75}X_1 + \underline{80.11}X_4 + \underline{96.91}X_6 + \underline{5,700.37}X_{12}; \quad R^2 = .81.$$

All coefficients in the equation are significant and logical in sign. Assuming the modification discussed above is reasonable, the following deductions are pertinent.

An increase in selling price of $5,700.37, the estimated effect of flood protection per sale, divided by the mean acres of flood plain (47 acres) represents an increase in the value of flood plain land of $121.27 per acre. If a capitalization rate of five percent is assumed, a capitalized value of $121.27 would result from a net annual benefit of $6.06 per acre of flood plain capitalized in perpetuity. Placing 95 percent confidence limits on the coefficient for flood protection gives a range of $1.49 to $11.76 annual benefits per acre of flood plain land capitalized at five percent in perpetuity.

The Soil Conservation Service estimated that annual direct benefits of $22.37 per acre of flood plain land would occur as a result of flood protection in Barnitz Creek Watershed. This estimate is almost twice as large as the upper limit of the regression estimate.

Average annual benefits per acre of flood plain land estimated by the Soil Conservation Service capitalized in perpetuity at five percent would increase the value of the affected land by $447.40 per acre. However, if the benefits estimated by the Soil Conservation Service are capitalized at the rate of 18.45 percent in perpetuity, the capitalized value is about $121.27 per flood plain acre which is the regression estimate. Results presented in Chapter IV tend to indicate that a capital rate of approximately 18 percent best explains current farm organization in the area under study.

It seems likely that none of the situations described above are exactly what has occurred in Barnitz Creek. However, the above analysis suggests that direct agricultural benefits have occurred as a result of flood protection and that these benefits have been capitalized into land values.

Analysis of Cavalry Creek Watershed

The analysis for Cavalry Creek is based upon 39 sales transferring title to 5,153 acres of land. Cavalry Creek Watershed was developed for flood protection in 1956. Of the 39 bona fide sales, 10 occurred after the watershed was developed for flood protection.

The estimating equation for Cavalry Creek is:

$$(3.6) \quad \hat{Y}_2 = -7,358.36 + \underline{40.53}X_1 + \underline{59.85}X_2 + \underline{5.3}X_3 + \underline{64.69}X_4 + \underline{958.34}X_5 + 87.46X_6 - 3,159.96X_{12}; \qquad R^2 = .78.$$

Coefficients of the independent variables are logical in sign and magnitude and statistically significant with the exception of b_{12}, the coefficient for flood protection. This coefficient is not different from zero at the 10 percent probability level. Based on this analysis, there is no evidence that land values have increased as a result of flood protection. However, a check of the simple correlation coefficients reveals that a linear relationship exists between year of sale and X_{12}, the variable for flood protection ($r_{5,12}$ = .84, Appendix D, Table VI). Such a relationship might cause the coefficients for X_5 and X_{12} to be inaccurate.

An attempt to solve the problem was made. Equation (3.7) was fitted to the data for Cavalry Creek to remove the high correlation between X_5 and X_{12} and retain the effects of both variables in the equation.

$$(3.7) \quad \hat{Y}_2 = -1,420.31 + \underline{39.96}X_1 + \underline{40.77}X_2 + \underline{6.00}X_3 + \underline{69.80}X_4 - 778.31X_{12} + \underline{15.32X}_{13}; \qquad R^2 = .76.$$

Where X_{13} is a composite variable: year of sale (X_5) multiplied by acres of flood plain land (X_6). Multiplying year of sale by acres of flood plain eliminates the high correlation between year of sale and the variable for flood protection (Appendix D, Table VI). Acres of flood plain was selected as a component of the composite variable because equation (3.6) gives an estimate of this coefficient that is highly significant and the variable is not strongly correlated with other independent variables included in the equation. Otherwise, the choice of acres of flood plain was arbitrary.

Equation (3.7) does not directly give separate estimates of the effect of year of sale and flood plain land. It is desirable to have these estimates in order to compare coefficients obtained by each equation. Such estimates can be obtained by separating $b_{13}X_{13}$ into its component parts. An estimate of the effect of flood plain land is obtained by substituting the mean of one variable and evaluating the effect of the other.[8] The coefficient for flood plain land obtained by this procedure is \$87.17 compared with \$87.46 in equation (3.6). Thus, the best estimate of the value of an acre of flood plain land in Cavalry Creek Watershed is b_1 + \$87.17 or \$127.13 from equation (3.7) compared with $b_1 + b_6$ or \$127.99 from equation (3.6). The coefficient for year of sale obtained by the same procedure is \$5.74 per acre per year compared with \$7.25 from equation (3.6).

Rearranging the data consistent with equation (3.7) eliminates, to a large degree, high correlation among independent variables. Also, coefficients for all independent variables included in equation (3.6) were estimated. However, conclusions concerning the effect of flood protection are the same for both equations. Even though b_{12} increases from -\$3,159.96

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[8]For example, if $b_iX_i = b_iQ_iZ_i$, then $b_i\bar{Q}_iZ_i$ gives $b_i\bar{Y}_i$ as an estimate of the effect of Z at the mean of Q. The reverse process for obtaining an estimate of the effect of Q_i at the mean of Z is obvious.

in equation (3.6) to -$778.31 in equation (3.7), it is not statistically significant at the 10 percent level. Other regression equations were fitted to the sales data for Cavalry Creek. Some of these equations are presented in Appendix E. However, in each case the same conclusion was reached with respect to the effects of flood protection. That is, the analysis of farm sales data provided no evidence of a significant increase in land values as a result of flood protection.

A possible explanation as to why the regression analysis fails to show a significant increase in land values following flood protection is that benefits from flood protection may have been anticipated prior to actual protection in this watershed. If this is the case, anticipated benefits may have been capitalized at a much earlier date than the time flood protection actually occurred. Evidence that supports such a hypothesis is found in the _Work Plan Cavalry Creek Watershed of the Washita River Watershed_.[9] According to the _Work Plan_, individual landowners had constructed flood levees within the flood plain well before the watershed was fully developed. Channel improvement on the main stem of Cavalry Creek had also been attempted resulting in increased channel capacity. In addition to actions by individual landowners, two floodwater retarding structures, seven drop inlets, 3.5 miles of floodwater diversions, and 0.5 miles of roadside erosion control were completed in the watershed in 1948 under the provisions of a prior subwatershed work plan.

The watershed development that occurred in 1956 in Cavalry Creek watershed, with which this analysis is concerned, was based upon estimated

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[9] U. S. Department of Agriculture, Soil Conservation Service, _Work Plan Cavalry Creek Watershed of the Washita River Watershed_ (unpublished report, 1955), pp. 6-7.

benefits that excluded any benefits from prior flood protection. However, landowners in the watershed may have viewed the proposed additional development as a continuation of the earlier development and priced resources accordingly, since the additional watershed development was planned in 1951.[10]

If anticipated benefits were capitalized before 1956 as was suggested above, the nonsignificant coefficient for flood protection estimated by equation (3.7) is to be expected.

Analysis of Saddle Mountain Watershed

Data for Saddle Mountain consists of 29 sales transferring title to 4,336 acres of land during the period covered by the study. Of the 29 sales, 14 occurred after the watershed was protected from flooding in 1958.

The regression for Saddle Mountain Watershed is:

$$(3.8) \qquad \hat{Y}_3 = -1{,}992.16 + \underline{116.32}X_1 - 53.40X_2 + \underline{19.92}X_3 - 22.01X_4 + 204.69X_5 + 9.20X_6 + 1{,}967.11X_{12}; \qquad R^2 = .92.$$

Even though 92 percent of the variation in sale price of land and improvements was accounted for by fitting the equation, only b_1 and b_3 are significant at the 10 percent probability level. Dropping nonsignificant variables X_2, X_4, and X_5 from the equation resulted in appreciable changes in estimates of the remaining coefficients. The regression, with the above variables excluded, is:

$$(3.9) \qquad \hat{Y}_3 = -4{,}598.62 + \underline{105.23}X_1 + 12.76X_3 + 26.27X_6 + \underline{4{,}395.15}X_{12}; \qquad R^2 = .91.$$

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[10] Ibid., p. 11.

There was no basis for excluding year of sale from the analysis in this watershed, since year of sale is significant in the equation for Rainy Mountain Watershed (Appendix C). Also, two of the four independent variables remaining in the equation have coefficients that are not significantly different from zero.

The revenue regression model applied directly to the data for Saddle Mountain Watershed fails to give satisfactory results, and the number of sales is insufficient for fitting an equation for before protection and another for after protection similar to equation (3.2) and (3.3). However, there is an alternative means by which the effects of flood protection can be estimated.

Equation (3.2), the regression for protected watersheds before protection occurred, provides estimates of coefficients that are applicable to Saddle Mountain Watershed for the period of time before protection was provided. If flood protection has not significantly increased land values in Saddle Mountain Watershed, equation (3.2), where X_7 and $X_8 = 0$, should provide good estimates of revenue from land sales in Saddle Mountain Watershed, both before and after flood protection. On the other hand, if land values have increased by a significant amount as a result of protection the equation will not estimate accurately for sales that occurred after protection.

The specific procedure for accomplishing the above test is as follows:

(1) Compute $Z = Y - \hat{Y}$ for each sale that has occurred before and after flood protection using coefficients from equation (3.2).[11]

(2) Test for a significant trend in the Z's for before and after protection regressed on year of sale, X_5.

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[11] $\hat{Y}$ is the sale price estimated by equation (3.2) and Y is the observed price.

A significant positive trend in the Z's after protection would suggest that flood protection has increased land values.

The equation for sales before protection is:

$$(3.10) \qquad \hat{Z}_B = 1,387.55 - 210.29X_5$$

where $\hat{Z}_B = Y_{3B} - \hat{Y}_{3B}$

The b coefficient is not significantly different from zero. However, there is a positive trend in the Z's for sales that occurred in Saddle Mountain Watershed after protection occurred. The equation for after protection is:

$$(3.11) \qquad \hat{Z}_A = -28,637.18 + \underline{2,397.93}X_5.$$

The large negative intercept is due to extrapolation of a positive trend over the observed range of year of sale, to year zero. For example, the value of $\hat{Z}_A$ for 1958, the year protection occurred is:

$$\hat{Z}_A(12) = 137.98.$$

Analysis of variance indicates that the regression equation for sales before protection (3.10), differs significantly from the regression for after protection. Results of the test for difference are shown in Table V.

Equation (3.11) estimates that flood protection has increased land values $50.76 per acre of flood plain land.[12] The Soil Conservation Service estimate of benefits per flood plain acre capitalized at five per-cent in perpetuity is $97.80 or almost twice the regression estimate. If a capitalization rate of 9.63 is assumed, the present value of average annual benefits estimated by the Soil Conservation Service capitalized

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[12]This estimate was derived by dividing the coefficient for X_5 in equation (3.11) by the mean acres of flood plain (49.24 acres).

TABLE V

ANALYSIS OF VARIANCE FOR TESTING FOR DIFFERENCE IN REGRESSION EQUATIONS (3.10) AND (3.11)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Squares
Total	860,893,115	28	
SSR_T		1	
SSD_T	825,617,086	27	
SSD_B	241,678,375	13	
SSD_A	384,399,523	12	
$SSD_B + SSD_A$	626,077,898	25	25,043,116
$SSD_T - (SSD_B + SSD_A)$	199,539,188	2	99,769,594
$F = \frac{99,769,594}{25,043,116} = 3.98$		$F_{(.05)} = 3.38$	

in perpetuity is approximately the same as the regression estimate. Regression analysis of the data for Saddle Mountain Watershed suggests that the flood protection provided in 1958 has resulted in benefits that have been capitalized into land values.

Summary of Regression Analysis

The statistical analysis was designed to give empirical estimates of the effects of watershed development upon the revenue obtained from the sale of affected land. The statistical model postulated in Chapter II was employed for this purpose. The model was adapted to fit the particular equations presented in the various sections of the chapter. Parameters of the land value structure within the six watershed areas included in this study were estimated. These estimates seem to meet the requirements necessary for the model to be useful for empirical estimation.

The data from all protected watersheds were divided into sales that occurred before flood protection and sales that occurred after protection and a test made for differences between regressions fitted to the two groups of data. The result of the test indicates that the regression estimating land value after protection differed significantly from the regression estimating land values before protection. This is consistent with the hypothesis that direct agricultural benefits are capitalized into land values.

Tests for significant increases in land values in the separate protected watersheds following flood protection were made. A regression, including a zero-one or dummy variable to take account of flood protection, was fitted to data for each of the protected watersheds. High intercorrelation between year of sale and the dummy variable for flood protection was a problem in this analysis. In one case, one of the problematic variables could logically be dropped from the model, in another, interdependent variables were combined into one variable and the equation estimated. The hypothesis that land values have increased as a result of watershed development for flood protection fails to be rejected in Saddle Mountain and Barnitz Creek Watersheds. However, the regression analysis provided no evidence that land values in Cavalry Creek Watershed had been significantly affected following flood protection. However, there is reason to expect that benefits from flood protection had been capitalized into land values prior to the time that flood protection, provided in 1956, actually occurred. Some degree of protection from flooding had occurred by 1948 in Cavalry Creek Watershed, and it is likely that landowners in the area considered the protection provided in 1956 as a continuation of the previous watershed development.

The best estimates of the increase in land values following flood protection based on the regression analysis are $121.27 per acre of flood plain in Barnitz Creek Watershed, $50.76 per flood plain acre in Saddle Mountain Watershed, and no increase in land values in Cavalry Creek Watershed.

The regression estimates are discussed further in the summary to Chapter IV. This summary will include a comparison of regression estimates with those obtained from linear programming of typical resource situations within the protected watershed. The programming analysis and results are presented in Chapter IV.

CHAPTER IV

LINEAR PROGRAMMING ANALYSIS AND RESULTS

The purpose of this chapter is to estimate directly the changes in the productivity value of farm real estate resulting from watershed development for flood prevention.[1] The previous chapter estimated these changes indirectly through their effect on the revenue from sales of farm land. The analysis is confined to the three protected watersheds (Barnitz, Cavalry, and Saddle Mountain). However, implications of the analysis are relevant to other similar watersheds.

The chapter is divided into four sections. First of all, estimates of returns to land, labor, capital, and management, both before and after flood protection are obtained for each resource situation programmed in the respective watersheds. Changes in returns to land and changes in the levels of resources used as a result of flood protection are estimated, and estimates of the capitalized value of changes in returns to land per acre of flood plain are obtained for each resource situation programmed. The estimates are weighted by acres of flood plain represented by each resource situation such that the weighted estimates are general for the respective watersheds. These analyses are presented in the first section of the chapter and constitute the programming model.

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[1]Farm real estate, as used in this chapter, refers to land and buildings including all rights inherent in the institution of property in land.

The results of the programs are presented in tabular form and are analyzed in the second section. A summary of the programming analysis makes up the third section and a comparison of estimates obtained in the second section of this chapter with those obtained with regression analysis in Chapter III, constitutes the final section.

The Programming Model

This chapter uses the programmed farm plans from a study of changes in land use following watershed development for flood protection.[2] In general, farm plans and corresponding returns were derived by means of a linear programming model that maximizes returns from a selected set of enterprise activities, subject to assumed restrictions.

Data

Information for the respective watersheds on flood damage, soil productivity, and yield was obtained from the Soil Conservation Service. Information concerning farm resource situations for the programming analysis, existing land use, farm enterprises, and other farm characteristics was obtained by a survey of farms in the area conducted in June and July of 1962 by the Agricultural Economics Department, Oklahoma State University in cooperation with the Economic Research Service, United States Department of Agriculture. Information about the entire farm unit was obtained from the farm operators interviewed.

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[2]Neil R. Cook, "Effects of Upstream Flood Protection on Land Use in the Upper Washita River Basin of Oklahoma" (unpub. Ph.D. dissertation, Oklahoma State University), 1964.

Sampling Procedure

A major objective of the sampling procedure was to insure that typical resource situations developed from the farm survey information were representative with respect to flood plain land. The typical flood plain is wider toward the mouth of a stream than at the head. However, the width of a particular flood plain may be very irregular. The sample was made representative with respect to flood plain width by stratifying the flood plain into widths of: (1) less than one-eighth mile; (2) one-eighth to one-fourth mile; and (3) one-fourth mile or more. An equal number of sampling units was selected at random from each width category. All farmers who operated flood plain land adjacent to the sample line segments were interviewed. Eighty useable schedules were obtained in the three protected watersheds. It was assumed that the number of acres of cultivable land in the sample farms was independent of the width classification.

Typical Resource Situations

The sample farms were classified according to the total acres of cultivable land. Cultivable land was used as a basis for classification rather than farm size since flood damages are highest for the more intensive cultivated crops and the amount of cropland may affect the willingness and ability to adjust farm organization following flood damage reduction.

Farms in Barnitz Creek watershed with less than 200 acres of cultivable land are referred to in this study as "small" farms and those with more than 200 acres of cultivable land as "large" farms. In Cavalry and Saddle Mountain watersheds, "small" and "large" farms are those with less than 300 and more than 300 acres of cultivable land, respectively. Small farms in Cavalry Creek were further divided into those with a ratio of cultivable bottomland to total cultivable land of one-third or more, and farms with a ratio of less than one-third cultivable bottomland to total cultivable land. Characteristics of the sample farms that fell into each category were averaged to obtain typical resource situations. Land resources of the typical situations were further broken down into productivity classes. Bottomland soils were divided into two classes of cultivable land (Bottomland 1 and Bottomland 2) and one class of range. Likewise, the upland was divided into two classes of cultivable land (Upland 1 and Upland 2) and two classes of range. Soils included in each productivity class were selected with the help of soil scientists in the area. Yield information for the various soils was obtained from the Soil Conservation Service. Yields used for each productivity class were weighted averages of yields for the soil types included in each class. Bottomland yields were those expected under flood free conditions.

All bottomland on the farms surveyed was assumed to be flood plain land since bottomland more nearly corresponded to the amount of flood plain land in the respective watersheds as delineated by the Soil Conservation Service, than did the land designated as flood plain in the descriptive legend of the county soils reports.

Range was converted to animal unit months of grazing (AUM).[3] Animal unit months are adjusted for the distribution of range quality in each

[3]An animal unit month is defined as the amount of grazing required by the average cow for a one month period.

resource situation. The resource situations programmed for the protected watersheds are shown in Table VI.

Crop and Livestock Enterprises

Enterprise budgets were developed for major enterprises found in the area under study. They include wheat, cotton, grain sorghum, barley, oats used for grain and pasture, alfalfa, forage sorghum, small grain for pasture, sudan, Johnson grass, variable range, and various livestock enterprises such as stocker and cow-calf operations. Enterprise budgets used for this study were modifications of budgets developed for Southern Regional Research Project S-42[4] and by Dale O. Anderson and W. B. Back.[5] Budget modifications included changes in yields and, therefore, harvesting costs, and changes in the assumed amount of custom operations. Based upon the large amount of family labor used on the farms surveyed and the

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[4]The S-42 studies referred to are: 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 Experiment Station in Cooperation with U.S.D.A., Processed Series P-369 (Stillwater, 1961); Larry J. Connor, William F. Lagrone, and James S. Plaxico, _Resource Requirements, Costs, and Expected Returns; Alternative Crop and Livestock Enterprises; Loam Soils of the Rolling Plains of Southwestern Oklahoma_, Oklahoma Agricultural Experiment Station in cooperation with U.S.D.A., Processed Series P-368 (Stillwater, 1961); and 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 Experiment Station in Cooperation with U.S.D.A., Processed Series P-357 (Stillwater, 1960).

[5]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.

TABLE VI

TYPICAL RESOURCE SITUATIONS IN BARNITZ, CAVALRY, AND SADDLE MOUNTAIN WATERHSEDS

Item	Unit	Barnitz Creek		Cavalry Creek			Saddle Mountain	
				Less Than 300 Acres				
		Less Than 200 Acres	More Than 200 Acres	Less Than 1/3 Bottomland	More Than 1/3 Bottomland	More Than 300 Acres	Less Than 300 Acres	More Than 300 Acres
Cultivable Land	Acres	125	463	139	146	452	157	564
Bottomland 1	Acres	29	74	8	33	42	30	83
Bottomland 2	Acres	48	120	20	75	99	48	129
Upland 1	Acres	22	121	56	15	124	12	53
Upland 2	Acres	26	148	55	23	187	67	299
In Gov't. Program	Acres	17	63	23	24	85	47	108
Range	AUM	141	504	74	66	107	140	324
	(Acres)	(179)	(632)	(95)	(84)	(142)	(221)	(537)
Family Labor	Hours	2,238	2,238	2,966	2,966	2,966	2,531	2,531
Dec.-April	Hours	724	724	821	821	821	602	602
May-June	Hours	447	447	715	715	715	608	608
July-Aug.	Hours	489	489	740	740	740	663	663
Sept.-Nov.	Hours	578	578	690	690	690	658	658

relatively small amount of custom work reported, it was assumed that the only custom operation in the area was stripping cotton and that two-thirds of the cotton harvested was custom stripped.

Livestock enterprises in the watersheds vary among farms and for particular farms from year to year. Several of the more stable livestock enterprises were included in the study. Cow-calf enterprises with various range, temporary pasture, and purchased forage requirements are represented. Feeder enterprises that make use of wheat pasture and other temporary pasture along with range requirements were included.

Quantity weighted averages of monthly 1961 prices were used for product prices. A list of the product prices used is given in Appendix F, Table II. Costs used in this study were those assumed in the S-42 studies.[6]

Restrictions

Land--Land resources entered the programs as a nonpriced factor of production. Since there were no provisions for buying or renting additional land, this resource was restricted to the acreages of the various land classes present in the typical resource situations (Table VI). As was discussed above, range land entered the programs as animal unit months rather than as acres.

It was assumed that the amount of land allocated to government programs, such as the conservation reserve was independent of watershed development and would, therefore, remain unchanged over the levels of flood damage. An alternative assumption would have been that acreage in

[6]The S-42 studies referred to are listed in Footnote 4 of this chapter.

such government programs was positively correlated with the degree of flood damage. However, information required to test such an hypothesis was not available.

Labor--Family labor entered the programs at zero cost. The amount of family labor assumed to be available in each time period was based upon family labor reported to be available in the survey of farmers in the area. It was assumed that one-third of the operator's labor would be required for activities not included in budget requirements. Therefore, the labor reported to be available by the operator was reduced by one-third for each of the respective resource situations programmed. In addition to family labor available, it was assumed that additional labor could be hired in any period at a cost of $1.00 per hour.

Capital--The amount of nonland capital available was assumed to be unlimited. The only restriction placed on capital use is the rate of return required. The required rates of return on capital vary among watersheds and among resource situations within watersheds. The rate of return assumed for a particular resource situation was that rate resulting in programmed land use closely approximating existing land use.

Restricting capital in this manner tends to make the programming model predictive in nature. An attempt was made to approximate present land use by varying the cost of family labor as well as capital. However, land use was so sensitive to family labor charges that this approach was abandoned. Capital costs were assumed to remain constant from unprotected to protected conditions so that differences in returns and farm organization are the result of flood protection alone.

The specific capital charges so derived were 24 percent for Barnitz Creek farms, 17 percent for Saddle Mountain farms, 24 percent for small Cavalry Creek farms, and 21 percent for large farms in Cavalry Creek Watershed. The above rates were charged on total nonland capital rather than on annual capital.[7]

Technology and Management--The level of management assumed was intended to approximate the level existing in the area under study. The level of management enters the programming model primarily through yields and farm management practices used in the various enterprise budgets. It was assumed that the level of management did not change from unprotected to protected conditions. This assumption implies that farm operators did not change their management practices for a particular enterprise as a result of flood protection. For example, if cotton grown on flood plain land was cultivated five times under protected conditions, it was assumed that it was cultivated five times under unprotected conditions. Whether flood protection results in an increase (or decrease) in the intensity of crops grown on flood plain land before protection is a question that requires further research, but was considered to be beyond the scope of this study.

The survey of farmers in the area indicated that large tractors were usually available on small as well as large farms. Therefore, four-row equipment was assumed to be available for each resource situation programmed.

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[7]Total nonland capital is the capital required for the programmed farm organization for the entire year. Annual nonland capital is total nonland capital multiplied by the fraction of the year that capital is actually used.

Protected Versus Unprotected Conditions

Protected conditions means the present state of the watersheds analyzed in this chapter, all three of which have had watershed development for flood protection. This does not imply that flooding never occurs in a protected watershed. The watershed development program does not attempt to give absolute flood protection, rather it attempts to substantially reduce the flood menace.

Unprotected conditions are inferred for watersheds actually protected from flooding by making use of damage factors developed by the Soil Conservation Service for each watershed. These damage factors are the yield reductions expected for a composite acre of the watershed. The factors were modified for programming purposes to an individual crop basis from the watershed composite acre. The frequency of flooding, time of flooding, and the depth of innundation are incorporated in these damage factors for each watershed. The damage factors used in the programming analysis are shown in Appendix F, Table I.

Damage factors do not take into account all damages that occur as a result of flooding. Flood plain scour, "other" agricultural damage, and sediment damage are not accounted for in the damage factors. However, reduction in crop and pasture damage and the benefits from changes in land use make up 74 percent of direct agricultural benefits in the watersheds under study. Table VII gives a break-down of benefits on a per acre of flood plain basis. It was assumed that benefits from reduction in flood plain scour, reduction in sediment damage, and reduction in "other" agricultural damage will accrue to flood plain land owners since ownership alone is sufficient for receiving these benefits. On the other hand,

TABLE VII

SOIL CONSERVATION SERVICE ESTIMATES OF BENEFITS PER ACRE OF FLOOD PLAIN FROM WATERSHED DEVELOPMENT

Watershed	Benefits from Change in Land Use and Reduction in Crop and Pasture Damage	Benefits from Reduction in Flood Plain Scour, Sediment Damage, and Other Agricultural Damage	Total Direct Agricultural Benefits
	- Dollars Per Acre -		
Three watersheds	11.90	4.13	16.03
Barnitz	17.98	4.39	22.37
Cavalry	10.69	6.24	16.93
Saddle	2.82	2.07	4.89

Source: The data in this table were computed from information contained in Work Plans prepared by the Soil Conservation Service for each of the watersheds.

benefits from reduction in crop and pasture damage and land use changes may involve changes in other resource use such as labor and capital and, thus, these benefits may accrue to one or more of these resources.

The programming results and the implications of the crop and pasture damage factors with respect to returns to resources are presented in the next section.

Programming Results

Returns to and levels of resource use for Barnitz, Cavalry, and Saddle Mountain watersheds for unprotected and protected conditions are shown in Table VIII. Capital costs and the cost of hired labor charged in the programs have been added back so that the programmed income reported is returns to land, labor, capital, and management.

Resource Levels

The amount of land used remains the same from unprotected to protected conditions, consistent with information obtained from the farm survey of the area. Changes in returns are the result of some combination of reduction in crop and pasture damages, changes in land use, and changes in the levels of labor and capital used in conjunction with land resources. These changes have been summarized in Table IX. Changes in labor and capital use, relative to the amounts used before protection, are probably insignificant with the possible exceptions of the 11.5 percent increase in labor in the large Barnitz Creek farms and the 7.6 percent increase in capital used in small Cavalry Creek farms with less than one-third bottomland. The increase in labor use in the large Barnitz Creek farms is likely associated

TABLE VIII

PROGRAMMED RETURNS TO LAND, LABOR, CAPITAL, AND MANAGEMENT; LEVEL OF RESOURCE USE, BY TYPICAL RESOURCE SITUATION, BY WATERSHED, UNPROTECTED AND PROTECTED CONDITIONS

		Barnitz Creek		Cavalry Creek			Saddle Mountain	
				Less Than 300 Acres				
Item	Unit	Less Than 200 Acres	More Than 200 Acres	Less Than 1/3 Bottomland	More Than 1/3 Bottomland	More Than 300 Acres	Less Than 300 Acres	More Than 300 Acres
				UNPROTECTED CONDITIONS				
Returns to Land, Labor, Capital and Management	Dol.	3,715	11,838	4,671	4,765	12,372	4,776	13,554
Land Used	Ac.	304	1,097	234	230	594	378	1,101
Labor Used	Hr.	1,050	2,258	1,064	795	2,479	886	2,381
Capital Used	Dol.	6,741	19,714	9,068	5,233	15,590	6,083	17,590
				PROTECTED CONDITIONS				
Returns to Land, Labor, Capital and Management	Dol.	5,001	15,464	5,088	5,698	13,654	5,126	14,386
Land Used	Ac.	304	1,095	234	230	594	378	1,101
Labor Used	Hr.	1,025	2,517	1,074	795	2,479	901	2,425
Capital Used	Dol.	6,430	20,103	9,755	5,233	15,590	5,945	17,324

TABLE IX

CHANGE IN PROGRAMMED RETURNS TO LAND, LABOR, CAPITAL, AND MANAGEMENT; AND CHANGES IN RESOURCE USE FROM UNPROTECTED TO PROTECTED CONDITIONS, BY TYPICAL RESOURCE SITUATION, BY WATERSHED

Item	Unit	Barnitz Creek		Cavalry Creek			Saddle Mountain	
				Less Than 300 Acres				
		Less Than 200 Acres	More Than 200 Acres	Less Than 1/3 Bottomland	More Than 1/3 Bottomland	More Than 300 Acres	Less Than 300 Acres	More Than 300 Acres
Change in								
Returns to Land, Labor, Capital and Management	Dol.	1,286	3,626	417	933	1,282	350	832
Land Used	Ac.	0	0	0	0	0	0	0
Labor Used	Hr.	-25	259	10	0	0	15	44
Capital Used	Dol.	-311	389	687	0	0	-138	-266
Percent Change in*								
Returns to Land, Labor, Capital, and Management	Pct.	34.6	30.6	8.9	19.6	10.4	7.3	6.1
Land Used	Pct.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Labor Used	Pct.	-2.4	11.5	0.9	0.0	0.0	1.7	1.8
Capital Used	Pct.	-4.6	2.0	7.6	0.0	0.0	-2.3	-1.5

*Change from unprotected to protected as a percentage of unprotected returns or resources used.

with the shift of cotton acreage from upland to bottomland following flood protection, since bottomland cotton is assumed to require more labor than upland cotton. Changes in capital used in the small Cavalry Creek farms are a result of an increase in livestock following flood protection. Programmed farm organizations for unprotected and protected conditions are given in Appendix F, Tables VI-XII.

Resource Returns

Returns to land and management, labor, and capital for unprotected and protected conditions, assuming a labor cost of $1.00 per hour and two capital cost situations, are given in Tables X and XI, respectively. The two capital cost situations are: (1) the rates charged in the programs; and (2) 6 cents per dollar of capital. Returns to land and management are dependent upon the rather arbitrary assumptions as to the unit price of capital and labor.[8] For this reason returns per acre of land were not computed. However, returns to land and management, labor, and capital are reported in order that returns to any resource can be computed for alternative assumptions about prices of labor and capital.

Changes in returns to land following flood protection for both capital cost situations are shown in Table XII. These increased returns to land are independent of returns to management under the assumption that the quality and level of management and, therefore, returns to management are unchanged following flood protection. Changes in returns per acre of flood plain land are computed by dividing the increase in land returns by the

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[8]Returns to land and management are the residual programmed income after each unit of capital and labor are paid their assumed unit prices.

TABLE X

PROGRAMMED RETURNS TO LAND AND MANAGEMENT, LABOR, AND CAPITAL, FOR SPECIFIED LABOR AND CAPITAL CHARGES, BY TYPICAL RESOURCE SITUATION, BY WATERSHED, UNPROTECTED CONDITIONS

Item	Barnitz Creek		Cavalry Creek			Saddle Mountain	
			Less Than 300 Acres				
	Less Than 200 Acres	More Than 200 Acres	Less Than 1/3 Bottomland	More Than 1/3 Bottomland	More Than 300 Acres	Less Than 300 Acres	More Than 300 Acres
			- Dollars -				
Returns to Land and Mgmt., Labor, and Capital	3,715	11,838	4,671	4,765	12,372	4,776	13,554
Returns to Labor at $1.00 per Hour	1,050	2,258	1,064	795	2,479	886	2,381
Returns to Capital[a]	1,618	4,731	2,176	1,256	3,274	1,034	2,990
Returns to Capital[b]	404	1,183	544	314	935	365	1,055
Returns to Land and Mgmt.[a]	1,047	4,849	1,431	2,714	6,619	2,856	8,183
Returns to Land and Mgmt.[b]	2,261	8,397	3,063	3,656	8,958	3,525	10,118

[a]These returns assume programmed capital charges. The charges are 24 percent for Barnitz Creek farms and small Cavalry Creek farms, 21 percent for large Cavalry Creek farms, and 17 percent for Saddle Mountain farms.

[b]These returns assume capital cost of 6 percent.

TABLE XI

PROGRAMMED RETURNS TO LAND AND MANAGEMENT, LABOR, AND CAPITAL, FOR SPECIFIED LABOR AND CAPITAL CHARGES, BY TYPICAL RESOURCE SITUATION, BY WATERSHED, PROTECTED CONDITIONS

Item	Barnitz Creek		Cavalry Creek			Saddle Mountain	
			Less Than 300 Acres				
	Less Than 200 Acres	More Than 200 Acres	Less Than 1/3 Bottomland	More Than 1/3 Bottomland	More Than 300 Acres	Less Than 300 Acres	More Than 300 Acres
	- Dollars -						
Returns to Land and Mgmt., Labor and Capital	5,001	15,464	5,088	5,698	13,654	5,126	14,386
Returns to Labor at $1.00 per Hour	1,025	2,517	1,074	795	2,479	901	2,425
Returns to Capital[a]	1,543	4,825	2,341	1,256	3,274	1,011	2,945
Returns to Capital[b]	386	1,206	585	314	935	357	1,039
Returns to Land and Mgmt.[a]	2,433	8,122	1,673	3,647	7,901	3,214	9,016
Returns to Land and Mgmt.[b]	3,590	11,741	3,429	4,589	10,240	3,868	10,922

[a]These returns assume programmed capital charges. The charges are 24 percent for Barnitz Creek farms and small Cavalry Creek farms, 21 percent for large Cavalry Creek farms, and 17 percent for Saddle Mountain farms.

[b]These returns assume capital cost of 6 percent.

TABLE XII

CHANGES IN PROGRAMMED RETURNS TO LAND FROM UNPROTECTED TO PROTECTED CONDITIONS FOR SPECIFIED CAPITAL AND LABOR CHARGES, CHANGES IN RETURNS PER ACRE OF FLOOD PLAIN LAND, AND CAPITALIZED VALUE OF CHANGES IN RETURNS PER ACRE OF FLOOD PLAIN LAND, BY TYPICAL RESOURCE SITUATION, BY WATERSHED

	Barnitz Creek		Cavalry Creek			Saddle Mountain	
			Less Than 300 Acres				
Item	Less Than 200 Acres	More Than 200 Acres	Less Than 1/3 Bottomland	More Than 1/3 Bottomland	More Than 300 Acres	Less Than 300 Acres	More Than 300 Acres
			- Dollars -				
Change in:							
Returns to land[a]	1,386.00	3,273.00	242.00	933.00	1,282.00	358.00	833.00
Returns to land[b]	1,329.00	3,344.00	366.00	933.00	1,282.00	343.00	804.00
Returns per acre of flood plain[a]	17.54	14.68	6.91	6.81	7.82	3.44	2.88
Returns per acre of flood plain[b]	16.82	15.00	10.46	6.81	7.82	3.33	2.78
Returns capitalized at 5 percent[a]	350.80	293.60	138.20	136.20	156.40	68.80	57.60
Returns capitalized at 5 percent[b]	336.40	300.00	209.20	136.20	156.40	66.60	55.60

[a]These returns assume programmed capital charges. The charges are 24 percent for Barnitz Creek farms and small Cavalry Creek farms, 21 percent for large Cavalry Creek farms, and 17 percent for Saddle Mountain farms.

[b]These returns assume capital cost of 6 percent.

number of flood plain acres within each of the respective resource situations. While returns to land were highly sensitive to the costs of labor and capital assumed, changes in returns to land were affected much less by such assumptions.

Capitalized Values of Increase in Return

In order to estimate the capitalized value of increases in returns per acre of flood plain land, a capitalization rate must be assumed. A rate of five percent was assumed in this study, however, sufficient information is given such that alternative rates can easily be applied. The capitalization procedure assumes that there was no increase in annual expenses associated with flood plain land ownership as a result of flood protection. This assumption probably holds for the short-run but not in the long-run. For example, as land values increase as a result of flood protection benefits, taxes on land will be increased and, thus, a portion of the benefits of flood protection to flood plain landowners may go to cover such an increase in expenses.

Next, the change in return to land per acre of flood plain and its capitalized value were allocated to each protected watershed on the basis of their flood plain acres and resource situations. These estimates for both capital cost situations are given in Table XII along with the associated changes in the amount of labor and capital used.

It appears that changes in returns to land on a per acre of flood plain basis (Table XIII) account for the benefits from reduction in crop and pasture damage and changes in land use as estimated by the Soil Conservation Service (Table VII). Returns to land are slightly lower in

TABLE XIII

THE PROGRAMMED EFFECTS OF FLOOD DAMAGE REDUCTION AND LAND USE CHANGE FROM FLOOD PROTECTION IN THREE WATERSHEDS

Watershed	Estimated Changes after Flood Protection: Returns to Land: Annually Per Acre of Flood Plain Land	Returns to Land: Capitalized Value at Five Percent	Levels of Nonland Factors: Labor	Levels of Nonland Factors: Capital
	- Dollars Per Acre -		(Hours)	(Dollars)
Barnitz	15.16[a] 15.30[b]	303.20[a] 306.00[b]	156.44	136.22
Cavalry	7.55[a] 7.77[b]	151.00[a] 155.40[b]	2.33	160.30
Saddle	3.07[a] 2.96[b]	61.40[a] 59.20[b]	27.43	-192.86

[a]These returns assume programmed capital charges. The charges are 24 percent for Barnitz Creek farms and small Cavalry Creek farms, 21 percent for large Cavalry Creek farms, and 17 percent for Saddle Mountain farms.

[b]These returns assume capital cost of 6 percent.

both Barnitz and Cavalry Creek watersheds, but exceed estimated benefits in Saddle Mountain watershed. This strongly supports the hypothesis that benefits of flood protection accrue as income to land and will likely be capitalized into land values.

The capitalized returns to land were rather stable within watersheds, even though two levels of capital costs were imposed. However, the capitalized value of the change in returns per acre of flood plain land, assuming six percent capital cost, was less than the corresponding value assuming programmed capital charges in Saddle Mountain Watershed where the level of capital use declined following flood protection. This follows from land receiving the residual returns, and the lower the capital cost the smaller the increment to land for a given decrease in capital use.

Direct Benefits from Protection

In order to estimate the effects of total direct agricultural benefits from flood protection upon land values, it was necessary to employ an assumption made earlier in this chapter. This assumption was that benefits from reduction in sediment damage, reduction in flood plain scour, and reduction in "other" agricultural damage, will accrue to flood plain land. Estimates of direct agricultural benefits and the capitalized value of these benefits per acre of flood plain land are presented in Table XIV.

The changes in returns per acre are consistent in relative magnitude between the watersheds with the crop and pasture damage factors estimated by the Soil Conservation Service. This result is not surprising given the programming model and the fact that the programmed results call for little change in labor or capital use.

TABLE XIV

THE PROGRAMMED EFFECTS OF TOTAL DAMAGE REDUCTION LAND USE CHANGE AND OTHER BENEFITS FROM FLOOD PROTECTION IN THREE WATERSHEDS

Watershed	Changes in Returns Per Flood Plain Acre	Value of Change in Returns Capitalized at 5 Percent
	(Dollars Per Acre)	(Dollars)
Barnitz	19.55[a]	391.00[a]
	19.69[b]	393.80[b]
Cavalry	13.79[a]	275.80[a]
	14.01[b]	280.20[b]
Saddle	5.14[a]	102.80[a]
	5.03[b]	100.60[b]

[a]These returns assume programmed capital charges. The charges were 24 percent for Barnitz Creek farms and small Cavalry Creek farms, 21 percent for large Cavalry Creek farms, and 17 percent for Saddle Mountain farms.

[b]These returns assume capital costs of 6 percent.

Effect of Arbitrary Prices Used

The distribution of income between land (and management), labor, and capital was based upon rather arbitrary prices for labor and capital. A price of $1.00 per hour for family labor may be somewhat high in view of the relatively large amount available and the lack of off-farm employment in the area. Also, when a charge of $1.00 for family labor was included as a restriction on family labor use, low quality land was left idle in the programmed results which is inconsistent with actual land use. The programmed capital costs represent the required rates of return on capital so that programmed land use closely approximated present land use when family labor is considered a free resource. The capital cost of six percent was assumed to represent a minimum charge that must be paid on all borrowed capital, but may be well below the rate of return necessary to induce farmers to use capital in quantities presently being employed in the area.

While returns to land depend upon the prices of labor and capital assumed, changes in returns to this resource are dependent only upon changes in the amount of labor and capital used. In other words, returns to land following flood protection vary only as the amount of labor and capital used vary under the constant price assumptions. In effect, this reduces the importance of the somewhat arbitrary prices of labor and capital used in imputing changes in returns to land.

Summary of Programming Implications

Implications of the programming analyses are that by far the major portion of direct agricultural benefits resulting from flood protection accrues to the land protected from flooding. This analysis assumes that prices of labor and capital, and the level and quality of management are unaffected by watershed development. Assuming a constant price for labor and capital seems warranted in view of the relatively small changes in the amounts used from unprotected to protected conditions. The amount of labor used increases in each watershed following flood protection; however, the farm survey results indicate that much more labor is available on a yearly basis than is required by the programmed farm organizations for protected conditions.

The amount of capital used increased in Barnitz and Cavalry Creek Watersheds after protection and decreased in Saddle Mountain Creek. However, the changes in amount used were so small as to be insignificant. Whether or not flood protection reduces risk sufficiently to lower the required rate of return such that farmers would employ more capital is a question that requires further research. The basis for the constant capital charge assumed in this study was that the programming model adequately predicted actual land use in watersheds that have not been developed for flood protection as well as in protected watersheds.

Comparison of Programmed and Regression Estimates

The effects of flood protection on land values have been estimated by regression analysis of farm sales data and by programming analysis of resource situations representative of three protected watersheds. The major difference in these models is that the regression model is independent of estimated benefits of flood protection in that it estimates the change in actual sales price following protection. On the other hand, estimates obtained from the programming model are based upon flood damage factors estimated by the Soil Conservation Service.

Estimates of the increase in value per acre of flood plain land as a result of all direct benefits from flood protection using both models are shown in Table XV. The regression estimate for Cavalry Creek is likely due to program benefits being anticipated as was discussed in Chapter III. The regression estimate is approximately 30 percent of the increase per flood plain acre estimated by programming analysis for Barnitz Creek and about 50 percent of the programmed estimate for Saddle Mountain Watershed.

There are at least two possible explanations for the large discrepancy between estimates obtained by the two models. First, in order for the regression analysis to estimate the effects of flood protection benefits, such benefits must have been reflected through the land market. It is possible that insufficient time had elapsed for the full effects of flood protection to be reflected by the land market. However, this possibility is weakened somewhat by the apparent anticipation of benefits in Cavalry Creek Watershed.

A second possible explanation is that the annual beneifts from flood protection are overestimated by the Soil Conservation Service. The benefit-cost estimating procedures used by the Soil Conservation Service provide ample opportunities for errors to be made. Local pressures for a share of the scarce funds provided for watershed development projects

TABLE XV

COMPARISON OF ESTIMATES OF THE EFFECTS OF FLOOD PROTECTION ON THE VALUE PER ACRE OF FLOOD PLAIN LAND, BY WATERSHED[a]

Watershed	Estimated Increase in Value Per Acre: Regression	Estimated Increase in Value Per Acre: Programming
	- Dollars Per Acre -	
Barnitz	121.27	391.00[b] 393.80[c]
Cavalry	0.00	275.80[b] 280.20[c]
Saddle	50.76	102.80[b] 100.60[c]

[a]The programming estimates are a result of estimated direct agricultural benefits of flood protection.

[b]These estimates assume programmed capital charges. The charges are 24 percent for Barnitz Creek farms and small Cavalry Creek farms, 21 percent for large Cavalry Creek farms, and 17 percent for Saddle Mountain farms.

[c]These returns assume capital cost of 6 percent.

are also present. Inadequate data and other sources of error in the estimation procedure for benefit-cost ratios are discussed in Task Force Report on Water Resources and Power.[9]

In a study of Barnitz Creek Watershed, Clarenbach states that the Soil Conservation Service estimates of direct agricultural benefits are almost three times the net "flood free" returns to land of approximately equal productive capacity which he reports to be $7.00 or $8.00 per acre.[10] The upper limit of benefits from flood protection is, of course, set by the returns to comparable land not subject to flooding.

Even though there is a large difference in estimates of the value of flood protection obtained by regression and programming analysis, both procedures provide evidence that benefits have occurred following protection. The programming analysis indicates that by far the major portion of direct agricultural benefits turn up as income to land, and the regression analysis is consistent with the hypothesis that these benefits are capitalized into land values.

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[9]Fred A. Clarenbach, "Reliability of Estimates of Agricultural Damages from Floods," Commission on Organization of the Executive Branch of the Government: Task Force Report on Water Resources and Power (Washington, 1955), pp. 1277-1298.

[10]Ibid., p. 1292.

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of this study was to estimate the effects of watershed development for purposes of flood protection upon the productivity and market value of farm land.

Three pairs of watersheds were analyzed; Barnitz and Beaver Creeks, Cavalry and Boggy Creeks, and Saddle and Rainy Mountain Creeks, all sub-watersheds within the Washita River Basin of Oklahoma. Barnitz, Cavalry, and Saddle Mountain Watersheds were protected from flooding in 1954, 1956, and 1958, respectively. Beaver, Boggy, and Rainy Mountain Watersheds had been planned, but no flood prevention structures had been constructed at the time this study was made.

Farm sales data were collected from courthouse records. Information as to land quality was obtained from soils maps and from professional agricultural workers in the area. Data necessary for the programming analysis were collected by interviewing farm operators in the area. Enterprise budgets used in the programming analysis were adapted from those developed for use in other research projects for the geographical area.

The Regression Analysis

A Revenue Regression Model was used to analyze the farm sales data for various levels of aggregation. A multiple linear regression of all sales yielded estimates that were consistent with economic theory, statistically significant, and the model was sufficiently explanatory to render it useful in testing for effects of flood protection.

Sales that occurred in protected watersheds (Barnitz, Cavalry, and Saddle Mountain) were divided into those that occurred before the watersheds were developed for flood protection and those that occurred after flood protection. Regression analyses and analysis of variance indicated that the regression coefficients after protection differed significantly from the coefficients for unprotected sales. Inspection of coefficients in each equation revealed that the value of flood plain land increased after flood protection. These results are consistent with the hypothesis that benefits from flood protection are capitalized into the values of affected land.

Estimates of the market value of flood protection were obtained for each of the three protected watersheds. Flood protection was accounted for in the regression model by a "dummy" variable. The "dummy" variable technique assumes that all other parameters of the model are constant throughout the period covered by the data. An increase in land value as a result of flood protection in the individual protected watersheds is indicated by a significant positive coefficient for the "dummy" variable which implies a vertical shift in the regression surface. This model may tend to underestimate increases in land values that occur gradually over a period of time. For example, sales that occur during the period of adjustment before full capitalization of benefits, may result in benefits being underestimated. On the other hand, if benefits of flood protection are anticipated prior to actual project construction, capitalization of benefits may occur prior to watershed protection. Capitalization of anticipated benefits would also result in estimates that are below the actual price increase.

The hypothesis that land values have increased as a result of watershed development for flood protection fails to be rejected in Barnitz and Saddle Mountain Watersheds. However, the regression analysis provides no evidence that land values have been significantly affected by flood protection in Cavalry Creek Watershed. There is reason to suspect that expected benefits from flood protection were capitalized into land values prior to the time that flood protection, provided in 1956, actually occurred. Landowners in this watershed had invested in flood protection prior to the 1956 project and some flood protection was provided as early as 1948 under an earlier subwatershed project. It is likely that landowners considered the protection provided in 1956 as a continuation of the previous watershed development.

High intercorrelation between year of sale and the dummy variable for flood protection was a problem in the analysis of individual watersheds. This difficulty was overcome by either dropping one of the problematic variables from the analysis, or combining variables and re-running the analysis. The regression estimates of effects of flood protection on land values were $121.27 per acre of flood plain land in Barnitz Creek Watershed, $50.76 per flood plain acre in Saddle Mountain Watershed, and no increase in land values in Cavalry Creek Watershed.

The Programming Analysis

The purpose of the programming analysis was to estimate the change in the productivity value of land and other nonland resources assuming that flood damages estimated by the Soil Conservation Service are accurate. The programming model was made predictive by requiring a rate of return on nonland capital that resulted in programmed farm organizations that closely approximated current farm organizations in the protected watersheds under study. Unprotected conditions were imposed on the model by applying damage factors, in terms of yield reductions, to the crop and pasture enterprises. Programmed returns were imputed to labor, capital, and land and management for both unprotected and portected conditions.

The programmed returns were distributed among resources by paying labor and nonland capital their per unit prices with the residual going to land and management. The prices of labor and capital were assumed to remain constant from unprotected to protected conditions. The constant price assumptions seem warranted in view of the small changes in the amounts of labor and capital required as a result of protection. Two levels of capital costs were assumed and labor was priced at $1.00 per hour. The two capital charges were those charged in the programs as restrictions on capital use and six percent per dollar of nonland capital. It was assumed that the level and quality of management was unchanged by flood protection. Under this assumption, estimates of changes in returns to land are independent of returns to management.

The programming analysis indicates that by far the major portion of benefits from flood protection turn up as income to land. In cases where adjustments to flood protection result in increased total returns and a decrease in the amount of nonland resources used, land may even receive returns that were being paid to nonland resources prior to watershed development. The decrease in capital requirements in Saddle Mountain Watershed illustrates this point. Since the amount of labor and capital used changes very little as a result of flood protection, it follows that the increase in income to land in each watershed is consistent in size with the degree of estimated flood damages. Programmed estimates of the increase in returns to land as a result of crop and pasture damage reduction capitalized at five percent in perpetuity were obtained for each watershed. These estimates were $304.60 per acre of flood plain land in Barnitz Creek, $153.20 per acre of flood plain land in Cavalry Creek, and $60.30 per acre of flood plain land in Saddle Mountain Watershed.[1]

Evaluation of Procedures

Estimates of the effects of flood protection upon the returns to land and other nonland resources differ widely depending upon the model used. The regression model estimates the change in the derived demand for land following flood protection. This model assumed that nonland factors remained fixed following flood protection so that the derived demand for land was a function of land and product prices only. The linear programming model was based upon weaker assumptions about the underlying production function. Here it was assumed that the production

[1]These estimates are a simple average of those obtained using two levels of capital cost in the respective watersheds.

function is made up of a set of linear processes and is, therefore, linear and homogeneous. This model estimates a marginal value product of land that is a function of these optimum processes which are, in turn, functions of the nonland and land factors, as well as product and factor prices. Nonland factors are not assumed to remain constant in the programming model.

Another major difference in the two models concern flood protection, a variable critical to the analysis. Changes in returns to land estimated by the programming model depend upon crop and pasture damage factors estimated by the Soil Conservation Service. On the other hand, the regression model estimated changes in actual sales price of farm real estate and was, therefore, independent of the estimation of flood damages.

The regression estimates may be somewhat lower than actual increases in land prices. The model, as specified in this analysis, will tend to underestimate increases in land values that occur as a result of anticipated benefits being capitalized into land values prior to the time physical protection is provided. Also, if a long period of time is required for the total effects of flood protection to be reflected in the land market, the model may underestimate the total effects. However, such errors would likely be small relative to the differences between the regression and programming estimates. Overestimation of actual flood damages is a possible explanation for the discrepancies between estimates from the two models.

Analyses using both models indicate that benefits have occurred as a result of flood protection and that these benefits have been capitalized into land values. The programming analysis indicates that by far the major portion of flood protection benefits are in the form of increased returns to land.

Need for Further Research

The need for further research is implied by problems encountered in this study and the necessity of making rather arbitrary assumptions about potentially important variables. The regression analysis of this study was handicapped by the small number of farm sales that could be classified as bona fide sales based on information contained in courthouse records. All transactions that transferred title to land in the area under study could be verified by personal interview of the buyer or seller. Such a procedure would greatly increase the number of useable sales. In addition to increasing the number of useable sales, additional information could be obtained that would allow more complete specification of the regression model. For example, acreage allotments and number of acres in cultivation could be obtained along with more detailed information concerning the suitability of the land for agricultural purposes than can be obtained from soils maps. A larger number of usable sales would allow the time period covered by the analysis to be shortened, thereby, decreasing the probability of exogenous changes in the land market.

Additional information is needed concerning the length of time required for landowners to evaluate flood protection and to make the adjustments necessary to realize the full economic potential of watershed development.

The programming analysis implies large increases in the value of flood plain land following flood protection. Since this increase depends upon estimates of flood damage reduction, these estimates are critical to the analysis. Additional research is needed to provide more complete information about actual flood damages net of any beneficial effects of flooding. More accurate estimates of the physical damages caused by flooding and more complete information about the effects of flood risk on decisions by farm operators should lead to accurate estimates of effects of flood protection. At present these damage factors appear to be overestimated.

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A P P E N D I X E S

APPENDIX A

FARM SALES EXCLUDED FROM STUDY

A farm real estate sale was omitted from this study if it was found to have one or more of the following characteristics:

1. Sales of mortgaged property, unless the deed stated that the mortgage in terms of numbers of dollars was a part of the purchase price,
2. Sales that contained no flood plain land,
3. Foreclosure sales,
4. Sales that included personal property,
5. Sales of less than 20 acres of land,
6. Names of sellers and buyers suggest kinship, or the words "love and affection" were cited in the consideration,
7. Either buyer or seller was a corporation or an agent of government,
8. Only a partial interest was transferred,
9. Total acreage not given in deed, and the legal description inadequate to determine the number of acres in sale or its location,
10. Selling price not given in the deed, and there was no record of Federal taxes paid when the deed was recorded,
11. Not possible to identify the assessment record corresponding to the property transferred by the deed,
12. Sales to nonprofit institutions, and
13. Other evidence that the sale price was not true market value.

APPENDIX B

ESTIMATION OF SALE VALUE OF FARMS FROM FEDERAL TAXES ON DEEDS

Federal taxes at the rate of 55 cents per $500 of sale price (or fraction thereof) are collected on all deeds transferring title to farm real estate at the time the deeds are recorded. Revenue stamps in the amount of the Federal tax are affixed to the deed and provide a basis for estimating the sale price.

The last 55 cents of revenue stamps may represent a range of values from one dollar to $500 since many sales are not in even $500 amounts. Of all sales recorded from court house records, the sale price was cited in the deed for 252 sales. Inspection of the value of revenue stamps for these sales showed that each 55 cents in revenue stamps represented an average of $498 of sales value. This average was used to estimate the sales price if the total consideration was not cited in the deed for each sale used in this study.

APPENDIX C

REGRESSION ANALYSIS OF INDIVIDUAL UNPROTECTED WATERSHEDS

Regressions were fitted to the data for Beaver, Rainy Mountain, and Boggy Creek Watersheds primarily to estimate the effect of year of sale on land values in unprotected watersheds. The problem of high linear correlation between year of sale and the dummy variable to account for flood protection that was encountered in the analysis of protected watersheds was avoided since these watersheds have not been developed for flood protection.

Analysis of Beaver Creek Watershed

A total of 20 useable sales was tabulated in Beaver Creek Watershed for the time period covered by the data. Several regressions were fitted to the Beaver Creek data. First, a regression that includes all applicable variables of the revenue model developed in Chapter II was fitted. The resulting regression equation was:

$$(1) \qquad \hat{Y} = -24{,}205.30 + \underline{83.36}X_1 + \underline{167.62}X_2 + \underline{18.23}X_3 - 143.98X_4 + 399.69X_5 + 97.57X_6; \qquad R^2 = .82$$

where $\hat{Y}$ is estimated revenue from land sales in Beaver Creek Watershed, and the X_1 are defined as in Chapter III. Several coefficients in the equation are not significantly different from zero. At first glance it is surprising that the coefficients for upland suitable for cropland (X_4) and flood plain land (X_6) do not differ significantly from zero. However, inspection of the data revealed that 11 of the 20 sales contained no upland suitable for crops and averaged only 9.05 acres per sale. Also, acres of flood plain land averaged only 27 acres compared to the average acres in sale of 212.3. This could result in the variable for acres in sale (X_1) explaining most of the variation due to land quality.

Excluding variable X_4 and refitting the regression resulted in the following equation:

$$(2) \qquad \hat{Y} = -20{,}701.49 + \underline{80.03}X_1 + 123.32X_2 + \underline{16.96}X_3 + 467.53X_5 + 56.61X_6; \qquad R^2 = .80.$$

Dropping X_4 from equation (1) caused changes in the size of the coefficients remaining in the equation, particularly the coefficients for the percent of mineral rights transferred (X_2), year of sale (X_5), and acres of flood plain land. These changes occurred even though correlation among the independent variables was not excessive (Table I, this appendix).

Deleting the variable for year of sale (X_5) results in additional changes in the coefficients of the remaining variables. The equation with X_4 and X_5 excluded is:

$$(3) \qquad \hat{Y} = -24{,}637.79 + \underline{93.84}X_1 + \underline{157.24}X_2 + \underline{18.30X_3} + 105.72X_6; \qquad R^2 = .77.$$

The analysis shows that year of sale does <u>not</u> have a significant effect on land values in Beaver Creek which is consistent with results of the analysis of Barnitz Creek, the paired watershed.

Analysis of Boggy Creek Watershed

Only 12 useable sales were tabulated for Boggy Creek Watershed. The usefulness of estimates obtained by fitting a 7-variable regression equation to only 12 observations is questionable. However, the coefficient for year of sale was found to be statistically different from zero at the ten percent probability level. The regression for Boggy Creek is:

$$(5) \qquad \hat{Y} = -32,107.99 + 89.83X_1 + 215.52X_2 + 3.55X_3 + 6.75X_4 + \underline{1,748.82}X_5 + 147.36X_6; \qquad R^2 = .90.$$

Analysis of Rainy Mountain Watershed

Rainy Mountain Watershed lies adjacent to and to the west of Saddle Mountain Watershed in Kiowa County, Oklahoma. This watershed had been planned, but no floodwater retarding structures had been constructed at the time data for this watershed were collected. A total of 57 useable sales were collected for Rainy Mountain.

The regression for Rainy Mountain is:

$$(4) \qquad \hat{Y} = -9,411.33 + \underline{64.69}X_1 + \underline{58.05}X_2 - 1.40X_3 + \underline{41.05}X_4 + \underline{398.49}X_5 + \underline{57.65}X_6; \qquad R^2 = .78.$$

All coefficients, except b_3, are significantly different from zero at the 10 percent level.

This analysis indicates that year of sale is an important variable affecting land values in Rainy Mountain Watershed. Student's t-test indicated that this coefficient was actually significant at the one percent level.

APPENDIX C, TABLE I

MATRIX OF SIMPLE CORRELATION COEFFICIENTS, BEAVER CREEK WATERSHED

Variable	X_1	X_2	X_3	X_4	X_5	X_6	Y
X_1	1	-.56	-.31	-.25	.34	-.02	.52
X_2		1	.38	.47	.03	-.08	.03
X_3			1	.42	.22	.23	.46
X_4				1	.11	.35	.11
X_5					1	.40	.64
X_6						1	.27

APPENDIX C, TABLE II

MATRIX OF SIMPLE CORRELATION COEFFICIENTS, RAINY MOUNTAIN WATERSHED

Variable	X_1	X_2	X_3	X_4	X_5	X_6	Y
X_1	1	-.33	.35	.14	.03	.72	.82
X_2		1	-.12	-.11	-.61	-.32	-.25
X_3			1	.17	-.17	.34	.28
X_4				1	.19	-.34	.16
X_5					1	.03	.19
X_6						1	.69

APPENDIX C, TABLE III

MATRIX OF SIMPLE CORRELATION COEFFICIENTS, BOGGY CREEK WATERSHED

Variable	X_1	X_2	X_3	X_4	X_5	X_6	Y
X_1	1	.31	.42	.67	.11	.62	.82
X_2		1	-.10	.20	-.64	.32	.17
X_3			1	.20	.06	.19	.30
X_4				1	-.13	.17	.33
X_5					1	-.05	.40
X_6						1	.72

APPENDIX C, TABLE IV

AVERAGE VALUES OF SELECTED VARIABLES USED IN THE REGRESSION ANALYSIS[a]

Watershed	Y	X_1	X_2	X_3	X_4	X_5	X_6
Barnitz	15,551.33	251.30	75.00	208.07	25.85	51.30	47.00
Beaver	15,056.45	212.30	67.90	340.95	9.05	52.60	27.00
Cavalry	12,675.85	132.13	58.44	221.69	15.77	51.69	49.49
Boggy	27,369.42	175.00	87.50	206.00	10.00	52.58	85.42
Saddle	15,802.72	149.69	74.31	100.79	51.00	56.17	47.24
Rainy	9,538.44	117.58	69.39	125.58	24.39	53.07	63.74
Protected Watersheds	14,447.61	171.36	67.99	180.92	29.39	52.95	48.09
Before Protection	13,038.48	169.08	75.98	198.18	23.23	50.26	52.62
After Protection	17,654.59	176.55	49.79	141.62	43.41	59.07	37.79
Unprotected Watersheds	13,182.62	146.61	71.49	184.82	19.00	52.90	58.40
All Watersheds	13,835.74	159.39	69.68	182.80	24.36	52.92	53.08

[a]The variables are defined in Chapter III.

APPENDIX D, TABLE I

MATRIX OF SIMPLE CORRELATION COEFFICIENTS, SIX WATERSHEDS

Variable	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	Y_T
X_1	1	-.08	.16	.22	.06	.21	.37	-.14	-.04	-.27	.18	.66
X_2		1	.10	.001	-.40	.04	.08	-.20	.07	-.01	-.02	.04
X_3			1	.06	-.10	.15	.05	.09	-.16	-.17	.24	.32
X_4				1	.16	-.12	.01	-.10	.26	.003	-.12	.33
X_5					1	-.04	-.14	-.13	.29	.02	-.02	.27
X_6						1	-.05	-.04	-.06	.16	-.20	.44
X_7							1	-.21	-.18	-.28	-.14	.07
X_8								1	-.22	-.35	-.18	-.06
X_9									1	-.29	-.15	.08
X_{10}										1	-.23	-.27
X_{11}											1	.04

APPENDIX D, TABLE II

MATRIX OF SIMPLE CORRELATION COEFFICIENTS, PROTECTED WATERSHEDS

Variable	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	Y_P
X_1	1	.03	.15	.31	.02	.17	.44	-.29	.69
X_2		1	.17	.05	-.33	.09	.15	-.27	.05
X_3			1	.04	-.21	.21	.09	.16	.26
X_4				1	.18	-.04	-.04	-.22	.57
X_5					1	-.18	-.21	-.22	.26
X_6						1	-.02	.03	.41
X_7							1	-.53	.07
X_8								1	-.15

APPENDIX D, TABLE III

MATRIX OF SIMPLE CORRELATION COEFFICIENTS, PROTECTED WATERSHEDS, BEFORE PROTECTION

Variable	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	Y_{PB}
X_1	1	-.02	.16	.04	-.10	.12	.54	-.30	.62
X_2		1	.20	.07	-.06	-.03	.13	-.25	.04
X_3			1	.01	-.25	.16	.04	.20	.36
X_4				1	-.06	-.16	.16	-.11	.22
X_5					1	-.04	-.18	-.19	.01
X_6						1	-.06	.03	.55
X_7							1	-.62	.21
X_8								1	-.02

APPENDIX D, TABLE IV

MATRIX OF SIMPLE CORRELATION COEFFICIENTS, PROTECTED WATERSHEDS, AFTER PROTECTION

Variable	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	Y_{PA}
X_1	1	.17	.15	.57	.32	.45	.23	-.30	.82
X_2		1	-.07	.22	.35	.17	.003	-.54	.31
X_3			1	.18	.07	.42	.15	-.0001	.30
X_4				1	.31	.28	-.23	-.35	.73
X_5					1	-.08	.04	-.58	.49
X_6						1	-.03	-.04	.57
X_7							1	-.33	-.02
X_8								1	-.30

APPENDIX D, TABLE V

MATRIX OF SIMPLE CORRELATION COEFFICIENTS, BARNITZ CREEK WATERSHED

Variable	X_1	X_2	X_3	X_4	X_5	X_6	X_{12}	Y_1
X_1	1	.46	.31	-.17	-.05	.11	-.04	.72
X_2		1	.23	.35	-.53	.30	-.49	.23
X_3			1	.21	-.13	.41	-.04	.48
X_4				1	-.36	.12	-.29	.15
X_5					1	-.31	.91	-.0003
X_6						1	-.12	.51
X_{12}							1	.08

APPENDIX D, TABLE VI

MATRIX OF SIMPLE CORRELATION COEFFICIENTS, CAVALRY CREEK WATERSHED

Equation 3.6

Variable	X_1	X_2	X_3	X_4	X_5	X_6	X_{12}	Y_2
X_1	1	-.21	-.18	.18	.11	.43	.02	.53
X_2		1	.25	-.002	-.53	.01	-.52	.09
X_3			1	-.12	-.19	.11	-.18	.19
X_4				1	-.09	-.19	-.22	.20
X_5					1	-.05	.84	.23
X_6						1	-.20	.64
X_{12}							1	-.05

Equation 3.7

Variable	X_1	X_2	X_3	X_4	X_{12}	X_{13}	Y_2
X_1	1	-.21	-.18	.18	.02	.39	.53
X_2		1	.25	-.002	-.52	-.22	.09
X_3			1	-.12	-.18	-.06	.19
X_4				1	-.22	-.20	.20
X_{12}					1	.33	-.05
X_{13}						1	.67

APPENDIX D, TABLE VII

MATRIX OF SIMPLE CORRELATION COEFFICIENTS, SADDLE MOUNTAIN WATERSHED

Variable	X_1	X_2	X_3	X_4	X_5	X_6	X_{12}	Y
X_1	1	-.11	.49	.84	.33	.27	.33	.93
X_2		1	.19	-.16	-.28	.05	-.39	-.19
X_3			1	.47	.06	.27	.20	.55
X_4				1	.31	-.03	.42	.77
X_5					1	-.29	.78	.42
X_6						1	-.25	.27
X_{12}							1	.44

APPENDIX E

ALTERNATIVE REGRESSION MODELS FITTED TO DATA FOR CAVALRY CREEK

Other regression models fitted to sales data for Cavalry Creek led to the same conclusion concerning the effect of flood protection on land values as the revenue regression model reported in Chapter III, equations (3.6) and (3.7).

Of the 39 total useable sales for Cavalry Creek, only 10 sales occurred after the watershed had been protected in 1956. Since the number of observations after protection was so small, there was no attempt made to fit one equation to the data for before protection and one to the data for after protection and test for a significant difference in the two regressions. However, equation (3.2), the regression for protected watersheds before protection occurred, provides coefficients that can be used to estimate revenue from land sales in Cavalry Creek Watershed and test for a significant increase in land values following flood protection. The procedure for accomplishing the test is given in Chapter III in the analysis of Saddle Mountain Watershed and will not be repeated here. The equation for sales that occurred before the watershed was developed is:

$$\hat{Z}_B = -94.50 + 25.58X_5 \quad (1)$$

The coefficient for year of sale (X_5) is not significantly different from zero which implies that the coefficients from equation (3.2) predicts sales price with no time trend for those sales that occurred in Cavalry Creek Watershed before protection. The equation for sales that occurred after protection is:

$$\hat{Z}_A = -365.12 + 23.43X_5 \quad (2)$$

The coefficient for X_5 is not significantly different from zero at the 10 percent level which implies that there was no significant positive trend in residuals computed using coefficients of equation (3.2). A positive trend could be expected if flood protection had caused land values in this watershed to increase.

Other regressions fitted to the data for Cavalry Creek included a price model. Acres in sale were included as an independent variable to account for the effect of the size of the tract sold. The resulting equation was:

$$(3) \quad \hat{Y} = 1.28 + \underline{1.10}X_1 + \underline{1.04}X_2 + .\underline{58}X_3 + 2.70X_4 + 27.65X_5 - .\underline{20}X_6 + .\underline{09}X_7; \qquad R^2 = .72$$

where:

Y = price per acre of land and improvements,

X_1 = percent flood plain land,

X_2 = percent upland suitable for crops,

X_3 = percent of mineral rights transferred,

X_4 = year of sale (1947 = 1),

X_5 = 1 if sale occurred before protection, 0 otherwise,

X_6 = acres in sale,

X_7 = assessed value of improvements (dollars per sale).

The coefficients for year of sale (X_4) and for flood protection (X_5) are not significantly different from zero. A check of the simple correlation coefficients reveals that there is a relatively strong linear relationship between these two variables (Table I, this appendix).

The results of fitting the above model does not change the conclusion with respect to the effect of flood protection.

A variation of the above model was also fitted. The differences in the two models are (1) the way land enters the model, and (2) the dummy variable for flood protection is defined differently. The regression is:

$$(4) \qquad \hat{Y} = 287.02 - \underline{33.86}X_1 + .\underline{60}X_2 + \underline{4.19}X_3 - 10.18X_4 - .\underline{21}X_5 + .\underline{09}X_6; \qquad R^2 = .69$$

where:

Y = price per acre of land and improvements,

X_1 = weighted productivity rating,

X_2 = percent of mineral rights transferred,

X_3 = year of sale (1947 = 1),

X_4 = 1 if sale occurred before protection, 0 otherwise,

X_5 = acres in sale,

X_6 = assessed value of improvements.

The differences in (3) and (4) are apparent from the definitions of the variables included in each regression. Information necessary for computing the weighted productivity rating was given in Soils Survey: Washita County, Oklahoma.[1] Briefly, soils in the county were rated from 1 for the most productive soils to 10 for the least productive soils. These ratings were used to compute a weighted productivity rating for the soils in each sale.

The variable for flood protection (X_4) was defined differently to see if the correlation between this variable and year of sale would be significantly reduced. Redefining X_4 did not correct the problem (Table II, this appendix).

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[1] W. A. Goke, C. A. Hollopeter, and C. F. Fisher, Soils Survey Washita County, Oklahoma, U. S. Department of Agriculture in cooperation with Oklahoma Agricultural Experiment Station (Washington, 1941), pp. 27-50.

The coefficient for flood protection in equation (4) is not significantly different from zero. Therefore, this regression provides no evidence that flood protection has affected land values in Cavalry Creek Watershed. Neither equation (3) nor equation (4) gave direct estimates of the value of an acre of flood plain land or upland suitable for cropland. The effects of these two variables cannot be obtained from equation (4) due to the method used to include land in the model. Estimates of the value of flood plain land and upland suitable for cropland can be estimated from equation (3), but further computations are required. For example, estimating the value of an acre of flood plain land from equation (3) requires the following computations:

(a) compute the total value of an increase of one percentage point in flood plain land (increase in price per acre of land multiplied by mean acres in sale);

(b) compute the number of acres of flood plain land represented by a one percentage point increase in this variable (mean acres of flood plain ÷ mean acres in sale = percent flood plain land. Increase this percent by one and compute acres of flood plain land required); and,

(c) divide total value computed in (a) by the increase in acres of flood plain computed in (b) to obtain an estimate of the value of an acre of flood plain land.

Estimates obtained by the above procedures were $110.08 per acre of flood plain land, and $104.08 per acre of upland suitable for crops. These estimates compare with $127.99 per acre of flood plain, and $105.22 per acre of upland suitable for crops estimated by equation (3.6) reported in Chapter III. However, this attempt to escape the problem of high correlation between year of sale, and the variable for flood protection by combining variables failed to show any statistically significant effect of flood protection.

APPENDIX E, TABLE I

MATRIX OF SIMPLE CORRELATION COEFFICIENTS, CAVALRY CREEK WATERSHED, EQUATION (3)

Variable	X_1	X_2	X_3	X_4	X_5	X_6	X_7	Y
X_1	1	-.37	.07	-.08	-.29	-.15	.12	.40
X_2		1	-.01	-.08	-.16	.03	-.01	.13
X_3			1	-.53	-.44	-.21	-.21	.33
X_4				1	.84	.11	-.15	.05
X_5					1	.12	-.08	-.03
X_6						1	-.16	-.35
X_7							1	.57

APPENDIX E, TABLE II

MATRIX OF SIMPLE CORRELATION COEFFICIENTS, CAVALRY CREEK WATERSHED, EQUATION (4)

Variable	X_1	X_2	X_3	X_4	X_5	X_6	Y
X_1	1	-.03	.14	-.35	.11	-.11	-.47
X_2		1	-.53	.36	-.21	.21	.33
X_3			1	.81	.11	-.15	.05
X_4				1	-.14	.03	-.01
X_5					1	-.16	-.35
X_6						1	.57

APPENDIX F, TABLE I

ESTIMATES OF DAMAGE FACTORS BY CROPS, BARNITZ, CAVALRY, AND SADDLE MOUNTAIN WATERSHEDS[a]

Crops	Watershed Barnitz	Watershed Cavalry	Watershed Saddle Mountain
	- Percent Yield Reduction -		
Wheat	32.18	15.92	7.82
Alfalfa	21.33	10.61	7.25
Cotton	41.54	13.79	4.37
Oats	32.31	18.99	7.25
Barley	32.31	18.99	7.25
Meadow	--	9.61	5.39
Pasture	12.97	5.67	3.15
Grain Sorghum	31.30	12.32	6.61
Small Grain Pasture	22.64[b]	12.33	5.20
Sudan	16.62	7.65	6.61
Forage Sorghum	--	12.30	6.61
Johnson Grass	21.13	8.81	--
Corn	42.77	--	--

[a]Damage factors for each crop were developed from information provided by the Soil Conservation Service as to the degree of damages as a result of flooding within the watersheds.

[b]Average of small grain and pasture.

APPENDIX F, TABLE II

PRODUCT PRICES USED IN THE PROGRAMMING ANALYSIS

Product	Unit	Price (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 F, TABLE III

YIELDS ASSUMED UNDER PROTECTED CONDITIONS FOR BARNITZ CREEK FARMS, BY PRODUCTIVITY CLASS[a]

Crop	Unit	Land Productivity Class						
		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	-	-	-
Cultivable Pasture	AUM	1.00	1.00	.80	.80	-	-	-
Native Range	AUM	--	--	--	--	1.00	.80	.34

[a]Land productivity class:
1. Cultivable bottomland 1
2. Cultivable bottomland 2
3. Cultivable upland 1
4. Cultivable upland 2
5. Bottomland range
6. Upland range, good
7. Upland range, rough and broken.

APPENDIX F, TABLE IV

YIELDS ASSUMED UNDER PROTECTED CONDITIONS FOR CAVALRY CREEK FARMS, BY PRODUCTIVITY CLASS[a]

		Land Productivity Class						
Crop	Unit	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 class:

1. Cultivable bottomland 1
2. Cultivable bottomland 2
3. Cultivable upland 1
4. Cultivable upland 2
5. Bottomland range
6. Upland range, good
7. Upland range, rough and broken.

APPENDIX F, TABLE V

YIELDS ASSUMED UNDER PROTECTED CONDITIONS FOR SADDLE MOUNTAIN FARMS, BY PRODUCTIVITY CLASS[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	-	-	-
Cultivable Pasture	AUM	1.25	1.25	.80	.80	-	-	-
Native Range	AUM	--	--	--	--	1.25	.80	.34

[a]Land productivity class:

1. Cultivable bottomland 1
2. Cultivable bottomland 2
3. Cultivable upland 1
4. Cultivable upland 2
5. Bottomland range
6. Upland range, good
7. Upland range, rough and broken

APPENDIX F, TABLE VI

PROGRAMMED FARM ORGANIZATION FOR SMALL BARNITZ CREEK FARMS

Item	Unprotected		Protected		Change from Unprotected to Protected	
	Bottomland	Upland	Bottomland	Upland	Bottomland	Upland
Crops						
Cotton	0	20	20	0	20	-20
Wheat	29	12	19	22	-10	10
Alfalfa	48	0	38	0	-10	0
Barley	0	0	0	0	0	0
Temporary Pasture[a]	0	5	0	11	0	6
Grain Sorghum	0	4	0	0	0	-4
Forage Sorghum	0	2	0	2	0	0
Cultivable Pasture	0	5	0	13	0	8
Livestock						
Cows	15		16		1	
Feeders	0		0		0	

[a]Includes small grain pasture and Sudan grass.

APPENDIX F, TABLE VII

PROGRAMMED FARM ORGANIZATION FOR LARGE BARNITZ CREEK FARMS

Item	Unprotected		Protected		Change from Unprotected to Protected	
	Bottomland	Upland	Bottomland	Upland	Bottomland	Upland
Crops						
Cotton	0	54	54	0	54	-54
Wheat	137	61	107	91	-30	30
Alfalfa	25	0	33	0	8	0
Barley	0	0	0	8	0	8
Temporary Pasture[a]	15	18	0	37	-15	19
Grain Sorghum	16	0	0	16	-16	16
Forage Sorghum	0	6	0	6	0	0
Cultivable Pasture	0	130	0	111	0	-19
Livestock						
Cows	63		61		-2	
Feeders	0		0		0	

[a]Includes small grain pasture and Sudan grass.

APPENDIX F, TABLE VIII

PROGRAMMED FARM ORGANIZATION FOR SMALL CAVALRY CREEK FARMS WITH LESS THAN A ONE-THIRD BOTTOMLAND-UPLAND RATIO

Item	Unprotected		Protected		Change from Unprotected to Protected	
	Bottomland	Upland	Bottomland	Upland	Bottomland	Upland
Crops						
Cotton	8	13	8	13	0	0
Wheat	0	43	7	36	7	-7
Alfalfa	20	0	13	0	-7	0
Barley	0	1	0	1	0	0
Temporary Pasture[a]	0	47	0	54	0	7
Grain Sorghum	0	7	0	7	0	0
Forage Sorghum	0	0	0	0	0	0
Cultivable Pasture	0	0	0	0	0	0
Livestock						
Cows	29		33		4	
Feeders	0		0		0	

[a]Includes small grain pasture and Sudan grass.

APPENDIX F, TABLE IX

PROGRAMMED FARM ORGANIZATION FOR SMALL CAVALRY CREEK FARMS WITH GREATER THAN A ONE-THIRD BOTTOMLAND-UPLAND RATIO

	Unprotected		Protected		Change from Unprotected to Protected	
Item	Bottomland	Upland	Bottomland	Upland	Bottomland	Upland
Crops						
Cotton	17	0	17	0	0	0
Wheat	69	15	69	15	0	0
Alfalfa	22	0	22	0	0	0
Barley	0	7	0	7	0	0
Temporary Pasture[a]	0	16	0	16	0	0
Grain Sorghum	0	0	0	0	0	0
Forage Sorghum	0	0	0	0	0	0
Cultivable Pasture	0	0	0	0	0	0
Livestock						
Cows	10		10		0	
Feeders	0		0		0	

[a]Includes small grain pasture and Sudan grass.

APPENDIX F, TABLE X

PROGRAMMED FARM ORGANIZATION FOR LARGE CAVALRY CREEK FARMS

Item	Unprotected		Protected		Change from Unprotected to Protected	
	Bottomland	Upland	Bottomland	Upland	Bottomland	Upland
Crops						
Cotton	42	17	42	17	0	0
Wheat	27	173	27	173	0	0
Alfalfa	72	0	72	0	0	0
Barley	0	57	0	57	0	0
Temporary Pasture[a]	0	41	0	41	0	0
Grain Sorghum	0	22	0	22	0	0
Forage Sorghum	0	0	0	0	0	0
Cultivable Pasture	0	0	0	0	0	0
Livestock						
Cows	26		26		0	
Feeders	0		0		0	

[a]Includes small grain pasture and Sudan grass.

APPENDIX F, TABLE XI

PROGRAMMED FARM ORGANIZATION FOR SMALL SADDLE MOUNTAIN CREEK FARMS

Item	Unprotected		Protected		Change from Unprotected to Protected	
	Bottomland	Upland	Bottomland	Upland	Bottomland	Upland
Crops						
Cotton	32	0	32	0	0	0
Wheat	33	44	43	34	10	-10
Alfalfa	3	0	3	0	0	0
Barley	0	8	0	8	0	0
Temporary Pasture[a]	0	0	0	33	0	33
Grain Sorghum	0	1	0	1	0	0
Bermuda	10	0	0	0	-10	0
Cultivable Pasture	0	26	0	3	0	-23
Livestock						
Cows	17		15		-2	
Feeders	0		0		0	

[a]Includes small grain pasutre and Sudan grass.

APPENDIX F, TABLE XII

PROGRAMMED FARM ORGANIZATION FOR LARGE SADDLE MOUNTAIN CREEK FARMS

Item	Uprotected		Protected		Change from Unprotected to Protected	
	Bottomland	Upland	Bottomland	Upland	Bottomland	Upland
Crops						
Cotton	60	0	60	0	0	0
Wheat	105	196	147	154	42	-42
Alfalfa	23	0	5	0	-18	0
Barley	0	80	0	80	0	0
Temporary Pasture[a]	0	0	0	82	0	82
Grain Sorghum	0	3	0	3	0	0
Bermuda	24	0	0	0	-24	0
Cultivable Pasture	0	73	0	33	0	-40
Livestock						
Cows	40		36		-4	
Feeders	0		0		0	

[a]Includes small grain pasture and Sudan grass.

VITA

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