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Economic evaluation of alternative crop and soil management systems for reducing soil erosion losses on West Tennessee farms

David Lee Hunter

To the Graduate Council:

I am submitting herewith a dissertation written by David Lee Hunter entitled "Economic evaluation of alternative crop and soil management systems for reducing soil erosion losses on West Tennessee farms." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Agricultural Economics.

Luther H. Keller, Major Professor

We have read this dissertation and recommend its acceptance:

John Brooker, Thomas Klindt, Frank Bell

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

To the Graduate Council:

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Frank L. Bell

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ECONOMIC EVALUATION OF ALTERNATIVE CROP AND SOIL MANAGEMENT SYSTEMS FOR REDUCING SOIL EROSION LOSSES ON WEST TENNESSEE FARMS

A Dissertation

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Degree

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David Lee Hunter

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ABSTRACT

The purpose of this study was to evaluate farm firm behavior and adjustment that might be expected when certain key factors related to soil conservation were allowed to vary over time. Three typical commercial upland crop producing farms located in the Deep Loess Soil Region of West Tennessee were selected for analysis. Enterprises considered for each farm were corn, soybeans, cotton, soybeans-wheat double-crop, meadow, pasture, and beef cow-calf. Up to 41 cropping systems were considered for each field on each farm. Basic crop alternatives included a wide range of crop management systems including various combinations of conventional tillage, contour tillage, cover crop, no-till, terraces, and various lengths of rotations. Potential soil loss for each cropping management system was estimated using the Universal Soil Loss Equation. Farm plans were developed for each of the three farms that would maximize discounted net returns with the upper limit on soil loss from erosion set alternately at 100, 25, 10, and 5 tons/acre/year. Alternative situations evaluated in the analysis also included three discount rates, five planning horizons, and variations in alternative crop management systems considered.

Standard budgetary techniques were utilized in estimating costs and returns and investment and operating capital requirements for the various cropping systems and beef enterprise considered in the analysis. Linear programming techniques were used to determine optimum resource allocations and enterprise combinations that would maximize the discounted net returns to land, labor, and management.

Based upon the assumptions and result of this study, through the use of no-till and double-cropping systems soil loss could be held at the 10-ton soil loss level with no effects upon net returns. The 5-ton level could be achieved with only a minor reduction in net returns (2-3 percent).

When no-till and double-cropping systems were eliminated, the effects of soil loss constraints upon net returns were more pronounced. In this case net returns were estimated to be reduced by approximately 3-5 percent to achieve the 10-ton soil loss limit and by 25-30 percent to achieve the 5-ton soil loss level.

TABLE OF CONTENTS

CHAPTER PAGE

CHAPTER PAGE

LIST OF TABLES

TABLE PAGE

TABLE PAGE

TABLE PAGE

CHAPTER I

INTRODUCTION

A. THE PROBLEM

The Federal Pollution Control Act Amendments of 1972 (PL-92-500), known as the Clean Water Act, provides for federal and state programs to prevent and reduce water pollution. The law seeks to achieve water safe for swimming, fishing, and the protection of wildlife by 1983. Section 208 of the 1972 Amendments calls for development of state and area-wide water quality management programs. The Environmental Protection Agency (EPA) funds the planning efforts. The water quality management process includes: identification of water quality problems, identification of pollution sources, recommendations of guidelines for locally developed "best management practices" to curb pollution from identified sources, and recommendations of state and local agencies needed to implement long-term water quality management programs (27).

Section 208 of this law also calls for development of state and area-wide water quality management programs for point and nonpoint sources of pollution. In agriculture nonpoint pollution includes sediment, nutrients, pesticides, salts, organics, and disease producing organisms. On a volume basis, sediment is the single greatest pollutant of surface water and soil loss[1] from cropland is the major source of

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[1]Soil loss as used in this study refers to gross soil erosion losses in tons/acre/year from the action of water when a particular cropping system is used.

sediment. A 1974 study published by the Senate Agriculture and Forestry Committee indicated that approximately 2 billion tons of sediment annually enter our nation's waters from 400 million acres of cropland (27). Furthermore, sediment carries nutrients and pesticides which are eroded from the soil and added to the water resources.

Although extensive erosion control technology has been developed over the past 50 years, a national authority estimated that in 1970 the sediment damages in the United States amount to approximately $500 million annually. Professional conservationists in Tennessee agree that erosion control is their major problem. According to the 1967 Tennessee Soil and Water Conservation Needs Inventory, 65 percent of all cropland needs one or more conservation practices to protect the soil and maintain its productivity (23).

The soil erosion problem has intensified in Tennessee, particularly in the western portion of the state where the soil particles (predominantly silty) are easily detached from loess derived soil and moved by water runoff. Also the rolling topography of West Tennessee and the high rainfall erosion index (R-factor) contribute to the movement of soil. Since the soils of West Tennessee are used primarily for clean cultivated row crop production, soil erosion has become a serious problem in this area. Certain areas of West Tennessee have estimated soil losses as high as 40 tons/acre/year (23).

Although erosion control measures have been developed, they may not be used by farmers for one or more of the following reasons: (1) some marginal land used for row crops may not justify the extra cost of conservation measures; (2) existing obstructions (fences, roads) may make it difficult to install cost effective conservation structures; (3) plow-disk-harrow has been accepted as an efficient method of tillage and farmers may resist change; (4) the necessary machinery may not be readily available for performing certain conservation practices; (5) sod crops may have lower value than row crops on a predominantly row crop farm; (6) the existence of undesirable soil conditions for seed germination and early growth produced when limited tillage practices are used; (7) dislike for appearance of residue; (8) fear of uncertainty presently associated with certain practices (adequate stand, pest); (9) soil and landscape characteristics may prohibit efficient use of some conservation practices; (10) short-term leases result in emphasis on short-run income goals; and (11) in many cases the conservation problem simply goes unrecognized (23).

While the decisions to conserve soil are sometimes based on ethical considerations, economical questions are basic when considering soil conservation or reduction of erosion. Many conservation measures may not result in a net return in the short run. The question is not whether to conserve but at what level to practice conservation. Individual farmers hold different views concerning the correct balance between present and future needs. Farmers must often decide between land-use systems that maximize their returns in the short run but often result in the depletion or exploitation of their land resources and other land-use systems that emphasize the maintenance or saving of the land resources over a longer period of time but may result in a decreased income in the short run. Conservation choices are likely to depend upon the operator's time preference--the relative weights given to income at some future date as compared with income at the present time (4).

Whether or not a farmer will accept and use conservation practices may depend upon one or more of the following: (1) the understanding he has of his conservation problem; (2) the urgency of his conservation problem; (3) his planning horizon; (4) his calculations regarding the effect of the proposed conservation program on his income now and in the foreseeable future; (5) his capital position; and (6) his time preference rate (29).

The 208 Water Quality Management Plan prepared by the Tennessee Department of Public Health, Division of Water Quality Control, has recommended that in order to achieve the goals of the Clean Water Act of 1977, soil losses in Tennessee stay within specified soil loss tolerance limits. The soil loss tolerance value is the estimated average annual soil loss that can be tolerated and yet achieve the degree of conservation needed for sustained economical production over a long period of time. It is expressed as the average annual soil loss in tons/acre/year (28).

Since the major source of farm income in West Tennessee is row crops and many row crop production systems currently used result in soil losses exceeding the tolerance levels, it would be desirable to determine if changes in crop production systems to reduce soil losses to a reasonable level would affect the level of net returns received by individual farmers in the Deep Loess Soil Region of West Tennessee.

B. OBJECTIVES

The principle objective of this study was to evaluate farm firm behavior and adjustment that might be expected when certain key factors related to soil conservation were allowed to vary over time. The assumed objective of the firm was to maximize the discounted present value of net returns. The specific objectives of the study were as follows:

1. Develop an appropriate mathematical farm firm model that integrates the economic and agronomic data in a manner to permit evaluation of the effect of certain economic and technical variables upon income, enterprise mix, soil loss, and conservation practices of three typical upland crop producing farms located in the Deep Loess Soil Region of West Tennessee.
2. Determine the optimum resource allocation, enterprise mix, and conservation practices that will maximize the discounted present value of net returns for each of the selected farms under a variety of economic and technical conditions. Variations were made in the following factors:
   a. Discount rate.
   b. Length of planning horizon.
   c. Permissible soil loss by water erosion.
   d. Crop yields over time.
   e. Crop and soil management alternatives.

C. PROCEDURE

The following procedure was used to accomplish the above objectives:

1. Three farms judged to be typical of the upland crop producing farms located in the Deep Loess Soil Region of West Tennessee were selected. These farms were judged to be typical in terms of size, soil series, and soil mapping unit. Soil conservation plans for these farms had been prepared by the Soil Conservation Service (SCS). Field arrangements for this study were taken from these plans. Enterprises considered were soybeans, corn, cotton, soybeans-wheat double-crop, hay, pasture, and beef cow-calf. Up to 41 cropping and soil management systems were considered for each field. These systems were differentiated by crop sequences, tillage practices, and conservation practices. Tillage practices considered were: conventional tillage up-and-down slope,[2] conventional tillage on the contour, and no-till. Soil conservation structures considered to reduce soil loss from water erosion were terraces, diversions, sediment basins, and grassed waterways.
2. The linear programming technique was used to maximize the discounted present value of net returns over time. Enterprise budgets were prepared for the enterprises considered and

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[2]Up-and-down slope tillage is sometimes referred to as straight row cultivation. In this study the two terms will be used interchangeably.

annual net returns were discounted over the appropriate planning horizon and expressed in present value terms. Initially all enterprise options were considered for each field on each farm. Subsequent plans eliminated first soybeans-wheat double-cropping, then soybeans-wheat double-cropping and no-till corn, and finally elimination of all double-cropping and no-till alternatives. Three discount and capital charge rates were considered. Since quantity of labor did not appear to be a constraint on any of the farms, only the owner-operator's labor was considered. Five planning horizons were considered for each farm: 1, 5, 10, 20, and 40 years. Soil erosion loss from water was allowed to vary from less than or equal to 100 tons/acre/year to less than or equal to five tons/acre/year. Yields over time were related to the inches of topsoil above the fragipan on Grenada and Loring soils and above the sandy loam layer for Lexington. No yield decline within a soil mapping unit was considered for Memphis soils; however, additional annual cost was included for smoothing gullies and rills caused by water erosion.

D. REVIEW OF LITERATURE

Research on the impact of soil erosion control policies on agriculture has been concentrated more on the national and regional level than at the farm level. However, the effect of soil erosion controls on the agricultural community will ultimately be realized at the farm level; therefore, crop production systems need to be found that will maximize the net incomes of farmers subject to the soil erosion constraints.

Economic Effects of Soil Loss Constraints

White and Partenheimer (29) investigated the economic effects of implementing erosion and sedimentation control plans on selected commercial dairy farms in Pennsylvania. Their study focused on farms for which SCS had formulated conservation plans. The results of their research showed that, in several simulated farm situations, there was a tradeoff between income and soil loss, especially in the short run. Their results also indicated that erosion and sedimentation control laws, if they required soil loss constraints at or near three tons per acre, could cause economic hardship for many farmers if their research were typical of dairy farms across Pennsylvania.

Boggess, et al. (5) studied the impact of soil loss controls on individual farm firms with varied soil types and soil loss limits. The study was short run in nature and no erosion related adjustments in soil productivity were made. They analyzed farms typical of the Ida-Monona soil association in west central Iowa, the Clarion-Nicollet soil association in north central Iowa, and the Tama-Muscatine soil association in east central Iowa. Two farm types were investigated: a cash grain farm and a livestock farm in each association. Their results indicated that soil loss controls differ among soil types with respect to soil management strategies, financial consequences, and environmental impacts. The changes in cropping systems required varied with the soil type. The changes in cropping systems required on Ida-Monona soils were quite large while those necessary on Tama-Muscatine and Clarion-Nicollet soils were minimal. The results of their study also indicated that policies limiting soil loss did not have as severe an impact on livestock farms as cash grain farms.

Zinn (30) selected four typical row crop farms of West Tennessee. The returns to land and management were estimated from the farmers' current soil management systems using yield data and crop budgets published in the University of Tennessee Agricultural Experiment Station bulletins. A set of 15 cropping systems and four soil management practices was used to develop soil management plans to hold soil loss at approximately five tons/acre/year, 10 tons/acre/year, and greater than or equal to 20 tons/acre/year. One group of plans allowed the use of minimum tillage to meet soil loss levels. The other group of plans relied on the use of terraces, contour cultivation, crop rotation, and land selection to conform to the soil loss standards. His results indicated it was possible on three of the farms to hold soil loss at approixmately five tons/acre/year and increase estimated returns to land and management over the returns estimated for the farmers' current soil management system.

Crop Yields Over Time

Degree of erosion and slope gradient have long been recognized as factors affecting crop yields. However, the effect of these factors on crop yields over time for different soil series is not well documented. Many studies have shown yield reduction of various crops due to erosion (1, 16, 19). These yield reductions were attributed to lower fertility and lower available water supplying capacity on eroded soils. Other studies have shown that addition of proper nutrients on certain soils can restore their productivity if the subsoil material is favorable for root growth and is as high in available water supply capacity as the soil lost (3, 10, 12). Other studies have indicated that when the subsoil material is less favorable than topsoil material, addition of fertilizer will not restore the productivity of severely eroded soils (3, 16).

Little current information is available concerning the effects of slope gradient on yields. Some workers have reported no differences in yields due to slope gradient (18, 20). Other have indicated lower yields on steep slopes (8, 19).

Atkins (2) estimated the decline in yields due to erosion with a formula based on the assumption that production practices would be constant at a moderately high level of conservation over the productive life of the soil; yields per acre would be stabilized at a level above zero; the level where yields were stabilized would depend largely on the characteristics of the subsoil; and yields per acre would decline slowly in the early stages of erosion with the rate of decline increasing at a constant rate.

Swanson and Harshberger (24) in studying the economics of soil conservation on Swygest soils in Illinois used a percent reduction in base yields directly proportional to the degree of slope. The percentage adjustment of yields due to the effects of erosion was related inversely to the depth of the A horizon.

Lee, et al. (17), in their Hambough-Martin watershed study, related the decline in yield to the change in the depth of the topsoil due to erosion. Their information on topsoil depth was taken from Illinois Agriucltural Experiment Station soil survey reports.

Swanson and Macallum (25) and Landgren and Anderson (15) allowed production costs to increase due to additional fertilizer needed to maintain productivity as topsoil is lost.

Denton (9) studied the effects of degree of erosion and slope characteristics on soybean yields on four West Tennessee soil series: Memphis, Grenada, Lexington, and Loring. Yield samples were collected for 1976 and 1977 on various soil mapping units of each soil series in soybean fields on West Tennessee farms and experiment stations. The yield data collected were analyzed by use of a least squares analysis of variance. The results in 1976 showed a trend toward reduced yields as slope gradient increases on all soils. Results in 1977 showed significant yield reductions of all soils due to the combined effects of degree of erosion and slope gradient. When both years were combined and analyzed, the data showed no significant difference in yield due to degree of erosion and slope gradient on Memphis soils; however, yields on the other three soils were reduced significantly by a combination of severe erosion and increased slope gradient.

CHAPTER II

ANALYTICAL FRAMEWORK

A. INTRODUCTION

Classical economic theory is usually formulated on the assumption that the firm seeks to maximize profits given a set of inputs or resources and a number of production alternatives. Linear programming is a mathematical technique which can be used to estimate the optimum allocation of limited resources of production among alternatives used to achieve a specific goal. This technique was used in this study to estimate the optimum allocation of resources to maximize the discounted present value of net returns to land, labor, and management of three typical upland crop producing farms located in the Deep Loess Soil Region of West Tennessee. Annual net returns in all future time periods were discounted using rates of 6, 9, and 12 percent.

A linear programming model was developed for each farm. Up to 41 cropping and soil management alternatives were specified to reflect possibilities including not only current practices but also a wide range of cropping systems designed to reduce soil erosion losses to tolerance limits. The specified production alternatives were differentiated by such characteristics as tillage methods, soil conservation methods, and cropping systems. This study was concerned with the major field crops in the area, namely soybeans, corn, cotton, wheat, and hay or meadow. A beef cow-calf enterprise was also included to utilize available forage.

Achievement of particular soil loss levels was possible through a combination of alternative crop sequences, tillage practices, and conservation practices. Permissible soil loss was constrained at various levels ranging from less than or equal to 100 tons/acre/year to less than or equal to five tons/acre/year. A constraint of less than or equal to 100 tons/acre/year was used as the base situation for this study.

Five planning horizons were considered in this study: 1, 5, 10, 20, and 40 years. A 20-year planning horizon was used as the base situation for this study.

B. STUDY AREA

The study area consisted of 12 western counties of Tennessee including Crockett, Dyer, Fayette, Gibson, Hardeman, Haywood, Lauderdale, Madison, Obion, Shelby, Tipton, and Weakley. They are a part of the Southern Mississippi Valley Silty Uplands Major Land Resource Area. These counties are also part of the Deep Loess Soil Region of West Tennessee. The parent material of the Deep Loess Soil Region is three feet or more of loess which overlays marine deposits.

This Deep Loess Soil Region of West Tennessee, often referred to as the Brown Soil Area, occupies approximately 16.5 percent of the state. The Grenada-Loring-Memphis and the Memphis-Loring soil associations are predominant in this area. The soils in this area are derived from a moderately deep to deep layer of loess over coastal plains material. The western portion of this Deep Loess Area is occupied by deep, well-drained soils on hilly to rolling relief; however, the soils of the middle and eastern portion of this region are characterized by fragipans with varying depth from the surface and thickness of the pan. This is largely a cash crop area. The major crops grown are soybeans, corn, cotton, and wheat. A serious erosion problem exists in this area due to the erosive nature of the soils and the extensive use of the soils for clean cultivated row crop production. The average size farm with sales of $2,500 and over for the area according to the 1974 U. S. Census of Agriculture was 372 acres.

C. CONSERVATION ALTERNATIVES

The principle factors which affect soil loss (erosion) are the R-factor, physical characteristics of the soil, length and steepness of the land slope, cropping systems, and conservation practices. Although farmers can have little or no influence upon some of these factors such as rate and distribution of rainfall, there are other factors which the farmer can influence such as cropping systems and conservation practices.

There are several conservation alternatives which can be used to control erosion ranging from physical structures such as terraces to varying the succession of different crops grown on a given area of land. The conservation methods used in this study were tillage practices, terraces and associated structures, crop rotations, and a winter crop for cover.

Tillage Practice

Tillage practices used in this study were: conventional tillage up-and-down slopes, conventional tillage on the contour, and no-till.

Conventional tillage is defined as plowing (disk or moldboard) in the spring or fall followed by other tillage operations (harrow, disk, etc.) Plant residue is mixed with the soil. Conventional tillage up-and-down or straight-row is done without regard to field slopes. Contour tillage is a method of conservation which involves cultivation across the slope rather than with it. Contouring and contouring with gradient terraces may require the use of point rows which increase machine and labor requirements since short point rows increase the amount of turning time required in a field when cultivating (6). Contour tillage can reduce soil losses by 50 percent or more depending upon the steepness of slope.

No-till[1] eliminates all tillage except for the planting with a sod planter. Chemicals are substituted for conventional tillage operations for control of weeds. The soil is only disturbed to open the seed row and provide enough loose soil to insure contact with the seed. Additional tillage operations before and after planting are not required.

Terraces

A terrace may be defined as an embankment or ridge constructed across a slope to control runoff and minimize soil erosion (11). One of the factors which influence the level of soil loss is the length of slope. The longer the slope length the greater will be the soil loss. The purpose of a terrace is to break up the length of long slopes into shorter ones, each terrace collecting and controlling the excess water from a definite area of the slope above it. The water collected in the terrace channel is then carried to an area where it will not cause erosion; or if the soil is very absorptive, the terraces may be built in such a way as to allow water to stand and soak into the ground. Soil

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[1]This system is often referred to as minimum till or limited till.

loss levels can often be reduced by 50 percent or more through the use of terraces.

Diversions, grassed waterways, and sediment basins, which are normally used in conjunction with terraces, were also used on the farms in this study to control excess runoff. It was assumed that once terraces were installed, tillage would be done on the contour. Terraces and all other conservation structures (waterways, diversions, etc.) were considered only on those fields where recommended by the Soil Conservation Service.

Rotations

Rotation of crops may be defined as a regularly recurrent succession of different crops grown on a given area of land. Rotations can be of different durations depending upon their purpose. The rotations used in this study were two, three, four, and five years in length. The crops commonly used in rotations are a cultivated row crop, in this case corn, soybeans, and cotton, followed by a small grain, a grass or a grass-legume mixture. The row crops in this study were followed by a fescue-ladino[2] clover meadow.

Rotations may have various purposes. Crops are normally rotated in order to maintain the productivity of the soil, control weeds, insects and disease, and to help maintain organic matter and nitrogen. However, in this study rotations were considered primarily to reduce the average annual level of soil loss. The annual soil loss for a grass-

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[2]Actual meadow mixtures used might vary and could include other legumes or grasses.

legume meadow is substantially below that for clean cultivated row crops. Therefore, when row crops are grown in rotation with meadow the soil loss from a given field, over the rotation period, would be considerably less than for a continuous row crop system.

Winter Cover Crop

The term cover crop has almost become synonymous with green manure crops; however, from a conservation standpoint there is a difference. Crops that serve as cover crops may or may not be used as green manure crops. Green manure crops are, however, naturally always cover crops. Green manure crops are grown and turned under for the purpose of improving the fertility and structure of the soil. Cover crops are planted primarily for the purpose of covering or protecting the soil at certain times during the year; however, they may also add to soil fertility.

Winter cover crops were considered as a conservation alternative in this study because of the protection they offer against fall and winter rains that cause greater erosion when the soil is unprotected.

D. RESOURCE ASSUMPTIONS

Land Resources

In this study three farms were selected which were considered to be generally typical of the commercial upland crop producing farms located in the Deep Loess Soil Region of West Tennessee. These farms were selected on the basis of their size, soil series, and soil mapping units.

Farm 1 was considered to be typical for farms with predominantly well drained soils (i.e., Memphis). Farms 2 and 3 were characterized by a combination of well drained and fragipans soils (i.e., Granada). Farm 2 also had 31.5 acres of Collins and 43.7 acres of Falaya, the most commonly occurring bottomland soils of the area. Conservation plans had been developed for each of the farms by the Soil Conservation Service. Farm and field acreage and detailed soil maps were available from the conservation plans. Acreage in each soil mapping unit was measured using acreage grids.

Farm 1 was located in Madison County, Tennessee, and consisted of 242 acres of cropland, 25 acres suitable only for hay and pastureland, 71 acres of woodland, and 12 acres of homestead and other uses, for a total of 350 acres. The predominant soils of Farm 1 were Collins silt loam (18.5 acres), Grenada silt loam (23.9 acres), Lexington silt loam (46.1 acres), Loring silt loam (10.1 acres), and Memphis silt loam (136.2 acres). The soil mapping unit inventory for Farm 1 is shown in Table 1. Most of the Lexington and Grenada soils were severely eroded.

Farm 2 was located in Haywood County, Tennessee, and consisted of 228 acres of cropland, 14 acres used for woodland and homestead, and a total of 242 acres. The soils of Farm 2 included Collins silt loam (37.5 acres), Falaya silt loam (43.7 acres), Grenada silt loam (96.2 acres), and Memphis silt loam (50.6 acres). The soil mapping unit inventory for Farm 2 is shown in Table 2. Over half of the upland soils were severely eroded fragipan type soils.

Farm 3 was also located in Haywood County, Tennessee, and consisted of 264 acres of cropland, 9 acres suitable only for hay and pastureland, and 50 acres of woodland for a total of 323 acres. The soils of Farm 3 included Falaya silt loam (22.1 acres), Grenada silt loam

TABLE 1

SOIL MAPPING UNIT INVENTORY, FARM 1

Soil Type	Percent Slope	Degree of Erosion[a]	Acres	Percent of Cropland
Calloway silt loam	0-2		1.9	.8
Collins silt loam	0-2		18.5	7.6
Falaya silt loam	0-2		5.3	2.2
Grenada silt loam	2-5	1	4.2	1.7
Grenada silt loam	2-5	3	4.3	1.8
Grenada silt loam	5-8	3	15.4	6.4
Lexington silt loam	5-8	3	15.6	6.4
Lexington silt loam	8-12	3	30.5	12.6
Loring silt loam	2-5	1	10.1	4.2
Memphis silt loam	0-2	1	8.0	3.3
Memphis silt loam	2-5	1	2.1	.9
Memphis silt loam	2-5	2	126.1	52.1
			242.0	100.0

[a]Degree of erosion is defined as follows: 1 = Uneroded, 2 = Eroded, 3 = Severely Eroded.

TABLE 2

SOIL MAPPING UNIT INVENTORY, FARM 2

Soil Type	Percent Slope	Degree of Erosion[a]	Acres	Percent of Cropland
Collins silt loam	0-2		37.5	16.4
Falaya silt loam	0-2		38.9	17.1
Falaya silt loam	2-5	1	4.8	2.1
Grenada silt loam	2-5	2	10.7	4.7
Grenada silt loam	2-5	3	60.1	26.4
Grenada silt loam	5-8	3	25.4	11.1
Memphis silt loam	2-5	2	50.6	22.2
			228.0	100.0

[a]Degree of erosion is defined as follows: 1 = Uneroded, 2 = Eroded, 3 = Severely Eroded.

(61.3 acres), Lexington silt loam (29.0 acres), and Memphis silt loam (151.6 acres). The soil mapping unit inventory for Farm 3 is shown in Table 3.

Field arrangements used in this study were the same as designated in the conservation plan developed by the Soil Conservation Service. However, certain fields were combined in the model for planning purposes if they had similar soil management requirements, similar potential for cropping intensities and crop yields, and if the same conservation practice has been recommended for each field.

TABLE 3

SOIL MAPPING UNIT INVENTORY, FARM 3

Soil Type	Percent Slope	Degree of Erosion[a]	Acres	Percent of Cropland
Falaya silt loam	0-2		22.1	8.4
Grenada silt loam	-25	3	61.3	23.2
Lexington silt loam	2-5	3	27.4	10.4
Lenington silt loam	5-8	3	1.6	.6
Memphis silt loam	2-5	2	44.5	16.8
Memphis silt loam	2-5	3	58.8	22.3
Memphis silt loam	5-8	3	48.3	18.3
			264.0	100.0

[a]Degree of erosion is defined as follows: 1 = Uneroded, 2 = Eroded, 3 = Severely Eroded.

Capital Availability

No limit was placed on the capital available to the farmers. The interest charge for both investment and operating capital was varied in the analysis. Rates of 6, 9, and 12 percent were used in developing the crop and livestock budgets.

Since net returns were computed as returns to land, labor, and management, no charge was made for land capital. It was assumed that operating capital for crop production would only be used in the production activity for six months; therefore, the charge for operating capital was 6, 9, and 12 percent for six months. Interest rate variation was considered to be significant for conservation systems requiring relatively large initial investment costs. Nine percent was used as the base situation for both the interest on investment and for discount rates on net returns in various time periods.

Labor Availability

Labor requirements for the different enterprises were obtained from the Farm Planning Manual (22). Both labor requirements and availability were expressed in terms of two-month periods. The owner-operator was assumed to supply a maximum of 500 hours of labor per time period on each of the three study farms. Additional labor could be hired at $3.50 per hour if needed. Jobs requiring two or more laborers were assumed to be handled by utilizing other family labor, exchange labor with neighboring farmers, or by hired labor.

E. PRODUCTION ALTERNATIVE

The cropping systems and soil management practices considered in this study consisted of the major crops and production practices common on farms in West Tennessee (Table 4). Terraces were considered only on those fields where they had been recommended in the conservation plan developed by the Soil Conservation Service. Since the cropping systems for corn and soybeans were the same, they are discussed together. On each field where appropriate the following cropping systems were considered.

TABLE 4

PRODUCTION ALTERNATIVES CONSIDERED

Continuous Cropping Systems[a]		Symbol	Corn	Soybeans	Cotton	Doublecrop Wheat/Soybeans[b]
Up-and-down slope:	No winter cover	SRCC	X	X	X	X
	With winter cover	SRCP	X	X	X	
Contour tillage:	No winter cover	CT	X	X	X	
	With winter cover	CTCC	X	X	X	
Terraces:	No winter cover	CTTS	X	X	X	
	With winter cover	CCTS	X	X	X	
No-till system:	Planted in residue	NT	X	X		X
	Planted in winter cover	NTCC	X	X		
	With terraces	NTTS	X	X		X
Rotational systems:	5 year	C-4M	X	X	X	
	4 year	C-3M	X	X	X	
	3 year	C-2M	X	X	X	
	2 year	2C-2M	X	X	X	

[a]Chemical weed control and residue left for all systems.

[b]Wheat for grain followed by no-till soybeans.

Corn and Soybeans

Thirteen different cropping systems were considered for corn and soybeans, single-crop, ranging from conventional tillage up and down the slope to a five-year rotation of corn or soybeans followed by a fescue-ladino clover meadow. Conventional tillage up and down the slope was considered with and without a small grain (wheat) winter cover crop.

Conventional tillage on the contour and terraces, which can reduce soil loss by 50 percent or more depending upon the steepness of the slope, were considered with and without a small grain winter cover crop. It was assumed that once terraces were installed, all tillage would be done on the contour.

Three no-till systems were considered including seed planted in prior year's crop residue, seed planted in a herbicide killed winter cover crop, and seed planted in prior year's crop residue with terraces.

Four rotation systems were considered. These included corn or soybeans followed by two, three, and four years of a fescue-ladino clover meadow.

All systems considered included chemical weed control and crop residue left on the soil.

Cotton

No-till systems were not considered for cotton. All other systems were the same as those considered for corn and soybeans.

Wheat-Soybeans Double-Crop

Three double-crop systems of wheat-soybeans were considered. These included fall seeded wheat for grain using conventional tillage up and down the slope followed by no-till soybeans late seeded for grain. Also considered were fall seeded wheat for grain, conventional tillage on the contour, with and without terraces, followed by late seeded no-till soybeans for grain. Because of the delayed planting of soybeans when used as a double-crop with wheat, soybean yields were reduced 25 percent below the level for single-crop soybeans. No reduction in yields was made for wheat.

Forages

The forage considered in this study was a mixture of fescue and ladino clover utilized either for pasture or hay and renovated at least every four years. The forage produced could either be harvested as hay and sold or used to meet the hay and pasture requirement for a beef cow-calf system.

Beef Enterprise

In order to stay within the soil loss tolerance limits on certain fields, it was assumed that farmers might find it necessary to include certain forage crops in their cropping systems. The beef enterprise was included as an alternative to utilize forages that might be included in the cropping system.

Cost and resource requirements were based on a 35-animal unit herd (30 cows plus replacements). Cows were assumed to calve in January, February, and March, with average calving date around February 15. Calves were to be weaned around October 15 at an average weight of 510 pounds for steer calves and 465 pounds for heifer calves.

The pasture requirement was calculated in cow acre day (CAD) units. Each animal unit was assumed to require the equivalent of 240 CAD units of grazing based on an eight-month grazing period. Pasture production estimates were also expressed in CAD terms and were varied among the soil groups to reflect relative differences in production level of each particular soil.

In the beef budget it was assumed that hay was fed at a rate of 16 pounds per day per head for 75 days prior to calving and 25 pounds per day per head for 45 days following calving. Replacement heifers and the bull consumed about 1.0 tons of hay per animal unit. Total hay required for the 35-animal units was 39.9 tons. In addition to the hay, the calves were assumed to have access to crop residue and permanent pasture during the winter months.

A death loss of 2 percent of the cows was assumed. All cow replacements would be derived from keeping "home grown heifers" with an annual replacement rate of 16-2/3 percent. For the 30-cow herd, five heifers would be retained each year while five cull cows, 13 steers, and nine heifers would be sold.

Enterprise Budgets

Standard budgetary techniques were used to develop cost and returns for the alternative crop management systems. Budgets were developed for soybeans, corn, cotton, soybeans-wheat double-crop, hay (ladino and fescue), permanent pasture (ladino and fescue), and a beef cow-calf fed hay over winter. These budgets were developed from data synthesized from the Farm Planning Manual (21, 22), private communications with agricultural research and extension specialists of the

University of Tennessee and from data supplied by district conservationists of the Soil Conservation Service.

The major components included in the crop budgets were prices of inputs and products, types and amounts of technical inputs such as seed, fertilizer, chemicals, machine requirements to produce a unit of output, and estimates of the yields for various soil mapping units.

Estimated costs of inputs such as seed, pesticides, and fertilizer were 1980 prices obtained from the Tennessee Farmers Cooperative which supplies inputs to farm operators throughout Tennessee (Table 5). Output prices were projected from published data, Tennessee Crop Reporting Service, and from consultation with personnel in the Department of Agricultural Economics and Rural Sociology at the University of Tennessee and personnel from Cooperative Extension Service, Agriculture Economics Section, at the University of Tennessee. Prices used were 1980 level adjusted to maintain the average price relationship that existed for 1974-79. Output prices used were as follows: corn, $2.80 per bushel; soybeans, $6.50 per bushel; wheat, $3.10 per bushel; cotton lint, $66 per hundredweight; hay, $55 per ton; heifer calves (465 pounds), $50 per hundredweight; steer calves (510 pounds, $60 per hundredweight; and cull cows, $45 per hundredweight.

Machinery costs were calculated on the basis of 1980 machinery price levels.

Labor Requirement

Annual labor requirements for the various cropping systems are shown in Table 6. These labor requirements were estimated based on information obtained from the Farm Planning Manual (22), private

TABLE 5

MAJOR INPUT PRICES

Item	Unit	Price ($)
Seed		
Corn	bu.	50.00
Soybeans	lb.	.17
Cotton	lb.	.37
Wheat	bu.	8.25
Ladino	lb.	2.60
Fescue	lb.	.32
Fertilizer		
N	lb.	.23
P_2O_5	lb.	.25
K_2O	lb.	.12
Fuel		
Gasoline	gal.	1.20
Diesel	gal.	.88
Lime	ton	10.50
Boron	lb.	1.35
Furadan	lb.	.77
Weed control		
Atrazine	qt.	2.31
Dual 8E	pt.	3.54
Paraquat	pt.	4.69
Treflan	pt.	3.57
Basagran	pt.	8.10
Lorox	lb.	4.26
Lasso	qt.	2.25

TABLE 6

ANNUAL LABOR REQUIREMENTS PER ACRE FOR THE VARIOUS CROPPING SYSTEMS[a]

Continuous Cropping Systems		Corn	Soybeans	Cotton	Doublecrop Wheat/Soybeans
		hours			
Up-and-down slope:	No winter cover	3.00	2.54	7.82	4.01
	With winter cover	3.56	2.79	8.07	--
Contour tillage:[b]	No winter cover	3.16	2.68	8.20	--
	With winter cover	3.74	2.94	8.46	--
Terraces:[b]	No winter cover	3.22	2.74	8.26	--
	With winter cover	3.80	3.00	8.52	--
No-till system:	Planted in residue	1.87	1.82	--	4.21
	Planted in winter cover	2.43	2.09	--	--
	With terraces	2.00	1.98	--	4.27
Rotational systems:[c]	5 years	4.96	4.87	5.93	--
	4 years	4.83	4.73	6.04	--
	3 years	4.60	4.40	6.18	--
	2 years	4.24	4.00	6.65	--

[a]Annual labor requirement adapted from the Farm Planning Manual (22).

[b]Annual labor requirement for contour tillage and terraces may vary with the field depending upon length and width of field and the number of feet of terraces present.

[c]Annual labor requirements for the rotational systems are weighted averages of the row crop and hay.

communication with agricultural economics research and extension specialists of the University of Tennessee, andthe University of Tennessee agriculture engineers. Comparing the continuous cropping systems, the greatest labor requirements per acre were for the cotton cropping systems, followed by wheat-soybeans double-crop, corn, and soybeans single-crop. Because of the fewer field operations needed the labor requirements for the no-till systems were less than for the conventional tillage system.

The annual labor requirements for the rotation systems were weighted averages of the labor requirement for the row crops (corn, soybeans, cotton) and the hay crop. These labor requirements were somewhat higher than for the nonrotation systems because of the heavy labor requirement per acre during the summer months for baling and storing the hay.

Capital Requirement

The annual capital requirements (investment and operating) for the various cropping systems are shown in Table 7. Operating capital included estimated costs of annual inputs such as seed, fertilizer, chemicals, and fuel for machines. Investment capital was an estimate of the protated share of machinery investment necessary to produce an acre of a particular crop. Investment capital does not include land investment. Among the continuous cropping systems, capital requirements were greatest for the cotton cropping systems followed by wheat-soybeans double-crop, corn, and soybeans single-crop. The use of a winter cover crop increased the operating capital requirement by approximately $20 for each crop enterprise.

TABLE 7

ANNUAL CAPITAL REQUIREMENTS PER ACRE FOR THE VARIOUS CROPPING SYSTEMS[a]

Continuous Cropping System		Corn		Soybeans		Cotton		Doublecrop Wheat/Soybeans	
		INV	OPR	INV	OPR	INV	OPR	INV	OPR
		-----------	-----------	-----------	dollars	-----------	-----------	-----------	-----------
Up-and-down slope:	No winter cover	107.71	96.64	104.48	74.60	214.86	145.54	157.52	125.90
	With winter cover	126.38	118.45	112.67	93.68	223.05	164.62	--	--
Contour tillage:	No winter cover	113.10	97.78	109.70	75.65	225.60	147.72	--	--
	With winter cover	132.70	119.59	118.30	94.73	234.20	166.87	--	--
Terraces:	No winter cover	115.92	98.57	112.52	76.44	228.42	148.51	--	--
	With winter cover	135.52	120.38	121.12	95.52	237.02	167.66	--	--
No-till system:	Planted in residue	85.33	101.56	85.33	81.16	--	--	165.40	127.52
	Planted in winter cover	104.00	123.37	93.52	100.24	--	--	--	--
	With terraces	92.42	103.14	92.42	82.74	--	--	168.22	128.31
Rotational systems:[d]	5 years	140.85	65.02	140.21	60.61	162.28	74.80	--	--
	4 years	138.78	66.99	137.98	61.48	165.57	79.22	--	--
	3 years	135.33	70.25	134.22	62.94	171.03	86.59	--	--
	2 years	128.43	76.88	126.81	65.86	182.00	101.33	--	--

[a]Annual capital requirements adapted from the Farm Planning Manual (22).

[b]INV = investment capital.

[c]OPR = operating capital; utilized for six months.

[d]Capital requirements for the rotational systems are weighted yearly averages of the row crop and hay.

The investment capital requirements for the corn and soybean no-till systems were less than for the conventional systems because of less machine time required due to fewer field operations. However, the operating capital requirements for the no-till systems were somewhat greater than for the conventional systems due to additional seed, herbicide, and pesticide requirements.

Crop Yields

The proportion of each soil mapping unit was determined for each field. A weighted average yield for the different crops was determined for each field. Yield estimates for the different soil mapping units were obtained from Buntley and Bell (7). However, since the average annual cotton yields reported by the Tennessee Crop Reporting Service have been consistently lower for the past few years than the potential yields as given by this bulletin, the expected yields for cotton were adjusted downward to reflect more recent yield levels in the area. The cotton yields as shown by Buntley and Bell (7) were decreased by 40 percent. The average yields per acre over the past five years for the study area as reported by the Tennessee Crop Reporting Service (26) were as follows: corn, 71 bushels; soybeans, 24 bushels; cotton, 384 pounds; and wheat, 35 bushels. Because of the delay in planting date, soybean yields were reduced 25 percent when used in a double-crop system with wheat (Table 8).

The yields used in this study were somewhat higher than the average state yields and are based on an assumption of above average level of managerial ability.

TABLE 8

ESTIMATED YIELDS PER ACRE FOR THE SOIL MAPPING UNITS ON THE THREE STUDY FARMS[a]

Soil Type	Slope Gradient	Degree of Erosion	Corn (bushels)	Soybeans (bushels)	Cotton (pounds)	Wheat (bushels)	Fescue HE/Tons[b]
Calloway silt loam	0-2		95	42	450	50	3.4
Collins silt loam	0-2		120	46	525	52	3.5
Falaya silt loam	0-2		100	38	465	36	3.4
Grenada silt loam	2-5	1	90	34	435	52	3.1
Grenada silt loam	2-5	2	85	30	420	46	3.0
Grenada silt loam	2-5	3	70	24	360	40	2.7
Grenada silt loam	5-8	3	55	20	300	38	2.4
Lexington silt loam	2-5	3	80	28	390	49	2.9
Lexington silt loam	5-8	3	75	30	375	48	2.8
Lexington silt loam	8-12	3	70	24	360	47	2.7
Loring silt loam	2-5	1	105	40	495	56	3.4
Memphis silt loam	0-2	1	120	44	540	56	3.5
Memphis silt loam	2-5	1	110	40	510	54	3.4
Memphis silt loam	2-5	2	105	36	495	52	3.4
Memphis silt loam	2-5	3	95	32	450	48	3.2
Memphis silt loam	5-8	3	75	28	375	44	2.8

[a]Yield estimates obtained from Buntley and Bell with adjusted cotton yields (7).

[b]HE = Hay Equivalent.

Net Returns

A comparison of annual net returns to land, overhead cost,[3] labor, and management for the different cropping systems for representative yield levels is shown in Table 9. Weighted average yields for the different crops were obtained for each field for each of the three farms. The costs used included both variable and fixed cost. Investment and operating capital were charged off at the rate of 9 percent. the cost of terraces included depreciation (over 20 years), interest on investment, and yearly maintenance.

Net returns per acre were greatest from the corn cropping systems followed by wheat-soybeans double-crop, soybeans single-crop, and cotton. The net returns per acre for all corn cropping systems were greater than the equivalent cropping system with soybeans or cotton. Labor and capital requirements per acre were lower for soybeans than for corn or cotton. Under the assumptions used in this study cotton appeared to be considerably less profitable than corn or soybeans for most situations. The greatest single net return was estimated from no-till corn at $106.58 per acre.

When a winter cover crop was added to conventional tillage up and down the slope, yearly net returns per acre were reduced $28.77 for corn, $22.46 for soybeans, and $22.46 for cotton. When a five-year fescue-ladino meadow rotation was considered with each row crop, as compared to

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[3]Certain costs are incurred that cannot be allocated to a particular enterprise. These may include such expenses as insurance, truck expenses, tools, and accounting service. It was assumed that these costs would be the same for every optimum system developed and were disregarded in this study. Thus, net returns shown are exclusive of overhead cost.

TABLE 9

COMPARISON OF ANNUAL NET RETURNS PER ACRE TO LAND, OVERHEAD COST, LABOR, AND MANAGEMENT FOR THE DIFFERENT CROPPING SYSTEMS[a]

Cropping System	Corn	Soybeans	Cotton	Wheat-Soybeans Double-Crop
	dollars			
SRCC	104.77	83.32	60.88	102.12
SRCP	76.00	60.85	38.43	--
CT	101.85	80.53	55.06	97.88
CTCC	72.54	57.86	32.39	--
CTTS[b]	95.62	74.38	48.91	91.73
CCTS	66.39	51.71	26.24	--
NT	106.58	82.65	--	--
NTCC	72.91	55.30	--	--
NTTS	93.23	74.31	--	--
C-4M	56.14	--	--	--
C-3M	59.28	--	--	--
C-2M	64.17	--	--	--
2C-2M	69.37	--	--	--
SB-4M	--	47.08	--	--
SB-3M	--	53.43	--	--
SB-2M	--	56.72	--	--
2SB-2M	--	63.39	--	--
CT-4M	--	--	45.21	--
CT-3M	--	--	45.65	--
CT-2M	--	--	46.33	--
2CT-2M	--	--	47.83	--

[a]In the analysis net returns were estimated for each separate field. Net returns shown here were based on the following yields per acre: corn = 85.8 bushels; soybeans = 30.0 bushels; cotton = 416.9 pounds; wheat = 44.7 bushels; hay = 3.0 tons. Capital charge = 9 percent; 20-year planning horizon; 5 percent additional machine time for contouring tillage.

[b]Cost of terraces includes depreciation assuming a 20-year life of terraces, interest on average investment, and yearly maintenance. Initial cost of terrace was assumed to be $56.48 per acre. Net return would decrease with increases in cost of terraces or a reduction in planning horizon.

continuous cropping up-and-down slope, average annual net returns were reduced \$48.63 for corn, \$36.23 for soybeans, and \$15.67 for cotton. The addition of terraces, as compared to up-and-down slope, reduced average annual net returns per acre from \$104.77 to \$95.70 for corn, from \$83.31 to \$74.38 for soybeans, and from \$60.88 to \$48.91 for cotton. Net returns for a particular use varied among the fields on the three farms due to differences in yield levels and the projected effect of erosion levels on yields of crops on certain soils over time.

F. CONSERVATION IMPROVEMENTS

Contour Tillage

Contour tillage can be an effective conservation practice when properly used. Its effectiveness depends on row ridges made with tillage implements which retard water running downhill. Soil loss from contoured fields may vary from 100 percent to 50 percent of that expected from up-and-down slope tillage, depending upon the steepness of the slope (13). On the three study farms upland soils used for cropland included 2-5, 5-8, and 8-12 percent slopes. No slopes greater than 12 percent were cropped. Using standard soil loss estimating techniques, contour tillage will reduce soil loss by 50 percent on the 2-5 and 5-8 percent slopes and by 40 percent on the 8-12 percent slopes.

Bradley conducted various field operations on row crop plots to measure pattern efficiency (6). Pattern efficiency was defined as machine operating time divided by machine operating time plus turning time.

$$\text{Pattern Efficiency} = \frac{\text{Operating Time}}{\text{Operating Time + Turning Time}}$$

Using test plots that included a wide variety of field layouts varying from large wide fields with many turns to narrow fields with few turns, pattern efficiency varied from 81.9 percent on large wide fields with many turns to 96.4 percent on narrow fields with few turns. His study was used as a basis for determining the difference in machine time required for contour tillage as compared to up-and-down slope.

Dimensions of each field in this study were estimated from aerial photographs obtained from the Soil Conservation Service. If a field was designed in such a way that fewer turns would be made if contour tillage were practiced, it was assumed that the farmer would naturally till in the direction of the contour and no additional machine time was added for contour tillage. When tillage on the contour required more machine time than up and down the slope, this additional machine time was incorporated into the cost of machinery of the crop budgets. In this study, the additional machine time required for contour tillage ranged from 1 to 10 percent and averaged about 5 percent.

Conservation Structures

On the study farms the number of feet of terraces and acres of grassed waterway and diversion were estimated from the SCS conservation plans. Both parallel and gradient terraces were used on all three study farms. Grassed waterways and diversions were assumed to be 35 feet wide. The acres in diversions and waterways were subtracted from the total cropland in the fields where they were located. No land was removed from production for terraces and sediment basins.

Improvements required by the conservation plans were inventoried for each field on each farm selected. Considerations in this study were limited to those improvements which directly affect, or are inseparably linked to erosion and sediment control. The improvements considered were terraces, diversions, grassed waterways, and sediment retention. Other nonconstruction types of measures such as winter cover crops, crop rotations, contouring, and different residue management practices were included in the crop budgets. Conservation practices and costs by field are given in Table 10 for the three farms. Costs as given were estimated by the district conservationist.

The effects of contouring and terracing are explicitly taken into account in the Universal Soil Loss Equation (USLE), but the effects of such measures as waterways and sediment retention structures are not. Waterways are used to carry water from drainage systems, diversions, terraces, or from natural outlets in the fields. Waterways dispose of excess water which might otherwise result in surface runoff, but their effects on soil loss cannot be accounted for explicitly.

Other measures such as woodland management, wildlife management, and pond construction were not considered because of their secondary importance to erosion and sedimentation control from cropland.

A 20-year life expectancy for the terrace structures with yearly maintenance was assumed for this study.

Maintenance Cost for Conservation Structures

Maintenance on terraces consisted of one extra plowing of the terrace each year when the soil was being prepared for planting with the furrow being thrown toward the center of the terrace. The additional machine time required was included as a cost of production on the fields where the terraces were present.

TABLE 10

ESTIMATED COST OF CONSERVATION STRUCTURES ON THE THREE STUDY FARMS

Structure	Unit	Amount	Cost Per Unit	Total Cost
			-------dollars--------	
Farm 1				
Terraces[a]	Linear feet	9,919	.42	4,166
Diversions	Linear feet	4,250	.63	2,678
Grassed waterways	Acres	6.2	500	3,100
Debris basins	#/basins	4	225	900
Farm 2				
Terraces[a]	Linear feet	9,000	.15	1,350
		2,500	.16	400
		4,000	.18	720
		1,600	.50	800
Grassed waterways	Acres	2.25	300	675
Farm 3				
Terraces	Linear Feet	6,800	.15	1,020
		11,000	.16	1,760
		2,600	.17	442
		3,500	.18	630
		10,000	.20	2,000
Grassed waterways	Acres	1.2	250	300
		2.2	300	660

[a]Terracing cost on the three study farms was considerably lower than normally expected especially for Farms 2 and 3. Unpublished data from a recent survey of 60 West Tennessee farms indicated an average cost of $.67 per foot for building terraces in 1980 (14).

As an illustration, if the average number of feet of terrace per acre were 217.5[4] feet and the width of the terrace were 26 feet, then the terraced area would be 5,655 square feet of terrace--about .13 acre. Using 1980 machine prices and the time required to plow an acre as indicated in the Farm Planning Manual (22), the total cost of plowing an acre was $6.70. This means the yearly maintenance cost for terraces on this acre would be $.87 (excluding labor cost). This does not take into account the additional cost for contour tillage required when terraces are installed.

The conservation plan for Farm 1 in Madison County called for acreage in two fields to be designated as "critical areas," considered unsuitable for crop production. These areas were placed in permanent cover similar to the grassed waterways or diversions. The maintenance cost on these areas was assumed to be the same as for grassed waterways and diversions.

The yearly charges made for maintenance on the other conservation structures are shown in Table 11.

Soil Loss

The generally accepted method of estimating gross soil erosion loss from a particular cropping system involves the use of the Universal Soil Loss Equation (USLE). The USLE considers the major factors that are known to influence rainfall erosion. The equation predicts the average annual soil loss in tons per acre per year that is expected to

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[4]Average feet of terraces installed per acre on 60 farms as indicated by a recent survey conducted by the Department of Agricultural Economics of district conservationists in 12 West Tennessee counties.

TABLE 11

YEARLY MAINTENANCE COST ON CONSERVATION STRUCTURES[a]

Structure	Cost/Year/Acre of Structure: Farm 1 Madison County	Farms 2 and 3 Haywood County
	---dollars---	
Grassed waterways	50	30
Diversions	50	30
Critical areas	50	30
Sediment basins[b]	25	25

[a]Estimates made in consultation with the local district conservationists.

[b]$25.00 per structure and not per acre of structure.

occur over a period of years. The predictions obtained using USLE are valid only when applied over a period of years and may not be true for any one specific year because of year-to-year fluctuations. This equation predicts the amount of soil that is moved within the field by forces of rainfall striking the soil and by surface water runoff. Much of the soil may be redeposited in grassed areas or flatter ground and not leave the field. This equation does not predict the amount of soil that may actually enter the streams. The soil loss equation has the form:

$$A = RKLSCP$$

where

A = the soil loss in tons per acre per year

R = the erosion index (EI) which indicates the erosion potential of rainfall in a partiular locality.

K = soil erodibility factor, reflecting the rate at which different types of soil erode, expressed in soil loss in tons per acre per unit of rainfall erosion index (R) from cleaned-tilled continuous fallow on a 9 percent slope, 72.6 feet long

L = slope length factor, expressed as soil loss on a given length of slope to that from a slope 72.6 feet long with all other conditions identical

S = slope steepness factor, expressed as soil loss on a given percent slope compared to soil loss on a 9 percent slope with all other conditions identical

C = the cropping-management factor, reflecting the expected ratio of soil loss from land cropped under specified conditions to soil loss from continuous fallow, all other conditions identical

P = conservation practice factor, indicating the ratio of soil loss with a particular conservation practice, such as contouring and terraces, in comparison to soil loss with straight row tillage

Much of the data necessary for estimating soil loss on farms in Tennessee has been published. The rainfall factor R, the soil erodibility factor K, the cropping-management factor C, and the soil conservation factor P, were obtained from Jent, Bell, and Springer (13) and certain addendums. The "C" factors for SB-4M, SB-3M, SB-2M, and 2S-2M were obtained by telephone communication from C. H. Jent, Soil Conservation Service, Nashville, Tennessee.

The steepness of slope factor S was taken from the soil and capability maps provided by SCS. The midpoint of the slope steepness for each soil mapping unit given on these maps was taken as the factor for use in the USLE. For example, 3.5 was used as the slope (S) factor when the slope steepness 2-5 percent was designated on the soil and capability maps. The soils with slopes of 0-2 percent were assumed to have no measurable soil loss.

The lengths of slopes used for the USLE were 150 feet for those fields where terraces were not recommended and 200 feet for those fields where terraces were recommended. It was assumed that fields where terraces were recommended would normally have longer slope than those fields where terraces were not recommended. These lengths were selected after extensive consultation with personnel from the Plant and Soil Science Department, University of Tennessee, and SCS soil scientists in the West Tennessee area. To simplify soil loss calculations a terrace spacing of 100 feet was used as an average value for all proposed terraces (30).

Using the appropriate factor values, an estimate of gross erosion specific to each cropping system of the model was computed using the USLE. The computations were made separately for each soil mapping unit for each field. The resulting soil loss estimates were averaged to arrive at a weighted average soil loss for each field. The soil loss estimates for each soil mapping unit by cropping system are given in Tables 12, 13, 14, and 15.

TABLE 12

SOIL LOSS ESTIMATES USING USLE FOR EACH SOIL MAPPING UNIT BY CROPPING SYSTEM FOR CORN

Series	Percent Slope	Length Slope (feet)	Cropping System												
			SRCC	SRCP	CT	CTCC	CTTS[a]	CCTS	NT	NTCC	NTTS	C-4M	C-3M	C-2M	2C-2M
			tons per acre per year												
Grenada	2-5	150	16.8	16.0	8.4	8.0	7.2	6.9	3.3	3.5	1.4	4.4	6.9	8.9	11.1
		200	18.6	17.7	9.3	8.9	7.2	6.9	3.7	3.9	1.4	4.9	7.6	9.9	12.3
Grenada	5-8	150	38.8	37.0	19.4	18.5	15.9	15.1	7.6	7.9	3.1	10.2	16.1	20.6	25.6
		200	44.9	42.8	22.5	21.4	15.9	15.1	8.9	9.2	3.1	11.8	18.6	23.9	29.6
Grenada	8-12	150	70.8	67.6	42.5	40.6	34.6	33.1	14.0	14.6	6.8	18.6	29.3	37.6	46.7
		200	81.8	78.1	49.0	49.1	34.6	33.1	16.2	16.9	6.8	21.5	33.8	43.4	53.9
Lexington	2-5	150	14.4	13.8	7.2	6.9	6.2	5.9	2.8	3.0	1.2	3.8	5.9	7.7	9.5
		200	16.0	15.2	8.0	7.7	6.2	5.9	3.2	3.4	1.2	4.2	6.5	8.5	10.6
Lexington	5-8	150	33.4	31.8	16.7	15.9	13.7	13.0	6.5	6.8	2.7	8.8	13.8	17.7	22.0
		200	38.6	36.9	19.4	18.4	13.7	13.0	7.7	7.9	2.7	10.1	16.0	20.6	25.5
Lexington	8-12	150	60.9	58.1	36.5	34.9	29.8	28.4	12.0	12.6	5.9	16.0	25.2	32.3	40.3
		200	70.3	67.2	42.2	40.3	29.8	28.4	13.9	14.5	5.9	18.5	29.1	37.3	46.4
Loring	2-5	150	14.4	13.8	7.2	6.9	6.2	5.9	2.8	3.0	1.2	3.8	5.9	7.7	9.5
		200	16.0	15.2	8.0	7.7	6.2	5.9	3.2	3.4	1.2	4.2	6.5	8.5	10.6
Memphis	2-5	150	14.4	13.8	7.2	6.9	6.2	5.9	2.8	3.0	1.2	3.8	5.9	7.7	9.5
		200	16.0	15.2	8.0	7.7	6.2	5.9	3.2	3.4	1.2	4.2	6.5	8.5	10.6
Memphis	5-8	150	33.4	31.8	16.7	15.9	13.7	13.0	6.5	6.8	2.7	8.8	13.8	17.7	22.0
		200	38.6	36.9	19.4	18.4	13.7	13.0	7.7	7.9	2.7	10.1	16.0	20.6	25.5
Memphis	8-12	150	60.9	58.1	36.5	34.9	29.8	28.4	12.0	12.6	5.9	16.0	25.2	32.3	40.3
		200	70.3	67.2	42.2	40.3	29.8	28.4	13.9	14.5	5.9	18.5	29.1	37.3	46.4

[a]A terrace spacing of 100 feet was used as an average value for all proposed terraces.

TABLE 13

SOIL LOSS ESTIMATES USING USLE FOR EACH SOIL MAPPING UNIT BY CROPPING SYSTEM FOR SOYBEANS

Series	Percent Slope	Length Slope (feet)	SRCC	SRCP	CT	CTCC	CTTS	CCTS	NT	NTCC	NTTS	SB-4M	SB-3M	SB-2M	2SB-2M
			tons per acre per year												
Grenada	2-5	150	16.8	17.2	8.4	8.6	7.3	7.5	5.6	5.3	2.4	2.8	3.3	4.3	6.4
		200	18.6	19.1	9.3	9.6	7.3	7.5	6.2	5.8	2.4	3.1	3.7	4.8	7.1
Grenada	5-8	150	38.9	40.0	19.5	20.0	15.9	16.4	13.0	12.3	5.3	6.4	7.7	9.9	14.9
		200	45.0	46.3	22.5	23.2	15.9	16.4	15.1	14.2	5.3	7.4	8.9	11.5	17.3
Grenada	8-12	150	71.0	73.0	42.6	43.8	34.7	35.7	23.7	22.5	11.6	11.7	13.9	18.0	27.1
		200	82.0	84.3	49.2	50.6	34.7	35.7	27.4	26.0	11.6	13.5	16.1	20.8	31.3
Lexington	2-5	150	14.5	14.9	7.3	7.5	6.3	6.4	4.8	4.6	2.1	2.4	2.8	3.7	5.5
		200	16.1	16.5	8.1	8.3	6.3	6.4	5.3	5.1	2.1	2.7	3.1	4.1	6.1
Lexington	5-8	150	33.5	34.4	16.8	17.2	13.7	14.1	11.2	10.6	4.5	5.5	6.6	8.5	12.8
		200	38.8	39.8	19.4	19.9	13.7	14.1	13.0	12.3	4.6	6.4	7.6	9.8	14.8
Lexington	8-12	150	61.1	62.8	36.7	37.7	29.9	30.7	20.4	19.3	10.0	10.1	12.0	15.5	23.3
		200	70.6	72.5	42.4	43.5	29.9	30.7	23.6	22.3	10.0	11.7	13.9	17.9	26.9
Loring	2-5	150	14.4	14.9	7.3	7.5	6.3	6.4	4.8	4.6	2.1	2.4	2.8	3.7	5.5
		200	16.1	16.5	8.1	8.3	6.3	6.4	5.3	5.1	2.1	2.7	3.1	4.1	6.1
Memphis	2-5	150	14.4	14.9	7.3	7.5	6.3	6.4	4.8	4.6	2.1	2.4	2.8	3.7	5.5
		200	16.1	16.5	8.1	8.3	6.3	6.4	5.3	5.1	2.1	2.7	3.1	4.1	6.1
Memphis	5-8	150	33.5	34.4	16.8	17.2	13.7	14.1	11.2	10.6	4.6	5.5	6.6	8.5	12.8
		200	38.8	39.8	19.4	19.9	13.7	14.1	13.0	12.3	4.6	6.4	7.6	9.8	14.8
Memphis	8-12	150	61.1	62.8	36.7	37.7	29.9	30.7	20.4	19.3	10.0	10.1	12.0	15.5	23.3
		200	70.6	72.5	42.4	43.5	29.9	30.7	23.6	22.3	10.0	11.7	13.9	17.9	26.9

Cropping System

TABLE 14

SOIL LOSS ESTIMATES USING USLE FOR EACH SOIL MAPPING UNIT BY CROPPING SYSTEM FOR COTTON

Series	Percent Slope	Length Slope (feet)	SRCC	SRCP	CT	CTCC	CTTS	CCTS	C-4M	C-3M	C-2M	2C-2M
			Cropping System									
			tons per acre per year									
Grenada	2-5	150	26.6	20.2	13.3	10.1	11.5	8.7	6.2	8.1	10.4	14.7
		200	29.5	22.4	14.8	11.2	11.5	8.7	6.9	9.0	11.5	16.3
Grenada	5-8	150	61.7	46.8	30.9	23.4	25.2	19.1	14.4	18.6	24.0	34.0
		200	71.4	54.2	35.7	27.1	25.2	19.1	16.7	21.5	27.8	39.4
Grenada	8-12	150	112.5	85.4	67.5	51.2	55.0	41.8	26.3	34.0	43.9	62.1
		200	129.9	98.6	77.9	59.2	55.0	41.8	30.4	39.3	50.7	71.7
Lexington	2-5	150	22.9	17.4	11.5	8.7	9.9	7.6	5.4	6.9	8.9	12.7
		200	25.4	19.3	12.7	9.7	9.9	7.6	5.9	7.6	9.9	14.1
Lexington	5-8	150	53.1	40.3	26.6	20.2	21.7	16.5	12.4	16.0	20.7	29.3
		200	61.5	46.7	30.6	23.2	21.7	16.5	14.4	18.5	24.0	33.9
Lexington	8-12	150	96.8	73.4	58.1	44.0	47.3	35.9	22.6	29.2	37.8	53.4
		200	111.8	84.8	67.1	50.1	47.3	35.9	26.1	33.7	43.7	61.7
Loring	2-5	150	22.9	17.4	11.5	8.7	9.9	7.6	5.4	6.9	8.9	12.7
		200	25.4	19.3	12.7	9.7	9.9	7.6	5.9	7.6	9.9	14.1
Memphis	2-5	150	22.9	17.4	11.5	8.7	9.9	7.6	5.4	6.9	8.9	12.7
		200	25.4	19.3	12.7	9.7	9.9	7.6	5.9	7.6	9.9	14.1
Memphis	5-8	150	53.1	40.3	26.6	20.2	21.7	16.5	12.4	16.0	20.7	29.3
		200	61.5	46.7	30.6	23.2	21.7	16.5	14.4	18.5	24.0	33.9
Memphis	8-12	150	96.8	73.4	58.1	44.0	47.3	35.9	22.6	29.2	37.8	53.4
		200	111.8	84.8	67.1	50.1	47.3	35.9	26.1	33.7	43.7	61.7

TABLE 15

SOIL LOSS ESTIMATES USING USLE FOR EACH SOIL MAPPING UNIT BY CROPPING SYSTEM FOR SOYBEANS-WHEAT DOUBLE-CROP, HAY, AND PASTURE

Series	Percent Slope	Length Slope (feet)	Cropping System				
			SRCC	CT	CTTS	HAY	PAST
			--------tons per acre per year--------				
Grenada	2-5	150	5.6	2.8	2.4	.19	.19
		200	6.2	3.1	2.4	.21	.21
Grenada	5-8	150	12.9	6.5	5.3	.44	.44
		200	14.9	7.5	5.3	.51	.51
Grenada	8-12	150	23.7	14.2	11.6	.81	.81
		200	27.4	16.4	11.6	.93	.93
Lexington	2-5	150	4.8	2.4	2.1	.16	.16
		200	5.3	2.7	2.1	.18	.18
Lexington	5-8	150	11.2	5.6	4.6	.38	.38
		200	13.0	6.5	4.6	.44	.44
Lexington	8-12	150	20.4	12.2	10.0	.70	.70
		200	23.6	14.2	10.0	.81	.81
Loring	2-5	150	4.8	2.4	2.1	.16	.16
		200	5.3	2.7	2.1	.18	.18
Memphis	2-5	150	4.8	2.4	2.1	.16	.16
		200	5.3	2.7	2.1	.18	.18
Memphis	5-8	150	11.2	5.6	4.6	.38	.38
		200	13.0	6.5	4.6	.44	.44
Memphis	8-12	150	20.4	12.2	10.0	.70	.70
		200	23.6	14.2	10.0	.81	.81

Soil Loss Estimates

Based on estimates using the USLE, among the crop management systems considered in this study, the greatest average annual soil losses per acre would occur with the cotton cropping systems. For the cotton systems estimates ranged from approximately 5 to over 100 tons/acre/year depending on the soil type, percent slope, length of slope, and cropping system (Table 14). Production of cotton with the up-and-down slope system on 8-12 percent slope Grenada soils would result in soil losses in excess of 100 tons/acre/year. The smallest soil losses occurred with meadow and pasture, less than one ton/acre/year in every situation. Estimated soil losses for the soybean and corn cropping systems were essentially the same on a particular soil when production practices used were similar. As the length and steepness of the slope increased, soil loss increased for all cropping systems. Soil losses for a 5-8 percent slope were more than double that for a 2-5 percent slope. Soil losses for an 8-12 percent slope were more than triple that for a 2-5 percent slope. For example, soil loss for corn conventional tillage up-and-down slope on a Lexington, Loring, or Memphis soil, 2-5 percent slope, 150 feet in length, was 14.4 tons. For the same soils and slope length soil loss was estimated to be 33.4 tons with 5-8 percent slope and 60.9 tons with 8-12 percent slope. Soil losses for cotton, on the same soil series and slope length, were 22.9 tons at the 2-5 percent slope, 53.1 tons at the 5-8 percent slope, and 96.8 tons at the 8-12 percent slope. No-till systems were not considered for cotton.

Estimated soil losses were greater than five tons for all cotton cropping systems considered. Soil loss tolerance levels are five tons or less on all the upland soils on the three study farms.

For no-till soybeans produced in double-crop combination with wheat on a Lexington, Loring, or Memphis soil and an assumed slope length of 150 feet, soil losses were estimated to be 4.8 tons on 2-5 percent slopes, 11.2 tons on 5-8 percent slopes, and 20.4 tons on 8-12 percent slopes. The addition of terraces, using the same cropping systems was estimated to reduce soil losses to 2.1 tons on the 2-5 percent slope, 4.6 tons on the 5-8 percent slope, and 10.0 tons on the 8-12 percent slope.

Estimates indicated that the most highly erosive cropping systems would be conventional tillage up and down the slope except in the case of soybeans where conventional tillage up and down the slope with winter cover would result in soil losses slightly higher than without winter cover. Soil losses would be five tons/acre-year or more for any continuous row crops except where no-till systems were used and the slope was less than 5 percent. When the no-till systems were used with terraces, soil losses on 2-5 percent slopes were reduced below two tons per acre for corn and to approximately two tons for soybeans. The established tolerance level for severely eroded Grenada and Lexington soil is two tons per acre. Soil losses on the Grenada soils were approximately 16 percent higher than for other upland soils on the study farms for all cropping systems. Because of its physical properties, the soil erodibility factor (K) is somewhat higher for Grenada than for Lexington, Loring, and Memphis. Based on estimates using the USLE, soil loss would be from 10-15 percent higher with 200-foot slope length than with 150-foot slope length depending upon the steepness of the slope.

Following is a comparison of the reduction in soil losses on Lexington, Loring, and Memphis soils for the various conservation alternatives used. In each case the comparison is made with conventional tillage up-and-down slope.

Winter Cover Crop

On corn produced up and down the slope the use of a small grain winter cover crop would reduce soil losses from 14.4 tons per acre to 13.8 tons per acre on 2-5 percent slopes 150 feet in length. The addition of the winter cover would reduce soil losses from 33.4 to 31.8 tons per acre on the 5-8 percent slopes and from 60.9 to 58.1 tons per acre on the 8-12 percent slopes.

Estimates indicated that a small grain winter cover crop would reduce soil losses from cotton production from 22.9 tons per acre to 17.4 tons/acre/year on 2-5 percent slopes 150 feet in length. On 5-8 percent slopes the winter cover would reduce soil losses from 53.1 to 40.3 tons per acre; a reduction from 96.8 to 73.4 tons could be expected on 8-12 percent slopes. The addition of a winter cover crop on soils used to produce soybeans (up and down the slope) would not reduce annual soil losses. The addition of a winter cover crop would increase production costs about $20 per acre.

Contour Tillage

Contour tillage, which creates small ridges that retard water running downhill, was estimated to reduce soil losses by 50 percent on the 2-5 and 5-8 percent slopes and by 40 percent on the 8-12 percent slopes for all crop enterprises. For corn on soils with 150-foot slopes soil losses would be reduced from 14.4 tons to 7.2 tons on the 2-5 percent slopes, from 33.4 to 16.7 on the 5-8 percent slopes, and from 60.9 to 36.5 tons on the 8-12 percent slopes. Contour tillage in combination with a winter cover crop would further reduce soil losses on land used for corn from 14.4 to 6.9 tons on 2-5 percent slopes, from 33.4 to 15.9 tons on 5-8 percent slopes, and from 60.9 to 34.9 tons on 8-12 percent slopes. The relationships were essentially the same for soybeans as for corn.

For cotton contour tillage on soils with 150-foot slope was estimated to reduce soil losses from 22.9 to 11.5 tons per acre on 2-5 percent slopes, from 53.1 to 26.6 tons per acre on the 5-8 percent slopes, and from 96.8 to 58.1 tons per acre on the 8-12 percent slopes. Contour tillage with a small grain winter cover crop would further reduce soil losses from 22.9 to 8.7 tons per acre on 2-5 percent slope, from 53.1 to 20.1 tons on 5-8 percent slopes, and from 96.8 to 44.0 tons per acre on the 8-12 percent slopes.

For soybeans-wheat double-crop on soils with 150-foot slope length contouring would reduce soil losses from 4.8 to 2.4 tons on the 2-5 percent slopes, from 11.2 to 5.6 tons on 5-8 percent slopes, and from 20.4 to 12.1 tons on 8-12 percent slopes.

Contour Tillage with Terraces

Terraces reduce the length of slope and thus slow down the rate of water runoff. If terraces were installed, it was assumed all tillage would be done on the contour. The combination of contour tillage and terraces was estimated to reduce soil losses from 14.4 tons per acre to 6.2 tons per acre for corn produced on 2-5 percent slopes, 150 feet in length. On the same length slope soil losses were reduced from 33.4 to 13.7 tons per acre on 5-8 percent slopes and from 60.9 to 29.8 tons per acre on 8-12 percent slopes. The addition of a winter cover crop on terraced land would have very minor effects on soil losses.

The combination of contour tillage and terraces on soils used for cotton would reduce soil losses from 22.9 to 9.9 tons per acre on 2-5 percent slopes 150 feet in length. On 150-foot slopes soil losses would be reduced from 53.1 to 21.7 tons per acre on 5-8 percent slopes and from 96.8 to 47.3 tons per acre on 8-12 percent slopes. Terraces in combination with a winter cover would reduce soil losses from 22.9 to 7.6 tons per acre on 2-5 percent slopes, from 53.1 to 16.5 tons on 5-8 percent slopes, and from 96.8 to 35.9 tons on 8-12 percent slopes.

The addition of terraces for the soybean-wheat double-cropping systems (no-till system for soybeans) would reduce soil losses from 4.8 to 2.1 tons per acre on 2-5 percent slopes, 150 feet in length. On 5-8 percent slopes soil losses were estimated to be reduced from 11.2 to 4.6 tons per acre, and from 20.4 to 10 tons per acre on 8-12 percent slopes.

<u>No-Till</u>

As indicated by the data in Tables 12 and 13 on pages 44 and 45, no-till systems can make a substantial contribution to the reduction of soil erosion losses. No-till alone was estimated to reduce soil losses for corn from 14.4 to 2.8 tons per acre on 2-5 percent slopes, from 33.4 to 6.5 tons per acre on 5-8 percent slopes, and from 60.9 to 12.0 tons on 8-12 percent slopes. For soybean production, no-till would reduce soil loss from 14.5 to 4.8 tons per acre on 2-5 percent slopes, from 33.5 to 11.2 tons per acre on 5-8 percent slopes, and from 61.1 to 20.4 on 8-12 percent slopes.

No-till production system in combination with terraces would further reduce soil losses; for corn the reduction would be from 14.4 to 1.2 tons per acre on 2-5 percent slopes, from 33.4 to 2.7 on 5-8 percent slopes, and from 60.9 to 5.9 on 8-12 percent slopes. For soybeans no-till and terraces would reduce soil losses from 14.5 to 2.1 tons per acre on 2-5 percent slopes, from 33.5 to 4.5 tons per acre on 5-8 percent slopes, and from 61.1 to 10.0 tons per acre on 8-12 percent slopes. All the illustrations given above for the effect of no-till assumed 150-foot slopes. The effect of using no-till systems would be less on shorter slopes and greater on slopes more than 150 feet in length.

Rotations

Each row crop was considered in a two-, three-, four-, and five-year rotation with a ladino-fescue used as the forage. Since forage provides a ground cover for the entire year, soil loss would be greatly reduced. In comparison to up-and-down the slope production methods, a five-year rotation for corn would reduce average annual soil losses from 14.4 to 3.8 tons per acre on 2-5 percent slopes, 150 feet in length. On 5-8 percent slopes soil losses would be reduced from 34.4 to 8.8 tons per acre and from 60.9 to 16.0 tons per acre on 8-12 percent slopes.

For soybeans the five-year rotation would reduce average annual soil losses per acre from 14.5 to 2.4 tons/acre/year on 2-5 percent slopes, 150 feet in length. Soil losses were reduced from 33.5 to 5.5

tons per acre on 5-8 percent slopes, and from 61.1 to 10.1 tons on 8-12 percent slopes.

By using a five-year rotation for cotton, soil losses could be reduced from 22.9 to 5.4 tons per acre on 2-5 percent slopes, 150 feet in length. On the 5-8 percent slopes soil losses could be reduced from 53.1 to 12.4 tons per acre and from 96.8 to 22.6 tons per acre on 8-12 percent slopes.

Crop Yields Over Time

Erosion through time results in the removal of the topsoil. The amount of soil loss on a given soil type is affected by crop rotation, tillage practices, and conservation practices. Soil loss rates will differ among different soil types. Soil losses from erosion may result in a decline in yield over time depending on such factors as topsoil depth and nature of the soil profile.

The predominant soils on the farms in this study were Grenada and Memphis. For Memphis soils, because the subsoils layers are so similar to that of the topsoil, it was assumed that no decline in yields over time would occur within a soil mapping unit (9). Although no decline in yields was assumed for Memphis, because of soil loss, gullies and rills may develop from one season to the next, requiring leveling before the field can be cultivated with farm machinery. The following average annual costs were included for each field for smoothing gullies and rills created by water erosion:

Soil Loss (Tons/Acre)	Cost ($)
$0 \leq 10$	0
$> 10 \leq 40$	5
$> 40 \leq 70$	10
$> 70 \leq 90$	15

Grenada, the other major soil, has a dense, brittle silt loam fragipan that is strongly acid. Even with little or no erosion the fragipan will be not more than 36 inches below the surface.[5] As soil erodes above this pan, the remaining soil becomes lower in water supplying capacity necessary for plant growth because of the decreased amount of soil from which the plant can extract water.

The depth of the topsoil of Grenada soil in this study was defined in terms of inches of topsoil above the fragipan. Denton defined the erosion classes for Grenada as follows: slightly eroded $\geq$ 20 inches above the fragipan with a maximum of 36 inches, moderately eroded 12 to 20 inches above the fragipan, and severely eroded < 12 inches above the fragipan (9). The depths of topsoil for Grenada and Loring that remained above the fragipan were determined in this study by calculating the midpoint for each erosion class. For example, erosion class one, slightly eroded, denotes that 20 or more inches up to a maximum of 36 inches of topsoil still remains above the fragipan. Thus, the midpoint for erosion class one was considered to be 28 inches. In a similar manner, moderately eroded Grenada was estimated to have 16 inches above the fragipan, and severely eroded to average six inches in depth above the fragipan.

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[5]The erosion-yield relationship for Grenada and Loring was handled in a similar manner. Only Farm 1 had Loring soils (10 acres).

Farms 2 and 3 contained 81 acres of Lexington silt loam. Lexington soils have reddish brown strongly acid, silt loam and silty clay loam upper subsoils overlying variable colored strongly acid, stratified sandy loam and loamy sand sediment. As topsoil erodes above this sandy loam sediment, the remaining soil becomes higher in acidity and lower in fertility. It was assumed that 15 inches of topsoil existed above the sandy loam sediment on severely eroded Lexington soils. The soil loss was not great enough for any of the cropping systems used in this study to be eroded down to the sandy loam layer over the planning horizons considered.

The current yields of each soil mapping unit for each cropping system were computed, as in a single year's analysis. The reduction in yields per acre as erosion class moves down from level to level was taken from Buntley and Bell (7). A weighted average yield reduction was computed for each cropping system for each soil mapping unit in each field.

These steps were necessary in defining the rate of yield reduction per acre inch of topsoil. Assuming the weight of one acre inch of topsoil to be 150 tons, the number of years required to erode an acre inch of topsoil was calculated for each cropping system. Thus, it was possible to estimate the annual crop yield decrease to be expected for each cropping system. Crop yields were assumed to stabilize once the fragipan was reached. Net returns were calculated for each time period on the basis of the expected crop yield in that time period. Management practices and levels of input applications were assumed to remain constant over the planning horizon. The effect of the crop yield reduction was reflected in the discounted net returns calculated for each of the different lengths of planning horizons. Expected present value of net returns from each cropping alternative was calculated for each field (planning unit) using discount factors of 6, 9, and 12 percent.

The estimated decline in crop yields per inch of soil loss for each soil mapping unit is shown in Table 16. The decline in yields per inch of topsoil increases within a soil mapping unit as the severity of the erosion increases (Table 16). For example, on a Grenada 2-5 percent slope, slight to moderate erosion, the decline in corn yield per inch of topsoil loss was .42 bushel; however, on the same soil mapping unit with severe erosion the decline in yield per inch of topsoil loss was 3.33 bushels. In a similar manner for soybeans on a Grenada 2-5 percent slope yields declined .33 bushel on the slight to moderate erosion level and 1.17 bushels per inch on the severely eroded soil.

As a further illustration, a 30-ton soil loss level would translate into a .5 bushel reduction in yield of corn per year on a Grenada soil, 5-8 percent slope, severely eroded. This would mean a reduction of $1.40 per year in net returns per acre or $14 over a 10-year period or $28 per acre reduction over a 20-year period.

TABLE 16

ESTIMATED DECLINE IN YIELDS PER INCH OF SOIL LOSS FOR EACH SOIL MAPPING UNIT

Erosion Level	Corn (bushels)	Soybeans (bushels)	Cotton (pounds)	Wheat (bushels)	Hay (tons)
Grenada 2-5 percent slope					
Slight to moderate (1)	.42	.33	1.25	.50	.01
Moderate to severe (2)	1.50	.60	6.00	.60	.03
Severe to fragipan (3)	3.33	1.17	18.00	2.00	.13
Grenada 5-8 percent slope					
Slight to moderate (1)	.83	.33	3.75	.42	.02
Moderate to severe (2)	1.00	.40	9.38	.50	.02
Severe to fragipan (3)	2.50	1.00	15.00	1.83	.12
Lexington 2-5 percent slopes					
Severe to pan	2.7	.93	13.0	1.63	.10
Lexington 5-8 percent slopes					
Severe to pan	2.2	.73	11.0	1.53	.09
Lexington 8-12 percent slopes					
Severe to pan	2.0	.60	10.5	1.43	.08

CHAPTER III

RESULTS OF THE ANALYSIS

The purpose of this study was to evaluate farm firm behavior when certain key factors related to soil conservation were allowed to vary over time. The following factors were varied: discount rate, length of planning horizon, permissible soil loss by water erosion, yields over time, and cropping management alternatives. Optimum farm organizations were derived using discount rates of 6, 9, and 12 percent. However, since change in the discount rate affected only the income level and made no significant difference in the optimum farm organization on either of the three farms, only the 9 percent discount rate will be reported. Also, since operator labor was not a constraint for any of the farm plans developed, no variations in resident labor supply were made.

Three farms were selected which were considered to be typical of the upland crop producing farms located in the Deep Loess soil region of West Tennessee. These farms were chosen to be representative of farms in the area with size, soil series, and soil mapping units. Soil erosion is a serious problem in this area due to the nature of the soils, the rolling topography of the land, the intensity of the rainfall, and the fact that the soils are used primarily for clean cultivated row crop production.

The enterprises considered were corn, soybeans, cotton, soybeans-wheat double-crop, meadow, pasture, and cow-calf. Up to 41 cropping systems were considered for each field on each farm. The basic planning unit was a field as delineated in the conservation plan developed by SCS.

The cropping systems were differentiated by crop sequence, tillage practices, and conservation practices. Various tillage practices, terraces, rotations, and winter cover crops were considered as conservation alternatives.

The optimum farm organizations for the three farms are discussed in this chapter. The first section of this chapter presents the optimum farm organizations for the three farms using a 20-year planning horizon when soil loss levels are allowed to vary from $\leq$ 100 tons/acre/year to $\leq$ tons/acre/year. Initially all cropping systems were considered. Subsequent plans eliminate first soybeans-wheat double-cropping, then soybeans-wheat double-cropping and no-till corn, and finally elimination of all double-cropping and no-till alternatives.

The second section of this chapter presents the optimum enterprise organizations and net returns for the three farms when all double-cropping and no-till systems were eliminated and variations were made in: (1) the planning horizon, and (2) permissible soil loss levels.

Section three of this chapter presents the optimum enterprise organizations and net returns for Farm 3 when the soil loss level was held at $\leq$ 5 tons/acre/year and variations were made in: (1) the planning horizon, and (2) the cropping management alternatives permitted. The results for this part of the analysis were not presented for Farms 1 and 2 since underlying relationships were very similar to the results shown for Farm 3.

Solutions for linear programming analysis are not constrained to integer values and may include small and fractional units of a particular production activity. If results were being applied to a practical situation some adjustments might need to be made.

I. Optimum Farm Organizations with Variations in Crop Management Systems Considered and Permissible Soil Loss Levels

The optimum organization of enterprises to maximize discounted net returns over a 20-year period for the three farms are presented in this section. Particular attention was given to the interrelationships between permissible soil loss by water erosion, and cropping management alternatives considered. As indicated in an earlier section crop yields on Grenada, Loring, and Lexington soils were projected to decline through time in a defined manner due to degree of erosion. Crop yields on Memphis soils were held constant over the planning horizon. The 20-year planning period was considered to be a reasonable expected horizon for a full-time commercial farmer operating on owned land.

Farmers may possess varying degrees of knowledge concerning production practices related to conservation. Managerial skills may vary widely among farmers and some farmers may have difficulty implementing conservation practices with relatively high managerial skills. Also, among some farmers there may be an inherent reluctance to try something new. On this basis certain cropping systems were successively eliminated (double-crop and no-till) to determine the effect of soil loss constraints upon net returns with various sets of enterprise production alternatives considered.

Farm 1, Madison County

Farm 1, located in Madison County, consisted of 242 acres of cropland, 25 acres of hay and pastureland, 71 acres of woodland, and 12 acres of homestead and other for a total of 350 acres. The soils of Farm 1 included Collins silt loam (18.5 acres), Grenada silt loam (23.9 acres), Lexington silt loam (46.1 acres), Loring silt loam (10.1 acres), and Memphis silt loam (136.2 acres). Collins is a bottomland soil; the remainder are upland soils. None of the Memphis soils were on slopes of greater than five percent.

Optimum farm organization, all cropping systems considered, Farm 1. The optimum farm organization for Farm 1 when all cropping systems were considered is shown in Table 17 for each of the four permissible soil loss levels considered. The optimum farm organization was the same for the $\leq$ 100 ton, $\leq$ 25 ton, and $\leq$ 10 ton soil loss levels and included 175 acres of no-till corn, 64 acres of soybeans-wheat double-crop planted on the contour, 25 acres of meadow, and 3 acres of soybeans-wheat double-crop using the straight row system. For the 11 fields on Farm 1 soil loss level per acre ranged from a high of 9.8 tons on one field to a low of .6 tons on another field and averaged about four tons on all fields. Since soil loss did not exceed 10 tons on any of the fields the optimum farm organizations did not change until soil loss constraints were reduced to 5 tons or less per acre. Soil loss exceeded the five-ton level on three fields. When the five-ton maximum soil loss level was imposed, 13.8 acres (portions of 3 fields) shifted from soybeans-wheat double-crop to meadow. On a third field where soil loss exceeded five

TABLE 17

THE EFFECT OF VARIATION IN PERMISSIBLE SOIL LOSS LEVELS ON OPTIMUM FARM ORGANIZATION, ALL CROPPING SYSTEMS CONSIDERED, 20-YEAR PLANNING HORIZON, FARM 1

	Soil Loss Levels (tons/acre/year)			
	≤ 100	≤ 25	≤ 10	≤ 5
	acres			
Cropping Systems				
Soybeans-wheat double-crop (SRCC)	3.0	3.0	3.0	.2
Soybeans-wheat double-crop (CT)	64.0	64.0	6.40	53.0
Corn (NT)	175.0	175.0	175.0	175.0
Meadow (SELLHAY)	25.0	25.0	25.0	38.8
Income Level				
Net returns ($)	305,495	305,495	305,495	298,301
Percent of base	100.0	100.0	100.0	97.6

tons, 2.8 acres shifted from soybeans-wheat double-crop using straight row tillage to soybeans-wheat double-crop produced using contour tillage.

On Farm 1, 25 acres were designated in the SCS Conservation Plan as suitable for meadow or pasture only because of steepness of slope. On this acreage forage was the only alternative considered. In the optimum plan this forage would be harvested as hay and sold. On Farm 1 the fields where soybeans-wheat double-crop contour tillage occurred were fields that were designed in such a way that the farmer would naturally practice contour tillage. This accounts for the fact that more acreage would be utilized for soybeans-wheat double-crop on the contour than straight row tillage. Net returns were reduced by 2.4 percent when the five-ton soil loss level was imposed.

Optimum farm organization without soybeans-wheat double-crop, Farm 1. When soybeans-wheat double-crop was removed as an alternative, the optimum farm organization with soil loss constraints of ≤ 100 tons and ≤ 25 tons included 238 acres of no-till corn, 25 acres of meadow, and 4 acres of soybeans produced utilizing conventional tillage on the contour (Table 18). The average soil loss level achieved at the ≤ 100-ton

TABLE 18

THE EFFECT OF VARIATION IN PERMISSIBLE SOIL LOSS LEVEL ON OPTIMUM FARM ORGANIZATION, SOYBEANS-WHEAT DOUBLE-CROP ALTERNATIVES EXCLUDED, 20-YEAR PLANNING HORIZON, FARM 1

	Soil Loss Levels (tons/acre/year)			
	≤ 100	≤ 25	≤ 10	≤ 5
	acres			
Cropping Systems				
Corn (NT)	238.0	238.0	227.4	216.6
Corn (NTTS)	--	--	10.6	7.4
Soybeans (CT)	4.0	4.0	4.0	4.0
Meadow (SELLHAY)	25.0	25.0	25.0	39.0
Income Level				
Net returns	300,401	300,401	300,210	294,433
Percent of base	100.0	100.0	99.9	97.7

level was 4.2 tons/acre/year and among fields varied from 11.2 tons per acre to .6 tons per acre. Three fields had soil losses greater than five tons/acre/year and one field had soil losses greater than 10 tons/acre/year. When the 10-ton soil loss constraint was imposed, 10.6 acres shifted from no-till corn to no-till corn with terraces in the field with the greater than 10 tons soil loss. While the maximum soil loss was reduced to five tons per acre 11 acres shifted from no-till corn to meadow. Again it should be noted that a 25-acre field had been designated as suitable only for meadow or pasture in the Conservation Plan of SCS. Net returns were 2.3 percent lower with the five-ton soil loss constraint than for the 100-ton limit level. Estimated total yearly labor requirement increased from 600 hours at the 100-ton soil loss level to 650 hours at the five-ton level. Increased labor was due to the additional labor requirement for baling more hay and the extra time requirement for contour tillage when terraces were installed.

<u>Optimum farm organization without soybeans-wheat double-crop and no-till corn, Farm 1</u>. When soybeans-wheat double-crop and no-till corn were eliminated as options, corn conventional tillage on the contour dominated all cropping systems at the 100-ton soil loss level with 238 acres (Table 19). The average soil loss level achieved by fields varied from a high of 29.2 tons to a low of .6 tons and averaged 11.7 tons/acre/year for all fields. Two fields had soil losses greater than 25 tons/acre/year. Six fields had soil losses greater than 10 tons and nine fields had soil losses greater than five tons. When the 25-ton soil loss level was imposed, three acres shifted from corn conventional tillage on the contour to meadow in those fields with soil loss of greater than

TABLE 19

THE EFFECT OF VARIATIONS IN PERMISSIBLE SOIL LOSS LEVELS ON OPTIMUM FARM ORGANIZATION, SOYBEANS-WHEAT AND NO-TILL CORN ALTERNATIVES EXCLUDED, 20-YEAR PLANNING HORIZON, FARM 1

	Soil Loss Levels (tons/acre/year)			
	≤ 100	≤ 25	≤ 10	≤ 5
	acres			
Cropping Systems				
Corn-conventional (CT)	238.0	235.0	198.0	44.2
Soybeans-conventional (CT)	4.0	4.0	4.0	4.0
Soybeans (NT)	--	--	21.6	24.7
Soybeans (NTTS)	--	--	--	126.4
Meadow (SELLHAY)	25.0	28.0	43.4	67.7
Income Level				
Net returns ($)	289,873	288,888	281,623	223,745
Percent of base	100.0	99.7	97.2	77.2

25 tons. This was necessary to keep all fields within the 25-ton limit. When the 10-ton constraint was imposed, 15.8 additional acres shifted to meadow and 21.6 acres shifted to no-till soybeans. With the five-ton soil loss constraint 126.4 acres shifted to no-till soybeans with terraces and 24.3 additional acres shifted to meadow. Net returns decreased by 22.8 percent as soil loss constraint was reduced from the 100-ton soil loss level to the five-ton soil loss level. The decrease in net return was due largely to the $25-$30 lower annual net return per acre from no-till soybeans with terraces as compared to corn produced with conventional

tillage. Total yearly labor requirement for the optimum plan was reduced from 873 at the 100-ton soil loss level to 771 hours at the 5-ton soil loss level. The labor requirement per acre was lower for no-till soybeans than for conventional tillage corn.

Optimum farm organization without soybeans-wheat double-crop and no-till, Farm 1. When soybeans-wheat double-crop and all no-till options were eliminated from consideration, corn conventional tillage on the contour again dominated in the optimal plan at the 100-ton/acre/year soil loss level with 238 of the 242 available row crop acres (Table 20). In

TABLE 20

THE EFFECT OF VARIATIONS IN PERMISSIBLE SOIL LOSS LEVELS ON OPTIMUM FARM ORGANIZATION, SOYBEANS-WHEAT AND NO-TILL ALTERNATIVES EXCLUDED, 20-YEAR PLANNING HORIZON, FARM 1

	Soil Loss Levels (tons/acre/year)			
	≤ 100	≤ 25	≤ 10	≤ 5
	acres			
Cropping Systems				
Corn-conventional (CT)	238.0	235.0	211.0	95.8
Soybeans-conventional (CT)	4.0	4.0	4.0	4.0
Soybeans (SB-2M)	--	--	--	89.7
Meadow (SELLHAY)	25.0	28.0	52.0	77.5
Income Level				
Net returns ($)	289,873	288,888	279,462	212,996
Percent of base	100.0	99.7	96.4	73.5

the optimal plan for soil loss constraint of 100 tons or less the average soil loss level achieved was 11.7 tons. Two fields had soil losses greater than 25 tons/acre/year. Six fields had soil losses greater than 10 tons and 9 fields had soil losses greater than five tons. As maximum soil loss permitted was reduced from 100 to 25 tons, 3.0 acres of corn were shifted to meadow. This shift occurred on parts of two fields with greater than 25 tons soil loss. When the 10 tons/acre/year soil loss constraint was imposed 24 acres shifted from conventional tilled corn to meadow. This shift occurred on parts of the six fields with soil losses greater than 10 tons.

When the 5-ton soil loss limit was imposed 25.5 additional acres shifted from corn to meadow and 89.7 acres shifted from corn into a soybean meadow rotation. These shifts occurred from the nine fields where soil loss could not be maintained at five tons with corn conventinal tillage on the contour. At the 5-ton soil loss constraint level net returns were 26.5 percent below the net returns when soil loss constraint was 100 tons per acre in the optimal plans. Average yearly labor requirements were 873 hours at the 100-ton soil loss level and 1120 hours at the 5-ton level.

Effect of soil loss constraints upon discounted net returns, Farm 1. A summary of the effects of soil loss constraints upon discounted net returns is shown in percentage terms in Table 21. When all cropping systems were considered, reduction in permissible soil erosion losses had no effect upon net returns until the 5-ton soil loss contraint was imposed; in this case the reduction was a modest 2.4 percent. This occurred because a 5-ton soil loss level could be achieved on all but

TABLE 21

EFFECT OF SOIL LOSS CONSTRAINTS UPON DISCOUNTED NET RETURNS WITH VARIATIONS IN CROP MANAGEMENT SYSTEMS CONSIDERED, 20-YEAR PLANNING HORIZON, FARM 1

	Soil Loss Levels (tons/acre/year)			
	≤ 100	≤ 25	≤ 10	≤ 5
	percent of base[a]			
Cropping Systems				
All cropping systems	100.0	100.0	100.0	97.6
Without soybeans-wheat double-crop	100.0	100.0	99.9	97.7
Without soybeans-wheat and no-till corn	100.0	99.7	97.2	77.2
Without no-till	100.0	99.7	96.4	73.5

[a]Base system was the ≤ 100-ton soil loss level.

three fields on Farm 1 in a strictly profit maximizing plan. When the 5-ton soil loss constraint was imposed, it became necessary to divert some acreage in three fields to meadow to reduce the soil losses to the permissible 5-ton limit imposed on each field.

When soybeans-wheat double-crop was eliminated as an option, net returns were reduced 2.3 percent as permissible soil loss was reduced from the 100-ton level to the 5-ton level. Again, reduction in the soil loss constraint was imposed. Utilization of relatively profitable no-till corn production systems kept soil losses below the 10-ton limit on most all fields. In order to stay within the 5-ton soil loss level, it was necessary to shift some acres from no-till corn to meadow in three fields.

When soybeans-wheat double-crop and no-till corn were eliminated as options, the reduction in net returns at the 5-ton soil loss level was more pronounced. Net returns were reduced 22.8 percent as permissible soil loss was reduced to the 5-ton level. When no-till corn was also eliminated from consideration, to stay within the 5-ton soil loss level, it was necessary to shift relatively large acreage from no-till corn to no-till soybeans and no-till soybeans on terraced land. As shown in Table 9 on page 35, representative budgets indicated net returns per acre for no-till corn was $106.58 as compared to $82.65 for no-till soybeans and $74.31 for no-till soybeans with terraces.

When soybeans-wheat duble-crop and all no-till systems were eliminated as production alternatives, net returns were reduced 26.5 percent as permissible soil loss was reduced from the 100-ton to the 5-ton level. The income reduction resulted from the shift of substantial acreage from corn produced with conventional tillage on the contour to meadow and to soybean meadow rotation.

Effect of excluding various cropping systems on discounted net returns, Farm 1. The effects of excluding various cropping systems upon discounted net returns at various soil loss levels are summarized in Table 22. At the 100-ton soil level elimination of soybean-wheat double-cropping and all no-till systems resulted in a reduction in net returns of 5.1 percent. At the 25-ton soil loss level a similar reduction in cropping systems considered reduced net returns slightly more (5.4 percent). Elimination of the no-till systems resulted in expanded

TABLE 22

EFFECT OF EXCLUDING VARIOUS CROPPING SYSTEMS UPON DISCOUNTED NET RETURNS WITH VARIATIONS IN PERMISSIBLE SOIL LOSS LEVELS, 20-YEAR PLANNING HORIZON, FARM 1

	Soil Loss Levels (tons/acre/year)			
	≤ 100	≤ 25	≤ 10	≤ 5
	percent of base[a]			
Cropping Systems				
All cropping systems	100.0	100.0	100.0	100.0
Without soybeans-wheat double-crop	98.3	98.3	98.3	98.7
Without soybeans-wheat and no-till corn	94.9	94.6	92.2	75.0
Without no-till	94.9	94.6	91.5	71.4

[a]Base system was the all-cropping systems.

acreage of corn produced with conventional tillage on the contour. The net returns per acre for corn produced with conventional tillage were only slightly lower than for no-till corn. However, the 5-ton maximum soil loss level could not be maintained with contour production of corn; the resulting shift of acreage to meadow and a soybean-meadow rotation had a more substantial impact on net returns. At the 5-ton soil loss level, elimination of all no-till production system reduced net returns by 28.6 percent as compared to the situation when all cropping systems were permitted.

Farm 2, Haywood County

Farm 2, located in Haywood County, was composed of 228 acres of cropland and 14 acres of woodland and homestead for a total of 242 acres. The soils of Farm 2 included Collins silt loam (37.5 acres), Falaya silt loam (43.7), Grenada silt loam (96.2 acres), and Memphis silt loam (50.6 acres). Over half of the upland soils were severely eroded fragipan type soils. Falaya and Collins are bottomland soils; Memphis and Grenada are upland soils. About 83 percent of the upland soils are 2-5 percent slope and 17 percent are 5-8 percent slope.

Optimum farm organization all cropping systems considered, Farm 2. The optimum farm organization for Farm 2 when all cropping systems were considered is shown in Table 23 for each of the four levels of soil loss considered. On Farm 2, as on Farm 1, no-till corn dominated all cropping systems with 206 acres when soil loss constraint was set at 100 tons per acre. The optimum plan also included 10 acres of soybeans-wheat double-crop using up and down slope tillage, and 12 acres of soybeans-wheat double-crop tilled on the contour. As shown in Table 9 (page 35), the net return per acre for soybeans-wheat double-crop up and down the slope for a representative field was $97.88 as compared to $91.73 for soybeans-wheat double-crop on the contour. The average soil loss per acre in the optimal plan was 3.0 tons and was above five tons per acre on only three fields. Reducing soil loss constraints to 25 and 10 tons per acre had no effect on the enterprise organization or the net returns for the optimum farm plan. No fields had a soil loss greater than 10 tons/acre/year in the base plan. When the 5-ton soil loss constraint was imposed, acreage of no-till corn was decreased by 23 and acreage of soybeans-wheat

TABLE 23

THE EFFECT OF VARIATIONS IN PERMISSIBLE SOIL LEVELS ON OPTIMUM FARM ORGANIZATION, ALL CROPPING SYSTEMS CONSIDERED, 20-YEAR PLANNING HORIZON, FARM 2

	Soil Loss Levels (tons/acre/year)			
	≤ 100	≤ 25	≤ 10	≤ 5
	acres			
Cropping System				
Corn (NT)	206.0	206.0	206.0	183.2
Corn (NTTS)	--	--	--	3.0
Soybeans-wheat double-crop (SRCC)	10.0	10.0	10.0	7.7
Soybeans-wheat double-crop (CT)	12.0	12.0	12.0	34.1
Income Level				
Net returns ($)	251,494	251,494	251,494	251,063
Percent of base	100.0	100.0	100.0	99.8

produced on the contour was increased by 22. In addition, on one field three acres of no-till corn were shifted to no-till corn with terraces. Net returns at the 5-ton soil loss level were only .2 of one percent lower than at the 100 tons/acre/year constraint level.

Optimum farm organization, without soybeans-wheat double-crop, Farm 2. When soybeans-wheat double-crop was eliminated as an option, the optimum farm plan for the ≤ 100 ton, ≤ 25, and ≤ 10 soil loss level situations involved the use of the entire 228 acres of cropland to produce no-till corn. Soil loss per acre averaged 2.9 tons for all fields, was less than 10 tons on all fields, and was greater than five tons on only two fields. When the 5-ton soil loss constraint was imposed, nine acres of land in these two fields were shifted to no-till corn with terraces (7.3 acres) and to meadow (1.7 acres). Net returns were reduced by only .3 of one percent at the 5-ton soil loss level in comparison to the less restrictive soil loss levels (Table 24).

TABLE 24

THE EFFECT OF VARIATIONS IN PERMISSIBLE SOIL LOSS LEVELS ON OPTIMUM FARM ORGANIZATION, SOYBEANS-WHEAT DOUBLE-CROP ALTERNATIVE EXCLUDED, 20-YEAR PLANNING HORIZON, FARM 2

	Soil Loss Levels (tons/acre/year)			
	≤ 100	≤ 25	≤ 10	≤ 5
	acres			
Cropping Systems				
Corn (NT)	228.0	228.0	228.0	219.0
Corn (NTTS)	--	--	--	7.3
Meadow (SELLHAY)	--	--	--	1.7
Income Level				
Net returns ($)	251,384	251,384	251,384	250,574
Percent of base	100.0	100.0	100.0	99.7

Optimum farm organization, without soybeans-wheat and no-till corn, Farm 2. When soybeans-wheat double-crop and no-till corn were excluded as options, corn conventional tillage, up and down slope, and corn conventional tillage on the contour dominated all cropping systems at the 100-ton soil loss level (Table 25). The average soil loss per acre was 7.5 tons. Four fields had greater than 10 tons per acre and

TABLE 25

THE EFFECT OF VARIATIONS IN PERMISSIBLE SOIL LOSS LEVELS ON OPTIMUM FARM ORGANIZATION, SOYBEANS-WHEAT AND NO-TILL CORN ALTERNATIVES EXCLUDED, 20-YEAR PLANNING HORIZON, FARM 2

	Soil Loss Levels (tons/acre/year)			
	≤ 100	≤ 25	≤ 10	≤ 5
	acres			
Cropping Systems				
Corn-conventional (SRCC)	53.0	53.0	45.0	43.0
Corn-conventional (CT)	175.0	175.0	152.0	42.5
Corn-conventional (CTTS)	--	--	9.8	44.5
Soybeans (NT)	--	--	11.9	13.7
Soybeans (NTTS)	--	--	8.9	57.6
Meadow (SELLHAY)	--	--	--	26.7
Income Level				
Net returns ($)	240,769	240,769	239,660	215,727
Percent of base	100.0	100.0	99.5	89.6

eight fields had greater than 5-ton soil loss per acre. There were no fields with greater than 25-ton soil loss per acre. When the 10-ton soil loss constraint was imposed, 9.8 acres shifted to corn conventional tillage with terraces, 11.9 acres shifted to no-till soybeans, and 8.9 acres shifted to no-till soybeans with terraces. While these shifts were necessitated to meet the 10-ton maximum soil loss level, they had very small and insignificant effects on net returns.

When the 5-ton soil loss level was imposed, 34.7 additional acres shifted to corn conventional tillage with terraces, and 26.7 acres shifted to meadow. Net returns were reduced 10.4 percent at the 5-ton soil loss level in comparison to net returns with the 100-ton soil loss constraint. Average yearly labor requirement for the optimal plan decreased from 696 at the 100-ton soil loss level to 675 at the 5-ton level.

Optimum farm organization without no-till, Farm 2. Expanding the enterprise exclusions to include no-till soybeans had no effect on the optimal plans for the 100- and 25-ton soil loss constraint levels; no-till soybeans were not included in the optimal organization even when permitted (Table 26). For the optimal plan for the 100- and 25-ton constraint level the average soil loss attained was 7.5 tons; four fields had soil loss levels greater than 10 tons; eight fields had soil loss levels greater than five tons; and no fields had greater than 25-ton soil loss. When the 10-ton soil loss constraint level was imposed, 21.4 acres shifted into corn conventional tillage with terraces and 7.3 acres shifted into meadow. Net returns were decreased by one percent.

TABLE 26

THE EFFECT OF VARIATIONS IN PERMISSIBLE SOIL LOSS LEVEL ON OPTIMUM FARM ORGANIZATION, SOYBEANS-WHEAT AND NO-TILL ALTERNATIVES EXCLUDED, 20-YEAR PLANNING HORIZON, FARM 2

	Soil Loss Levels (tons/acres/year)			
	≤ 100	≤ 25	≤ 10	≤ 5
	acres			
Cropping Systems				
Corn-conventional (SRCC)	53.0	53.0	45.1	43.0
Corn-conventional (CT)	175.0	175.0	154.2	34.6
Corn-conventional (CTTS)	--	--	21.4	83.3
Meadow (SELLHAY)	--	--	7.3	67.1
Income Level				
Net returns ($)	240,769	240,769	238,376	209,824
Percent of base	100.0	100.0	99.0	87.1

Imposition of the 5-ton soil loss constraint resulted in further shifts of acreage to corn conventional tillage with terraces, and to meadow. On many fields contour tillage was not sufficient to reduce soil loss to the 5-ton level. Average yearly labor requirement increased from 696 hours at the 100-ton soil loss level to 847 at the 5-ton level.

Effects of soil loss constraints upon discounted net returns, Farm 2. A summary of the effects of soil loss constraints upon discounted net returns for Farm 2 with varying sets of enterprise alternatives considered is shown in percentage terms in Table 27. When all cropping systems were considered, as in Farm 1, imposing successively more rigid soil loss constraint standard had no effects upon net returns until the 5-ton soil loss constraint was imposed; in this case the net returns reduction was only 0.2 percent. On Farm 2 soil losses could be held to five tons or less on most all fields using no-till production systems.

TABLE 27

EFFECT OF SOIL LOSS CONSTRAINTS UPON DISCOUNTED NET RETURNS WITH VARIATIONS IN CROP MANAGEMENT SYSTEMS CONSIDERED, 20-YEAR PLANNING HORIZON, FARM 2

	Soil Loss Levels (tons/acre/year)			
	≤ 100	≤ 25	≤ 10	≤ 5
	percent of base[a]			
Cropping Systems				
All cropping systems	100.0	100.0	100.0	99.8
Without soybeans-wheat double-crop	100.0	100.0	100.0	99.7
Without soybeans-wheat and no-till corn	100.0	100.0	99.5	89.6
Without no-till	100.0	100.0	99.0	87.1

[a]Base system was the ≤ 100-ton soil loss level.

When soybeans-wheat double-crop was eliminated as an option, net returns were not reduced until the 5-ton soil loss level constraint was imposed. Reducing soil losses to 5 tons or less per acre reduced net returns only 0.3 percent.

When soybeans-wheat double-crop and no-till corn were removed as options, reducing soil loss constraint to 25 tons had no effect on net returns; however, further reduction to the 10- and 5-ton soil loss level did affect the optimum farm organization and level of net returns. At the 10-ton constraint level net returns were 0.5 percent lower than at higher constraint levels. At the 5-ton level net returns were reduced to a level 10.4 percent lower than at the 100- and 25-ton limit level. The income effect resulted largely from the necessity to use more terracing to achieve the maximum soil loss limits. Net returns from terracing systems were considerably lower per acre than from no-till corn systems.

When the enterprise exclusions were expanded to include no-till soybeans, net returns were reduced by 1.0 percent to achieve the 10-ton soil loss limit and by 12.9 percent to achieve the 5-ton soil loss limit.

Effect of excluding various cropping systems on discounted net returns, Farm 2. The effects of successively excluding various cropping systems upon discounted net returns for Farm 2 are summarized in Table 28. At the 100-ton and the 25-ton soil loss levels elimination of soybean-wheat double-crop and all no-till systems resulted in a reduction in net returns of 4.3 percent. At the 10-ton soil loss level, elimination of double crop and all no-till resulted in a reduction in net returns of 5.2 percent. At the 100-, 25-, and 10-ton soil loss levels the no-till systems could be replaced by corn produced using conventional tillage on the contour with only minor changes in net returns. However, at the 5-ton soil loss level contour tillage was not sufficient on certain fields and more acreage was shifted to lower returning corn produced with conventional tillage on terraced land, soybean-meadow rotation, and meadow. At

TABLE 28

EFFECT OF EXCLUDING VARIOUS CROPPING SYSTEMS ON DISCOUNTED NET RETURNS WITH VARIATIONS IN PERMISSIBLE SOIL LOSS LEVELS, 20-YEAR PLANNING HORIZON, FARM 2

	Soil Loss Levels (tons/acre/year)			
	≤ 100	≤ 25	≤ 10	≤ 5
	----------percent of base[a]----------			
Cropping Systems				
All cropping systems	100.0	100.0	100.0	100.0
Without soybeans-wheat double-crop	99.9	99.9	99.9	99.8
Without soybeans-wheat no-till corn	95.7	95.7	95.3	85.9
Without no-till	95.7	95.7	94.8	83.6

[a]Base system was the all cropping systems.

the 5-ton soil loss level elimination of soybeans-wheat double-cropped and all no-till systems reduced net returns by 16.4 percent.

Farm 3, Haywood County

Farm 3, located in Haywood County, consisted of 264 acres of cropland, 9 acres of hay and pasture land, and 50 acres of woodland for a total of 323 acres. The soils of Farm 3 included Falaya silt loam (22.1 acres), Grenada silt loam (61.3 acres), Lexington silt loam (29.0 acres), and Memphis silt loam (151.6 acres). Falaya silt loam is a bottomland soil while the other soils are classified as upland. About 25 percent of the upland soils have a fragipan and 21 percent are on slopes of greater than 5 percent.

Optimum farm organization, all cropping systems considered, Farm 3. The effect of varying soil loss constraint levels on the optimum farm organization for Farm 3 when all cropping systems were considered is shown in Table 29. For Farm 3, as for Farm 1, at the 100-ton soil loss constraint level the optimal farm plan included primarily soybeans-wheat double-crop (98 acres) and no-till corn (166 acres). The use of one field (9 acres) was restricted to meadow or pasture as specified in the SCS Conservation Plan. At the 100-ton soil loss constraint level the

TABLE 29

THE EFFECT OF VARIATIONS IN PERMISSIBLE SOIL LOSS LEVELS ON OPTIMUM FARM ORGANIZATION, ALL CROPPING SYSTEMS CONSIDERED, 20-YEAR PLANNING HORIZON, FARM 3

	Soil Loss Levels (tons/acre/year)			
	≤ 100	≤ 25	≤ 10	≤ 5
	acres			
Cropping Systems				
Soybeans-wheat double-crop (SRCC)	98.0	98.0	85.1	42.0
Soybeans-wheat double-crop (CT)	--	--	12.9	44.9
Corn (NT)	166.0	166.0	166.0	166.0
Corn (NTTS)	--	--	--	10.8
Meadow (SELLHAY)	9.0	9.0	9.0	9.3
Income Level				
Net returns ($)	264,866	264,866	264,293	261,202
Percent of base	100.0	100.0	99.8	98.6

average soil loss for all fields was 4.8 tons and ranged from a high of 11.7 tons per acre on one field to a low of .4 tons per acre on the field with meadow. Since no field had a soil loss level of 25 tons or more, the optimal farm plan was the same with the 25 tons soil loss constraint as with the 100-ton soil loss level.

Imposing the 10-ton soil loss limit resulted in a shift of 12.9 acres from soybeans-wheat double-crop, up and down slope, to soybeans-wheat double-crop on the contour. This shift occurred on portions of three fields where the soil loss level was greater than 10 tons per acre.

When the 5-ton soil loss constraint was imposed, 32 additional acres shifted to soybeans-wheat double-crop on the contour and 10.8 acres shifted to corn no-till with terraces. These shifts were made on parts of three fields where soil losses could not be maintained at the 5-ton level with soybeans-wheat, up and down the slope. Achieving the 5-ton per acre soil loss level required only 1.4 percent sacrifice in potential net returns as compared to the least restrictive soil loss limit (100 tons).

Optimum farm organization without soybeans-wheat double-crop, Farm 3. Assuming a 100-ton soil loss limit when soybeans-wheat double-crop was excluded as an alternative on Farm 3, no-till corn replaced soybeans-wheat acreage and the entire 264 acres of cropland was utilized for no-till corn (Table 30). The nine-acre field restricted to forage use was allocated to the production of hay for sale. The average soil loss for all fields was 3.6 tons per acre per year. In the optimal plan no fields had a soil loss of 10 tons or greater; three fields had soil losses of

TABLE 30

THE EFFECT OF VARIATIONS IN PERMISSIBLE SOIL LOSS LEVELS ON OPTIMUM FARM ORGANIZATION, SOYBEANS-WHEAT DOUBLE-CROP ALTERNATIVE EXCLUDED, 20-YEAR PLANNING HORIZON, FARM 3

	Soil Loss Levels (tons/acre/year)			
	≤ 100	≤ 25	≤ 10	≤ 5
	acres			
Cropping Systems				
Corn (NT)	264.0	264.0	264.0	243.3
Corn (NTTS)	--	--	--	19.3
Meadow (SELLHAY)	9.0	9.0	9.0	10.4
Income Level				
Net returns ($)	258,655	258,655	258,655	256,881
Percent of base	100.0	100.0	100.0	99.3

five tons or more but less than 10 tons. The profit maximizing farm plan was the same at the 100-, 25-, and 10-ton soil loss limit levels.

When the 5-ton constraint was imposed, 19.3 acres shifted to no-till corn utilizing terraces and 10.4 acres were shifted to meadow. Since the net returns from no-till corn with terraces would be lower than no-till corn without terraces, achieving the 5-ton soil loss limit resulted in some reduction in income. Net returns were .7 of one percent lower at the 5-ton soil loss level than at less restrictive soil loss limits.

Optimum farm organization without soybeans-wheat and no-till corn, Farm 3. At the 100-ton soil loss limit when soybeans-wheat double-crop and no-till corn were excluded as options, the 264 acres of potential row cropland was allocated to corn conventional tillage, up and down the slope (56 acres), and corn conventional tillage on the contour (208 acres) (Table 31). Fields allocated to corn conventional tillage up and down the slope were composed predominantly of Memphis soils where erosion

TABLE 31

THE EFFECT OF VARIATIONS IN PERMISSIBLE SOIL LOSS LEVELS ON OPTIMUM FARM ORGANIZATION, SOYBEANS-WHEAT AND NO-TILL CORN ALTERNATIVES EXCLUDED, 20-YEAR PLANNING HORIZON, FARM 3

	Soil Loss Levels (tons/acre/year)			
	≤ 100	≤ 25	≤ 10	≤ 5
	------------------acres------------------			
Cropping Systems				
Corn-conventional (SRCC)	56.0	39.3	--	--
Corn-conventional (CT)	208.0	224.7	229.7	73.5
Corn-conventional (CTTS)	--	--	--	58.0
Soybeans (NT)	--	--	7.5	11.8
Soybeans (NTTS)	--	--	26.3	105.9
Soybeans (2SB-2M)	--	--	.5	7.7
Meadow (SELLHAY)	9.0	9.0	9.0	16.1
Income Level				
Net returns ($)	247,786	246,797	244,140	216,859
Percent of base	100.0	99.6	98.5	87.5

losses were assumed to have no effect on yield over time. At the 100-ton soil loss level, the optimal plan included three fields with projected soil losses of greater than 25 tons/acre/year. When the 25-ton soil loss constraint was imposed, 16.7 acres from these three fields were shifted to corn produced with conventional tillage on the contour as required to stay within the 25-ton limit. Net returns were decreased by .4 of one percent (compared to the 100-ton soil loss level). Total labor requirement increased slightly (9 hours) because of the additional time needed for contouring.

When the 10-ton soil loss constraint was imposed, the optimal plan included no corn produced with conventional tillage up and down the slope. About 34 acres shifted into no-till soybean (26.3 acres with terraces). At the 10-ton soil loss level, all of the upland fields had soil losses of greater than five tons per acre except the nine acres restricted to forage use.

When the 5-ton soil loss constraint was imposed, 58.0 acres shifted to corn conventional tillage on the contour with terraces, 11.8 acres shifted to no-till soybeans, and 105.9 acres shifted to no-till soybeans with terraces. The 5-ton soil loss level could not be maintained on any of the fields with conventional tillage alone. Net returns at the 5-ton soil loss level were 12.5 percent lower than at the 100-ton level. Average yearly labor requirement increased from 544 hours at the 100-ton level to 551 hours at the 5-ton level.

Optimum farm organization without no-till, Farm 3. Since no-till soybeans were not included in the optimal farm plan presented in the previous section for the 100- and 25-ton soil loss levels, removal of the no-till soybeans had no effect (Tables 31 and 32). However, after deletion of no-till soybeans and when the soil loss constraint was set at the 10-ton level, 32.7 acres were shifted to corn produced with conventional tillage on the contour on terraced land and 24.3 acres were shifted to meadow. In the optimal plan for the 10-ton level only two fields had soil losses below five tons per acre--a bottomland field and a field restricted to forage use. Net returns were 3.7 percent lower at the 10-ton soil loss level than when the soil loss constraint was 100 tons.

TABLE 32

THE EFFECT OF VARIATIONS IN PERMISSIBLE SOIL LOSS LEVELS ON OPTIMUM FARM ORGANIZATION, SOYBEANS-WHEAT AND NO-TILL ALTERNATIVES EXCLUDED, 20-YEAR PLANNING HORIZON, FARM 3

	Soil Loss Levels (tons/acre/year)			
	≤ 100	≤ 25	≤ 10	≤ 5
	acres			
Cropping Systems				
Corn-conventional (SRCC)	56.0	39.3	--	--
Corn-conventional (CT)	208.0	224.7	211.8	64.6
Corn-conventional (CTTS)	--	--	32.7	105.4
Soybeans (2SB-2M)	--	--	4.2	7.7
Meadow (SELLHAY)	9.0	9.0	24.3	95.3
Income Level				
Net returns ($)	247,786	246,797	238,666	200,010
Percent of base	100.0	99.6	96.3	80.7

When the 5-ton per acre soil loss constraint was imposed, the optimal plan included 64.6 acres of corn produced with conventional tillage on the contour, 105.4 acres of corn produced with conventional tillage on terraced land, and 95.3 acres of meadow. At the 5-ton soil loss contraint level, terraces were necessary on five fields to reduce soil losses to the 5-ton limit. Net returns at the 5-ton level were 19.3 percent lower than at the 100-ton soil loss constraint level. Total labor requirements were 215 hours higher at the 5-ton soil loss level compared to the 100-ton soil loss level.

Effects of soil loss constraints upon discounted net returns, Farm 3. The effects of variations in soil loss constraints upon discounted net returns for Farm 3 are summarized in percentage terms in Table 33. When all cropping systems were considered, as in Farm 1 and Farm 2, reduction in permissible soil loss level had essentially no effect on net returns. At the 5-ton soil loss constraint level net returns were only .7 of one percent lower than at the 100-ton level. No-till systems were not only more profitable but also made it possible to keep soil losses near or below the 5-ton limit level.

When soybeans-wheat double-crop was eliminated as an option, again net returns were essentially unaffected by lowering of the soil loss standard. No-till corn was the most profitable cropping system on all fields. There were minor shifts to no-till corn with terraces and meadow at the 5-ton soil loss level.

When both soybeans-wheat double-crop and no-till corn were eliminated as options, net returns were reduced slightly as soil loss constraints were lowered to 25 and 10 tons and were substantially reduced

TABLE 33

EFFECT OF SOIL LOSS CONSTRAINTS UPON DISCOUNTED NET RETURNS WITH VARIATIONS IN CROP MANAGEMENT SYSTEMS CONSIDERED, 20-YEAR PLANNING HORIZON, FARM 3

	Soil Loss Levels (tons/acre/year)			
	≤ 100	≤ 25	≤ 10	≤ 5
	percent of base[a]			
Cropping Systems				
All cropping systems	100.0	100.0	99.9	99.3
Without soybeans-wheat double-crop	100.0	100.0	100.0	99.3
Without soybeans-wheat and no-till corn	100.0	99.6	98.5	87.5
Without no-till	100.0	99.6	96.3	80.7

[a]Base system was the ≤ 100-ton soil loss level.

when soil loss limit was set at 5 tons (12.5 percent reduction). Corn conventional tillage dominated all cropping systems up to the 5-ton level. The 5-ton soil loss level could not be attained with corn conventional tillage alone. Thus substantial shifts were made to producing corn with conventional tillage with terraces and no-till soybeans with terraces.

When soybeans-wheat and all no-till options were removed as alternatives, net returns were reduced slightly as the soil loss limit was reduced from 100 to 25 tons per acre (less than 1 percent). However, when the soil loss level was set at 5 tons net returns were reduced by 19.3 percent below the income potential at the 100-ton level.

Effect of excluding various cropping systems on discounted net returns, Farm 3. The effects of excluding various cropping systems upon discounted net returns for specified soil loss levels are sumamrized in Table 34. For Farm 3 at the 100-ton soil loss level elimination of soybeans-wheat double-cropping and all no-till systems resulted in a reduction in net returns of 6.4 percent. At the 25-ton soil loss level similar reductions in enterprise options reduced net returns only slightly more (6.8 percent). At the 10-ton soil loss level when all no-till systems were eliminated, net returns were reduced by 9.7 percent. The 10-ton soil loss level could not be maintained with corn conventional

TABLE 34

EFFECT OF EXCLUDING VARIOUS CROPPING SYSTEMS ON DISCOUNTED NET RETURNS WITH VARIATIONS IN PERMISSIBLE SOIL LOSS LEVELS, 20-YEAR PLANNING HORIZON, FARM 3

	Soil Loss Levels (tons/acre/year)			
	≤ 100	≤ 25	≤ 10	≤ 5
	percent of base[a]			
Cropping Systems				
All cropping systems	100.0	100.0	100.0	100.0
Without soybeans-wheat double-crop	97.7	97.7	97.7	98.3
Without soybeans-wheat and no-till corn	93.6	93.2	92.4	83.0
Without no-till	93.6	93.2	90.3	76.6

[a]Base system was the all cropping systems.

tillage alone and acres were shifted to corn produced on terraced land and a larger acreage of meadow--a reduction in net returns in both cases.

At the 5-ton soil loss level removal of all no-till options made necessary the shifting of additional acres into corn on terraces and meadow. Net returns were reduced by 23.4 percent in comparison to the situation where all cropping systems were considered.

II. Optimum Farm Organizations with Variations in Planning Horizons and Permissible Soil Loss Levels

In this section the interrelationships between planning horizon and permissible soil loss level are examined. Planning horizons affect the choice of soil conservation production systems in two important ways. Some conservation practices, particularly terraces, have a large initial cost and the expected payoff occurs over a number of years. Operators with relatively short planning horizons are likely to forego such practices because the discounted value of the additional returns over time is insufficient to cover the initial cost. In addition erosion losses on some soils will result in yield declines over time as the topsoil thickness is reduced and farming occurs on less desirable and less productive soil material. All of the analysis of this section was completed with the exclusion as enterprise alternatives of soybeans-wheat double-crop, no-till production of corn, and no-till production of soybeans as a single crop.

Planning Horizon

Farmers tend to select the most profitable enterprises and practices within the particular planning period being considered. Planning horizons of farmers may vary from one to 40 years depending on age, financial position, whether land is owned or rented, or the individual's personal preference for income now or later. In this section, 1-, 5-, 10-, 20-, and 40-year planning horizons were considered.

Soil Loss and Crop Yields

The relationship between soil loss and crop yields over time is not well known. For some soils erosion may bring about yield reductions in a short period of time while on other soils, due to the nature of the soil profile, there may be little or no appreciable yield reduction due to erosion. In many cases potential yield reductions due to erosion may be offset by increased fertilization or masked by technological improvements. For soils where there is a decline in yields due to erosion, the greater the erosion the greater would be the decline in yields. Certain cropping systems with relatively high soil losses and lower production cost may yield greater net returns in the short run. Over time, however, the lower cost of production may be offset by the greater yield reduction due to the relatively high soil loss.

In this analysis yield declines over time as a result of soil losses due to erosion were projected for Grenada, Lexington, and Loring soils but not other upland soils. The erosion yield relationships projected for these soils were shown in Table 16 on page 58. As an illustration severely eroded Grenada's 5-8 percent slope was projected to show a decline in corn yield of 2.5 bushels per inch of topsoil lost. Assuming a weight of 150 tons per acre inch of topsoil, a land use system that resulted in an annual soil loss of 30 tons per acre per year would lose 300 tons of soil over a 10-year period. This would translate into a reduction in corn yield of five bushels and a reduction in net returns per acre of $14 using $2.80 per bushel as the value of corn.

The proportion of upland soils that were classified as Grendaa and Lexington was 28.9 percent on Farm 1, 42.2 percent on Farm 2, and 34.2 percent on Farm 3.

Terraces

Terraces can be used to significantly reduce soil loss from erosion as compared to straight row up and down the slope or even contour cultivation. Terraces can be expensive, however, in terms of additional cost. The cost of terraces may vary widely among farms. The economic justification of the terrace systems will depend primarily on the cost of the systems in comparison to the benefits realized in terms of maintaining crop yields over time. In some cases a terrace system may not be justified in the short run because of cost but may be justified over a longer planning horizon depending upon such factors as: (1) cost of terrace system, (2) crop being considered, (3) change in yields over time, and (4) discount rate.

Optimum farm organizations for various planning horizons with 100-ton soil loss constraint, Farm 1. Optimum farm organizations for each of the five planning horizons with various soil loss constraint levels for Farm 1 are shown in Tables 35 through 38. When a 100-ton soil loss constraint was specified, corn conventional tillage, up and down the slope, dominated all cropping systems for the one-year planning horizon with 171 acres (Table 35). The plan for the one-year horizon also included 67 acres of corn produced with conventional tillage on the

TABLE 35

OPTIMUM FARM ORGANIZATION FOR VARIOUS PLANNING HORIZONS, 100-TON SOIL LOSS CONSTRAINT, FARM 1[a]

Cropping Systems	Planning Horizon (years)				
	1	5	10	20	40
	acres				
Corn-conventional (SRCC)	171.0	3.0	3.0	--	--
Corn-conventional (CT)	67.0	235.0	235.0	238.0	238.0
Soybeans-conventional (CT)	4.0	4.0	4.0	4.0	4.0
Meadow (SELLHAY)	25.0	25.0	25.0	25.0	25.0

[a]Soybeans-wheat double-crop and all single crop no-till systems were excluded as alternatives.

TABLE 36

OPTIMUM FARM ORGANIZATION FOR VARIOUS PLANNING HORIZONS, 25-TON SOIL LOSS CONSTRAINT, FARM 1[a]

Cropping Systems	Planning Horizon (years)				
	1	5	10	20	40
	acres				
Corn-conventional (SRCC)	170.3	2.3	2.3	--	--
Corn-conventional (CT)	64.7	232.7	232.7	235.0	235.0
Soybeans-conventional (CT)	4.0	4.0	4.0	4.0	4.0
Meadow (SELLHAY)	28.0	28.0	28.0	28.0	28.0

[a]Soybeans-wheat double-crop and all single crop no-till systems were excluded as alternatives.

TABLE 37

OPTIMUM FARM ORGANIZATION FOR VARIOUS PLANNING HORIZONS, 10-TON SOIL LOSS CONSTRAINT, FARM 1[a]

Cropping Systems	Planning Horizon (years) 1	5	10	20	40
	acres				
Corn-conventional (SRCC)	23.5	--	--	--	--
Corn-conventional (CT)	185.5	211.0	211.0	211.0	211.0
Soybeans-conventional (CT)	4.0	4.0	4.0	4.0	4.0
Meadow (SELLHAY)	52.0	52.0	52.0	52.0	52.0

[a]Soybeans-wheat double-crop and all single crop no-till systems were excluded as alternatives.

TABLE 38

OPTIMUM FARM ORGANIZATION FOR VARIOUS PLANNING HORIZONS, 5-TON SOIL LOSS CONSTRAINT, FARM 1[a]

Cropping Systems	Planning Horizon (years) 1	5	10	20	40
	acres				
Corn-conventional (SRCC)	--	--	--	--	--
Corn-conventional (CT)	95.8	95.8	95.8	95.8	95.8
Soybeans-conventional (CT)	4.0	4.0	4.0	4.0	4.0
Soybeans-conventional (SB-2M)	89.7	89.7	89.7	89.7	89.7
Meadow (SELLHAY)	77.5	77.5	77.5	77.5	77.5

[a]Soybeans-wheat double-crop and all single crop no-till systems were excluded as alternatives.

contour, four acres of soybeans produced on the contour, and 25 acres of forage. The 67 acres of corn produced on the contour occupied fields which would naturally be cultivated on the contour because of the design of the field. The 25 acres of meadow were on a field that had been designated for meadow or pasture only by the SCS Conservation Plan. The average level of soil loss achieved on all the fields was 17.4 tons. Four fields had over 25 tons soil loss and one field had more than 40 tons per acre of soil loss.

At the 5- and 10-year planning horizons all corn production except three acres was shifted to conventional tillage on the contour. The average level of soil loss achieved was 10.7 tons. The shift to contouring of 168 acres reduced the overall average soil loss per acre by 39 percent.

At the 20- and 40-year planning horizons all corn production shifted to conventional tillage on the contour. The four acres of soybeans conventional tillage on the contour and the 25 acres of meadow remained unchanged. Average soil loss per acre was reduced slightly to 10.6 tons/acre/year. These shifts seem to indicate that over a short planning horizon corn conventional tillage up and down the slope was the most profitable; however, as the planning horizon increased to five years and beyond, the additional cost of contour tillage was more than offset by the decline in yields from up and down slope cultivation. Total labor requirement per year was 860 hours for the optimal plan developed for the one-year planning horizon and 873 hours for the plan developed for the 40-year planning horizon.

Optimum farm organizations for various planning horizons with 25-ton soil loss constraint, Farm 1. The profit maximizing plans for various planning horizons with the 25 tons/acre/year soil loss are shown in Table 36. The optimum farm organization for the 1-year planning span was very similar to the plan developed at the 100-ton soil loss level--predominantly corn produced up and down the slope (over 70 percent of the row crop land) and smaller acreage of corn and soybeans produced on the contour. With the 5-year planning horizon almost all the row crops would be produced on the contour. The optimal plans for the 10-, 20-, and 40-year planning horizons were essentially the same as for the 5-year period--primarily the production of corn on the contour.

Optimum farm organizations for various planning horizons with 10-ton soil loss constraint, Farm 1. At the 10-ton soil loss level, assuming a 1-year planning horizon, corn produced on the contour dominated all cropping systems. The plan for the 1-year planning horizon also included 23.5 acres of corn produced up and down the slope and 52.0 acres of meadow. Shifts in cropping systems were necessary on nine fields to stay within the 10-ton limit as compared to the 25-ton limit. Only the field with meadow and one other field with soils of 0-2 percent slope were below the 10-ton limit. The average level of soil loss achieved for all fields at the 1-year planning horizon was 9.1 tons. (See Table 37.)

As the planning horizon increased to five years, all corn production was shifted to contour tillage. Meadow and soybean acres remained unchanged. Optimal farm organizations for the 10-, 20-, and 40-year planning horizons was the same as for the 5-year planning horizon. The average level of soil loss achieved for all fields was 8.3 tons.

Optimum farm organizations for various planning horizons with 5-ton soil loss constraint, Farm 1. Reducing the soil loss constraint from 10 to five tons resulted in major shifts in the optimum enterprise organization for all planning horizons (Table 38). All corn was shifted to conventional tillage on the contour. Soil loss levels of 5 tons/acre/year on each field could not be maintained with conventional tillage up and down the slope. Meadow increased from 52.0 to 77.5 acres, and nearly half of the production of corn was shifted to soybeans-meadow rotation. There were no changes in cropping systems as the planning horizon was varied from one year to 40 years. The average soil loss achieved on all fields was 4.6 tons/acre/year. The maximum soil loss limit of five tons was reached on nine fields comprising 238 acres.

Effect of soil loss constraints upon discounted net returns over various planning horizons, soybeans-wheat and no-till alternatives excluded, Farm 1. The effects of soil loss constraints upon discounted net returns for various planning horizons are shown in dollar terms and percentage terms in Tables 39 and 40. Comparisons are made for given planning spans with variations in permissible soil loss levels. The effect of reduction in maximum soil loss on income was essentially the same for each of the planning horizons. Reducing the soil loss constraint from 100 to 25 tons had essentially no effect on discounted net returns for any of the planning horizons (0.3 to 0.4 percent).

At the 10 tons/acre/year soil loss constraint level discounted net returns were 4-5 percent lower than at the 100-ton level. Consistent with earlier findings reducing the soil loss constraint to five tons had significant income impacts. In comparison to the 100-ton level, net

TABLE 39

EFFECT OF SOIL LOSS CONSTRAINTS UPON DISCOUNTED NET RETURNS OVER VARIOUS PLANNING HORIZONS, SOYBEANS-WHEAT AND NO-TILL ALTERNATIVES EXCLUDED, FARM 1

Planning Horizons (years)	Soil Loss Levels (tons/acre/year) ≤ 100	≤ 25	≤ 10	≤ 5
	dollars			
1	29,955	29,824	28,507	21,590
5	124,689	124,209	119,808	91,100
10	204,947	204,190	197,184	150,090
20	289,873	288,888	279,462	212,996
40	339,837	338,771	328,245	250,503

TABLE 40

EFFECT OF SOIL LOSS CONSTRAINTS UPON DISCOUNTED NET RETURNS OVER VARIOUS PLANNING HORIZONS, SOYBEANS-WHEAT AND NO-TILL ALTERNATIVES EXCLUDED, FARM 1

Planning Horizons (years)	Soil Loss Levels (tons/acre/year) ≤ 100	≤ 25	≤ 10	≤ 5
	percent of base[a]			
1	100.0	99.6	95.2	72.1
5	100.0	99.6	96.1	73.1
10	100.0	99.6	96.2	73.2
20	100.0	99.7	96.4	73.5
40	100.0	99.7	96.6	73.7

[a]Base system was the 100-ton soil loss level for each planning horizon.

returns were reduced about 28 percent for the one-year planning horizon and about 26 percent for the 40-year horizon.

Optimum farm organizations for various planning horizons with 100- and 25-ton soil loss constraints, Farm 2. The changes in cropping systems that occurred over time at the various soil loss levels for Farm 2 are shown in Tables 41 through 43. Since the cropping systems for the 100-ton and 25-ton soil loss constraints were the same, they will be discussed together (Table 41). Reduction in permissible soil loss from 100 to 25 tons had no effect on cropping systems included in the optimal farm organization because soil loss on all fields was below 25 tons. For the 1-year planning horizon corn conventional tillage up and down slope was the dominant land use with 168 acres. The optimal plan also included 60 acres of corn produced with conventional tillage on the contour. This 60 acres of corn cultivated on the contour was on a field that the farmer would naturally cultivate on the contour because of the

TABLE 41

OPTIMUM FARM ORGANIZATIONS FOR VARIOUS PLANNING HORIZONS, 100- AND 25-TON SOIL LOSS CONSTRAINTS, FARM 2[a]

Cropping Systems	Planning Horizons (years)				
	1	5	10	20	40
	acres				
Corn-conventional (SRCC)	168.0	53.0	53.0	53.0	43.0
Corn-conventional (CT)	60.0	175.0	175.0	175.0	185.0

[a]Soybeans-wheat double-crop and all single crop no-till systems were excluded as options.

TABLE 42

OPTIMUM FARM ORGANIZATION FOR VARIOUS PLANNING HORIZONS, 10-TON SOIL LOSS CONSTRAINT, FARM 2[a]

Cropping Systems	Planning Horizons (years) 1	5	10	20	40
	acres				
Corn-conventional (SRCC)	65.5	45.1	45.1	45.1	43.0
Corn-conventional (CT)	149.8	170.2	163.3	154.2	161.7
Corn-conventional (CTTS)	--	--	9.7	21.4	19.3
Meadow (SELLHAY)	12.7	12.7	9.9	7.3	4.0

[a]Soybeans-wheat double-crop and all single crop no-till systems were excluded as options.

TABLE 43

OPTIMUM FARM ORGANIZATION FOR VARIOUS PLANNING HORIZONS, 5-TON SOIL LOSS CONSTRAINT, FARM 2[a]

Cropping Systems	Planning Horizons (years) 1	5	10	20	40
	acres				
Corn-conventional (SRCC)	43.0	43.0	43.0	43.0	43.0
Corn-conventional (CT)	110.5	82.8	44.9	34.6	34.6
Corn-conventional (CTTS)	--	29.5	76.2	83.3	83.3
Meadow (SELLHAY)	74.5	72.7	63.9	67.1	67.1

[a]Soybeans-wheat double-crop and all single crop no-till systems were excluded as options.

design of the field. The average soil loss per acre achieved for the farm organization developed for the 1-year planning horizon was 12.2 tons.

From the 5-, 10-, and 20-year planning horizons, 115 acres were shifted from corn produced up and down slope to contour tillage. As in the case of Farm 1, as the length of the planning horizon increased contour cultivation became more profitable than up and down the slope cultivation. The average level of soil loss achieved for all the fields for the optimal plans for 5-, 10-, and 20-year planning horizons was 7.5 tons per acre. Because of the increased labor requirement for contour tillage, total labor required increased somewhat as compared to the 1-year planning horizon.

At the 40-year planning horizon an additional 10-acre field shifted to corn conventional tillage on the contour. This field was designed in such a way that it took 10 percent additional machine time to plow on the contour. This was the reason that it took a longer planning horizon for the yield effect to offset the additional cost of contour cultivation. There was a minor decrease in the average level of soil loss to 7.2 tons per acre. The fields that remained in straight row cultivation consisted entirely or predominantly of bottomland soils.

<u>Optimum farm organization for various planning horizons with 10-ton soil loss constraints, Farm 2</u>. The effect of variations in planning horizons on cropping systems included in the most profitable farm organization is shown in Table 42 for Farm 2. When the soil loss constraint was set at 10 tons per acre, corn produced with conventional tillage on the contour was the dominant cropping system for each of the planning

horizons. At the 5-year planning horizon about 10 acres shifted from corn produced on the contour and meadow into corn produced on terraced land. At the 20-year planning horizon approximately 10 additional acres shifted to corn produced on terraced land. Again terraces began to appear in the optimum systems over the longer planning horizons.

Optimum farm organization for various planning horizons with 5-ton soil loss constraints, Farm 2. When the maximum soil loss level was reduced from 10 to 5 tons per acre for all planning horizons, the acreage of corn produced on the contour declined while acreage of corn produced on terraced land and acres of meadow increased. At the 5-ton soil loss level, the optimum farm plan for the 1-year planning span included 110.5 acres of corn produced on the contour, 43.0 acres of corn produced up and down the slope, and 74.5 acres of meadow. Eight fields were at the 5-ton soil loss limit level while four fields were below the 5-ton limit (fields that were predominantly bottomland). The average soil loss level achieved for all fields was 3.8 tons. When the planning span was increased to five years, nearly 30 acres of the corn were shifted to production on terraced land. Acreage of meadow was reduced slightly. Forty-three acres remained in corn produced up and down the slope. Increasing the planning span to 10 years resulted in additional expansion of corn produced on terraced land and reductions in corn produced on the contour and meadow land.

Increasing the planning span further increased the use of terraced land and further reduced the use of contour cultivation. The optimal farm organizations were identical for both the 20- and 40-year planning horizons (Table 43).

Effect of soil loss constraints upon discounted net returns over various planning horizons, soybeans-wheat and no-till alternatives excluded, Farm 2. The effects of varying soil loss constraints upon discounted net returns for Farm 2 for specified planning horizons are shown in dollar terms and percentage terms in Tables 44 and 45. For every planning horizon net returns were identical at the 100- and 25-ton soil loss levels. In each case in the optimal plan, soil loss per acre was 25 tons per acre or less on every field. Thus imposition of the 25-ton soil loss limit made no change in the most profitable cropping systems.

Imposing the 10-ton soil loss constraint had only minor effects upon net returns, varying from 0.6 percent for the 40-year planning horizon to 2.5 percent for the 1-year planning horizon. At the 10-ton level, there were major shifts from corn produced up and down the slope to corn produced on the contour and a small number of acres were shifted to terraces. This additional cost for contour tillage and terraces accounted for the decrease in net returns. At the 10-ton soil loss level, terraces were not included in the farm plans except for planning horizons of 10 years or more.

The effects on net returns were more pronounced when soil losses were reduced to the 5-ton level. In comparison to the 100-ton level, net returns were reduced 11.8 percent for the 40-year planning horizon and 17.0 percent at the 1-year planning horizon. The income reductions resulted from the need to greatly expand acreage of terraced land and to shift substantial acreage to meadow use in order to achieve the 5-ton soil loss level. Comparisons of Table 40 showing data for Farm 1 and

TABLE 44

EFFECT OF SOIL LOSS CONSTRAINTS UPON DISCOUNTED NET RETURNS OVER VARIOUS PLANNING HORIZONS, SOYBEANS-WHEAT AND NO-TILL ALTERNATIVES EXCLUDED, FARM 2

Planning Horizons (years)	Soil Loss Levels (tons/acre/year) ≤ 100	≤ 25	≤ 10	≤ 5
	dollars			
1	25,005	25,005	24,392	20,987
5	103,830	103,830	102,191	88,753
10	170,385	170,385	168,386	147,409
20	240,769	240,769	238,376	209,824
40	281,917	281,917	280,256	248,748

TABLE 45

EFFECT OF SOIL LOSS CONSTRAINTS UPON DISCOUNTED NET RETURNS OVER VARIOUS PLANNING HORIZONS, SOYBEANS-WHEAT AND NO-TILL ALTERNATIVES EXCLUDED, FARM 2

Planning Horizons (years)	Soil Loss Levels (tons/acre/year) ≤ 100	≤ 25	≤ 10	≤ 5
	percent of base[a]			
1	100.0	100.0	97.5	83.0
5	100.0	100.0	98.4	85.5
10	100.0	100.0	98.8	86.5
20	100.0	100.0	99.0	87.1
40	100.0	100.0	99.4	88.2

[a]Base system was the 100-ton soil loss level for each planning horizon.

Table 45 showing data for Farm 2 indicate that the income effect of lowering the soil loss constraint was less on Farm 2 than Farm 1 for every planning horizon. The lesser income impact on Farm 2 was due primarily to the relatively larger acreage of bottomland. Farm 2 had two fields that consisted entirely of bottomland and two fields that were predominantly bottomland soils. It should be noted again that the soil loss constraint was imposed on a field basis rather than a farm or individual acre basis.

Optimum farm organization for various planning horizons with 100-ton soil loss constraint, Farm 3. The effects or variations in planning horizon on the most profitable farm enterprise organization are shown in Tables 46 through 49 for Farm 3 for various permissible soil loss levels. The optimal cropping systems are shown in Table 46 where the soil loss level was set at a maximum of 100 tons. With a 1-year planning horizon, the plan included corn produced up and down the slope (192 acres), corn produced on the contour (72 acres), and meadow (9 acres). The 72 acres of corn produced on the contour occupied fields that would naturally be cultivated on the contour because of the shape and design of the field. The nine acres of meadow occupied a field that had been designated as suitable for meadow or pasture only by the SCS Conservation Plan and was so restricted in the model. The average soil loss level achieved per acre for all fields was 16.5 tons. Soil losses using this plan would exceed 25 tons on three fields, 10 tons on eight fields, and five tons on 10 fields.

TABLE 46

OPTIMUM FARM ORGANIZATION FOR VARIOUS PLANNING HORIZONS, 100-TON SOIL LOSS CONSTRAINT, FARM 3[a]

Cropping Systems	Planning Horizons (years) 1	5	10	20	40
	acres				
Corn-conventional (SRCC)	192.0	68.0	56.0	56.0	56.0
Corn-conventional (CT)	72.0	196.0	208.0	208.0	208.0
Meadow (SELLHAY)	9.0	9.0	9.0	9.0	9.0

[a]Soybeans-wheat double-crop and all single crop no-till systems were excluded as options.

TABLE 47

OPTIMUM FARM ORGANIZATION FOR VARIOUS PLANNING HORIZONS, 25-TON SOIL LOSS CONSTRAINT, FARM 3[a]

Cropping Systems	Planning Horizons (years) 1	5	10	20	40
	acres				
Corn-conventional (SRCC)	163.3	39.3	39.3	39.3	39.3
Corn-conventional (CT)	100.7	224.7	224.7	224.7	224.7
Meadow (SELLHAY)	9.0	9.0	9.0	9.0	9.0

[a]Soybeans-wheat double-crop and all single crop no-till systems were excluded.

TABLE 48

OPTIMUM FARM ORGANIZATION FOR VARIOUS PLANNING HORIZONS, 10-TON SOIL LOSS CONSTRAINT, FARM 3[a]

Cropping Systems	Planning Horizons (years)				
	1	5	10	20	40
	acres				
Corn-conventional (SRCC)	40.0	4.2	--	--	--
Corn-conventional (CT)	199.3	226.1	230.3	211.8	211.8
Corn-conventional (CTTS)	--	11.0	11.0	32.7	32.7
Soybeans-conventional (2SB-2M)	4.2	4.2	4.2	4.2	4.2
Meadow (SELLHAY)	29.5	27.5	27.5	24.3	24.3

[a]Soybeans-wheat double-crop and all single crop no-till systems were excluded.

TABLE 49

OPTIMUM FARM ORGANIZATION FOR VARIOUS PLANNING HORIZONS, 5-TON SOIL LOSS CONSTRAINT, FARM 3[a]

Cropping Systems	Planning Horizons)years)				
	1	5	10	20	40
	acres				
Corn-conventional (SRCC)	--	--	--	--	--
Corn-conventional (CT)	151.8	103.0	93.2	64.6	64.6
Corn-conventional (CTTS)	--	58.9	72.8	105.4	105.4
Soybeans-conventional (2SB-2M)	7.7	7.7	7.7	7.7	7.7
Meadow (SELLHAY)	113.5	103.4	99.3	95.3	95.3

[a]Soybeans-wheat double-crop and all single crop no-till systems were excluded.

Farm 1 and Farm 2, as the length of the planning horizon increased to five years and beyond, the increased cost of contour cultivation was offset by the decrease in yields, making contour cultivation more profitable over the longer planning horizons.

Optimum farm organization for various planning horizons with 25-ton soil loss constraint, Farm 3. The optimum farm organizations for Farm 3 for various planning horizons and with a soil loss constraint of 25 tons are shown in Table 47. In comparison with the 1-year plan when soil loss was set at a maximum of 100 tons, adjustments in cropping systems were required on three fields to stay within the 25-ton limit. With the 1-year planning horizon, the most profitable farm organization

As the length of the planning horizon was increased to five years, 124 acres shifted from corn conventional tillage up and down the slope to corn conventional tillage on the contour. At the 10- through the 40-year planning horizons, all systems remain the same except 12 additional acres of corn shifted to conventional tillage on the contour. The average level of soil loss achieved decreased to 13.1 tons. The soils of Farm 3 consisted of approximately 23 percent Grenada with 2-5 percent slope, 11 percent Lexington with 2-5 percent slope, 39 percent Memphis with 2-5 percent slope, and 18 percent Memphis with 5-8 percent slope. Total yearly labor requirement increased from 841 at the 5-year planning horizon to 861 at the 40-year planning horizon. This increase in labor was due to the additional time needed for contour cultivation. Again, as on included 163.3 acres of corn produced up and down the slope, 100.7 acres of corn produced on the contour, and nine acres of meadow. Soil loss per acre averaged 14.7 tons per acre for all fields. Total labor requirement was 850 hours.

As the length of the planning horizon was increased to five years and beyond, the production of corn conventional tillage up and down the slope was reduced substantially (to 39.3 acres), corn produced on the contour increased to 224.7 acres, and nine acres remained in meadow. The average soil loss per acre on all fields was 11.0 tons. Eight fields had soil losses exceeding 10 tons per acre. Labor requirement increased to 864 hours per year. No further changes in the optimal farm plan occurred as the planning span was increased to 10, 20, and 40 years.

Optimum farm organization for various planning horizons with 10-ton soil loss constraint, Farm 3. Reduction of the permissible soil loss from 25 to 10 tons resulted in major changes in the optimal farm organizations for every planning horizon (Table 48). Reductions occurred in the production systems up and down the slope and increases occurred in use of terraces, rotations, and continuous forages. With a 1-year planning span the cropping plan included 199.3 acres of corn produced on the contour, 40 acres of corn produced up and down the slope, 4.2 acres of soybean-meadow rotation, and 29.5 acres of continuous meadow. Shifts in cropping systems were required on eight fields to reach the 10-ton soil loss limit. The average level of soil loss for all fields was 8.8 tons.

As the length of the planning horizon increased to five years and beyond, corn shifted from up and down the slope to contour tillage and to some degree to production on terraced land. At the 20- and 40-year planning horizons, the optimal plan included 32.7 acres of corn produced on terraced land.

Optimum farm organization for various planning horizons with 5-ton soil loss constraint, Farm 3. At the 5-ton soil loss level all corn shifted to either conventional tillage on the contour or conventional tillage on the contour with terraces. At the 1-year planning horizon, the cropping system included 151.8 acres of corn on the contour, 113.5 acres of meadow, and a small number of acres in a soybean-meadow rotation. On several fields use of continuous forage was the only land use alternative that would achieve the 5-ton soil loss limit. Shifts in cropping systems occurred on all fields except two in order to stay witnin the 5-ton limit. One of these fields had been designated as meadow or pasture only and the other field consisted of bottomland soils. The average soil loss level achieved per acre for all fields was 4.8 tons.

At the 5-year planning horizon acreage was shifted from corn produced on the contour and meadow into corn produced on the contour with terraces (58.9 acres). The number of acres of terraces in the optimal plans increased as the length of the planning horizon increased. Acres shifted from corn produced on the contour and meadow to corn produced on terraced land at the 5-, 10-, and 20-year planning horizons. These results would seem to indicate that in the short run (one year), because of their cost, terrace systems are not the least cost alternative to control soil loss. In the long run, however, if soil loss must be held at five tons per acre per year and no-till systems are not viable alternatives, then cropping systems with terraces may be the most profitable alternative.

Effect of soil loss constraints upon discounted net returns over various planning horizons, soybeans-wheat and no-till alternatives excluded, Farm 3. The effects of varying soil loss constraints upon discounted net returns for five different planning horizons are shown for Farm 3 in dollar terms and percentage terms in Tables 50 and 51. Percentage changes in net returns are expressed in terms of the 100-ton soil loss limit level as the base. Reductions in the soil loss constraint level below the maximum permitted of 100 tons per acre had about the same effect for all planning horizons with slightly greater impacts for the shorter term planning horizons. Reducing the permissible soil loss limits from 100 to 25 tons per acre had only minor effects on net returns (0.3 to 0.4 percent). Attaining the 25-ton limit involved relatively minor shifts in corn acreage produced up and down the slope to contour tillage--alternatives with relatively minor income differences.

Further reduction of the soil loss constraint to 10 tons reduced potential net returns by 4-5 percent (5.0 percent with a 1-year planning horizon and 3.6 percent with a 40-year planning horizon). The income reduction resulted from the necessity for further shifts to contour tillage of corn, increased acreage utilized for meadow, and the need to use terraces on some acreage in order to meet the 10-ton soil loss limit.

To achieve the five-ton soil loss level, effects on net returns were more pronounced for all planning horizons. In comparison to the 100-ton soil loss limit, income reductions were 18 percent for the

TABLE 50

EFFECT OF SOIL LOSS CONSTRAINTS UPON DISCOUNTED NET RETURNS, OVER VARIOUS PLANNING HORIZONS, SOYBEANS-WHEAT AND NO-TILL ALTERNATIVES EXCLUDED, FARM 3

Planning Horizons (years)	Soil Loss Levels (tons/acre/year) ≤ 100	≤ 25	≤ 10	≤ 5
	dollars			
1	25,838	25,739	24,575	19,951
5	107,325	106,904	103,067	85,833
10	176,290	175,681	169,695	141,619
20	247,786	246,797	238,666	200,010
40	293,089	291,923	282,440	240,425

TABLE 51

EFFECT OF SOIL LOSS CONSTRAINTS UPON DISCOUNTED NET RETURNS OVER VARIOUS PLANNING HORIZONS, SOYBEANS-WHEAT AND NO-TILL ALTERNATIVES EXCLUDED, FARM 3

Planning Horizons (years)	Soil Loss Levels (tons/acre/year) ≤ 100	≤ 25	≤ 10	≤ 5
	percent of base[a]			
1	100.0	99.6	95.0	77.2
5	100.0	99.6	96.0	79.9
10	100.0	99.7	96.3	80.3
20	100.0	99.6	96.3	80.7
40	100.0	99.6	96.4	82.0

[a]Base system was the 100-ton soil loss level for each planning horizon.

40-year planning horizon and 22.8 percent for the 1-year planning horizon. As on Farms 1 and 2 major shifts to meadow and terraces were necessary to achieve the 5-ton soil loss limit. Average net returns per acre were substantially lower for meadow and terrace systems than straight row and contour tillage systems.

III. Optimum Farm Organization with Variations in Planning Horizons and Crop Management Systems Considered

In order to achieve the goals of the Clean Water Act of 1977, the 208 Water Quality Management Plan prepared by the Department of Public Health, Division of Water Quality, has recommended that soil losses stay within specified "tolerance limits." The tolerance value is the estimated maximum amount of soil loss that can occur in tons per acre per year and still achieve the degree of conservation needed to sustain economical production in the foreseeable future.

The purpose of this section was to determine the optimum enterprise organization and net returns for Farm 3 when soil loss was held at or near the tolerance level ($\leq$ 5 tons/acre/year) and variations were made in: (1) planning horizon, and (2) cropping management alternatives. Initially all cropping systems were considered. Soybeans-wheat double-crop was first eliminated, then soybeans-wheat and no-till corn, and finally elimination of all double-cropping and no-till alternatives. Since the results from this type analysis were similar for all three study farms, the interrelationships between planning horizon and admissible enterprise alternatives are presented here only for Farm 3.

Optimum farm organizations for Farm 3 for various planning horizons with all cropping systems considered and soil loss constraint of 5 tons. The most profitable farm organizations for planning spans of 1, 5, 10, 20, and 40 years are shown in Table 52 when all cropping systems were considered. The soil loss level was held at 5 tons/acre/year in each case. At the one-year planning horizon, the optimal farm organization included 42 acres of soybeans-wheat double-crop up and down the slope, 45.6 acres of soybeans-wheat double-crop on the contour, 166 acres of no-till corn, 8.5 acres of no-till corn on terraced land, and 10.8 acres of meadow.

TABLE 52

THE EFFECT OF VARIATIONS IN PLANNING HORIZON ON THE MOST PROFITABLE CROPPING SYSTEM, ALL CROPPING SYSTEMS CONSIDERED, FARM 3[a]

Cropping Systems	Planning Horizons (years)				
	1	5	10	20	40
	acres				
Soybeans-wheat double-crop (SRCC)	42.0	42.0	42.0	42.0	42.0
Soybeans-wheat double-crop (CT)	45.7	44.9	44.9	44.9	44.9
Corn (NT)	166.0	166.0	166.0	166.0	166.0
Corn (NTTS)	8.5	10.8	10.8	10.8	10.8
Meadow (SELLHAY)	10.8	9.3	9.3	9.3	9.3

[a]Soil loss constraint was 5 tons per acre for each planning horizon.

Only one minor shift in the cropping systems occurred as the planning horizon was increased to 5, 10, 20, and 40 years. At the 5-year planning horizon, 2.3 acres were shifted from soybeans-wheat double-crop and meadow into no-till corn with terraces. The average level of soil loss achieved for all fields was 3.6 tons. On all but two fields estimated soil losses were at the 5-ton constraint level. One of these unconstrained fields was in meadow; the other one consisted of bottomland soils. Total yearly labor requirement for the optimal plans was about 750 hours.

Optimum farm organizations for various planning horizons, soybeans-wheat double-crop alternative excluded and soil loss constraint at 5 tons, Farm 3. When soybeans-wheat double-crop was eliminated as an enterprise alternative, the maximum profit cropping system included 243.3 acres of no-till corn, 19.3 acres of no-till corn on terraced land, and 10.4 acres of meadow for all planning horizons. The average level of soil loss for all fields was 3.3 tons. Meadow and terrace were required in parts of three fields where the 5-ton soil loss level could not be maintained with no-till alone. These were fields which consisted predominantly of soils with 5-8 percent slope. There were six fields with soil losses of less than five tons per acre. These were fields which consisted predominantly of soils with 2-5 percent slope. Successive changes in the planning horizon to 5, 10, 20, and 40 years resulted in no changes in the optimal cropping system (Table 53).

TABLE 53

THE EFFECT OF VARIATIONS IN PLANNING HORIZON ON THE MOST PROFITABLE CROPPING SYSTEM, SOYBEANS-WHEAT DOUBLE-CROP ALTERNATIVE EXCLUDED, FARM 3

Cropping Systems	Planning Horizons (years)				
	1	5	10	20	40
	acres				
Corn (NT)	243.3	243.3	243.3	243.3	243.3
Corn (NTTS)	19.3	19.3	19.3	19.3	19.3
Meadow (SELLHAY)	10.4	10.4	10.4	10.4	10.4

[a]Soil loss constraint was 5 tons per acre for each planning horizon.

Optimum farm organizations for various planning horizons, soybeans-wheat double-crop and no-till corn alternatives excluded and soil loss constraint at 5 tons, Farm 3. Removal of both soybeans-wheat double-crop and no-till corn as enterprise alternatives resulted in major adjustments in the optimal farm plan (Table 54). For the 1-year planning horizon profits would be greatest with a cropping organization including 127.4 acres of corn produced with contour tillage, 31.4 acres of no-till soybeans, 13.9 acres of no-till soybeans produced on terraced land, and 92.6 acres of meadow producing hay for cash sale. Meadow would be producted on eight of the fields on the farm. On seven of these fields numerous production alternatives were specified but forage use was the most profitable alternative for achieving the 5-ton soil constraint level. The use of terraces would reduce soil losses below the permissible

TABLE 54

THE EFFECT OF VARIATIONS IN PLANNING HORIZON ON THE MOST PROFITABLE CROPPING SYSTEM, SOYBEANS-WHEAT DOUBLE-CROP AND NO-TILL CORN ALTERNATIVES EXCLUDED, FARM 3[a]

Cropping Systems	Planning Horizons (years)				
	1	5	10	20	40
	acres				
Corn-conventional (CT)	127.4	79.1	76.7	73.5	74.2
Corn-conventional (CTTS)	--	46.4	46.4	58.0	46.4
Soybeans (NT)	31.4	15.0	15.0	11.8	15.0
Soybeans (NTTS)	13.9	108.8	111.2	105.9	113.7
Soybeans-conventional (2SB-2M)	7.7	7.7	7.7	7.7	7.7
Meadow (SELLHAY)	92.6	16.0	16.0	16.1	16.0

[a]Soil loss constraint was 5 tons per acre for each planning horizon.

limit but cost would be prohibitive on a 1-year basis. One field was restricted to forage use in the model.

When the length of the planning horizon was increased to five years, a major shift to corn conventional tillage with terraces and no-till soybeans with terraces resulted. The 1-year plan included only 13.9 acres of terraced land; the 5-year plan included 155.2 acres of crops grown on terraced land. From the 5-year planning horizon through the 40-year planning horizon, minor additional shifts occurred with some increase in soybeans produced on terraced land and a reduction of corn produced on the contour. Because of their high initial cost, terrace systems were not the least cost alternative to control soil loss in the short run. In the long run, however, terrace systems were the most profitable alternative for achieving the 5-ton soil loss limit on a large proportion of the upland acres of Farm 3.

Effect of excluding cropping systems as production alternatives upon discount net returns for various planning horizons with soil loss constraint level of 5 tons per acre per year. The effects of excluding certain cropping systems upon discounted net returns for various planning horizons are shown in dollar terms and percentage terms in Tables 55 and 56. Comparisons are made using the situation when all cropping systems were included as the base.

For the 1-year planning span net returns varied from $26,548 when all cropping systems were included to $19,951 when all no-till alternatives had been eliminated--a reduction of approximately 25 percent.

Removal of soybeans-wheat double-crop system as an option had only minor effects on net returns, varying from 1.6 percent for the 40-year planning horizon to 2.3 percent for the 1-year planning horizon. On four fields of Farm 3, yield relationships were such that net returns from soybeans-wheat double-cropped were greater than for no-till corn.

Removal of both soybeans-wheat double-cropping and no-till corn as an option resulted in net returns reductions of 16 to 23 percent--16.4 percent for the 40-year planning span and 23.1 percent for the 1-year planning span. Net returns were considerably lower for the alternate cropping system which included considerable acreage of soybeans and soybeans produced on terraced land.

TABLE 55

DISCOUNTED NET RETURNS FOR VARIOUS PLANNING HORIZONS
WITH VARIATIONS IN CROPPING SYSTEMS CONSIDERED,
5-TON SOIL LOSS CONSTRAINT, FARM 3

Cropping Systems	Planning Horizons (years)				
	1	5	10	20	40
	dollars				
All cropping systems	26,548	112,353	185,353	216,202	309,516
Without soybeans-wheat double-crop	26,010	110,243	182,120	256,881	304,643
Without soybeans-wheat and no-till corn	20,424	91,549	153,107	216,859	258,601
Without no-till	19,951	85,833	141,619	200,010	240,426

TABLE 56

EFFECT OF EXCLUDING VARIOUS CROPPING SYSTEMS ON DISCOUNTED
NET RETURNS FOR VARIOUS PLANNING HORIZONS,
5-TON SOIL LOSS CONSTRAINT, FARM 3

Cropping Systems	Planning Horizons (years)				
	1	5	10	20	40
	percent of base[a]				
All cropping systems	100.0	100.0	100.0	100.0	100.0
Without soybeans-wheat double-crop	97.9	98.1	98.3	98.3	98.4
Without soybeans-wheat and no-till corn	76.9	81.5	82.6	83.0	83.6
Without no-till	75.2	76.4	76.4	76.6	77.7

[a]Base system was the all cropping systems.

Removal of all double cropping and no-till options resulted in further reductions in net returns for each planning horizon. For the 40-year planning horizon net returns were 77.7 percent of the potential when all enterprises were considered; for the 1-year planning span net returns were reduced by a somewhat greater amount--to 75.2 percent of the potential with all enterprise options. For the 1-year planning span over one-third of the farm acreage was in forage, which has a net return substantially lower than for row crops.

CHAPTER IV

SUMMARY AND CONCLUSION

I. Summary of Procedure

The primary objective of this study was to evaluate farm firm behavior and adjustment that might be expected when certain key factors related to soil conservation were allowed to vary over time. The assumed objective of the firm was to maximize the discounted present value of net return. The linear programming technique was utilized to obtain the optimum allocation of resources among the various production alternatives to achieve this goal under a variety of technical and economic conditions.

Three farms were selected which were considered to be typical of the upland crop producing farms located in the Deep Loess Soil Region of West Tennessee. These farms were selected based upon size, soil series, and soil mapping unit. The Grenada-Loring-Memphis and the Memphis-Loring Soil Associations are predominant in this area. These soils were derived from loess which overlies coastal plains material (primarily sand, gravelly material). A major erosion problem exists in this area due to the erosive nature of the soils and because most soils in this area are used for clean cultivated row crop production. The major crops grown are soybeans, corn, cotton, and wheat.

Enterprises considered for each farm in this study were soybeans, corn, cotton, soybeans-wheat double-crop, meadow, pasture, and a beef cow-calf livestock system. Standard budgetary techniques were utilized in developing costs and returns, and investment and operating capital requirements for the enterprises considered. Three capital charge rates were used. The budgets were developed from data synthesized from the Farm Planning Manual (21, 22), unpublished research data, and from consultations with agricultural engineers of the University of Tennessee and technical soil conservation specialists of the Soil Conservation Service (SCS). Cost of inputs such as seed, pesticides, and fertilizer were 1980 level prices obtained from the Tennessee Farmers Cooperative.

Five planning horizons were considered: 1, 5, 10, 20, and 40 years. Twenty years was used as the base planning horizon for this study. Since labor was not a constraint when only the owner-operator's labor was used, no variations in the labor situation were made.

Up to 41 production-management systems were considered for each field on each farm. These production-management systems included various combinations of conventional tillage, no-till, terraces, various lengths of crop rotations, and continuous forage. Soil losses for each system were estimated using the Universal Soil Loss Equation. Coefficients for the equation were obtained from Jent, Bell, and Springer (13) and certain addendums. Maximum soil losses were constrained at various levels from less than or equal to 100 tons/acre/year to five tons/acre/year. The predominant upland soil mapping units on the three farms were Memphis and Grenada (2-5 percent and 5-8 percent slopes). Yield levels for the different crops were obtained from Buntley and Bell (7). Yields over time were allowed to vary directly with the inches of topsoil above the fragipan for Grenada and Loring soils. For Lexington soils yields were allowed to vary directly with inches of topsoil above the stratified sandy loam and loamy sand sediment. For Memphis soils it was assumed there would be no change in yields over time within the different soil mapping units.

Conservation plans were available for these farms from the Soil Conservation Service. Field arrangements for the selected farms were taken from the SCS plans. Soil loss constraints were applied on a field basis. Conservation improvements suggested by SCS were inventoried for each field. Considerations in this study were limited to those improvements which directly affect erosion and sediment control. Conservation structures considered were terraces, diversions, sediment basins, and grassed waterways. It was assumed that all conservation structures would last for 20 years with yearly maintenance. The costs used for all conservation structures in the analysis were the cost estimates developed by the District Conservationists for the specific conservation plans for the three study farms.

In the analysis variations were also made in the alternative crop management systems considered. Optimum plans were first developed for each farm, soil loss level, and planning horizon when all crop management alternatives were considered. Subsequent analysis restricted the set of permissible production alternatives with successive deletions of soybeans-wheat double-cropped, no-till corn, and finally no-till soybeans as options.

II. Summary of Results

Optimum Farm Organizations with Variations in Crop Management Systems Considered and Permissible Soil Loss Levels

When all cropping systems were considered, the 10-ton soil loss level could be achieved on the three farms with no change in net returns. Soybeans-wheat double-crop and no-till corn were the predominant cropping systems at all soil loss levels for the three farms. Net returns were reduced by 2-3 percent on Farm 1 and less than 1 percent on Farm 2 and Farm 3 when the maximum soil loss constraint was set at five tons/acre/year.

When soybeans-wheat double-crop was excluded as a cropping alternative, no-till corn dominated the cropping systems on the three farms. Again the 10-ton soil loss level could be attained with no loss in net returns. At the 5-ton soil loss level net returns were reduced 2-3 percent on Farm 1 and less than 1 percent on Farm 2 and Farm 3.

Removal of soybeans-wheat double-crop and no-till corn as cropping alternatives resulted in corn conventional tillage on the contour dominating all cropping systems up to the 5-ton soil loss level. Net returns were reduced 2-5 percent at the 10-ton soil loss level in comparison to less restrictive levels. For Farm 1 at the 5-ton soil loss level acres were allocated to corn conventional tillage on the contour, no-till soybeans, no-till soybeans with terraces, and meadow. No-till soybeans with terraces dominated with 126.4 acres. On Farm 2, acres were allocated to corn conventional tillage up and down slope, corn conventional tillage on the contour, corn conventional tillage with terraces, no-till soybeans with terraces, and meadow. On Farm 3 acres were allocated to corn conventional tillage on the contour, corn conventional tillage with terraces, and no-till soybeans with terraces dominating with 105.9 acres. On the three farms net returns were reduced from 14 to 23 percent at the 5-ton soil loss level in comparison to the 100-ton limit level.

Removal of soybeans-wheat and all no-till options resulted in minor reductions in net returns at the 10-ton soil loss level (3-5 percent). At the 5-ton soil loss level net returns were reduced by 16-27 percent for the three farms. Corn conventional tillage on the contour, meadow, and a soybean-meadow rotation yielded the greatest net returns on Farm 1. On Farm 2 and Farm 3 corn conventional tillage on the contour, corn conventional tillage with terraces, and meadow became the most profitable.

Optimum Farm Organizations with Variations in Planning Horizons and Permissible Soil Loss Levels

In Section II the interrelationships between planning horizon and soil loss levels were examined. Soil loss levels were allowed to vary from 100 tons/acre/year to five tons/acre/year. Planning horizons were allowed to vary from one to 40 years. The analysis of this section was completed with the exclusion as enterprise alternatives of soybeans-wheat double-crop, no-till production of corn, and no-till production of soybeans as a single crop. When soybeans-wheat double-crop and all no-till systems were excluded as cropping alternatives corn conventional tillage up and down slope dominated all cropping systems for the 1-year planning horizon on the three case farms. As the length of the planning horizon increased to five years and beyond, corn conventional tillage on the contour replaced corn conventional tillage up and down the slope for soil loss constraints of 10 tons or more. At the 5-ton soil loss level, major shifts occurred to meadow and a soybean-meadow rotation on Farm 1 over all planning spans and corn conventinal tillage with terraces and meadow on Farm 2 and Farm 3 from the 5- to the 40-year planning span. Soil loss constraints had minor effects at the 10-ton soil loss level (3-5 percent); however, net returns were reduced by 20-30 percent at the 5-ton soil loss level for Farm 1 and Farm 3 and 10 to 20 percent on Farm 2 over all planning horizons.

Optimum Farm Organizations with Variations in Planning Horizons and Crop Management Systems Considered, Farm 3

The analysis in Section III presented the optimum enterprise organizations and net returns for Farm 3 when the soil loss level was held at five tons/acre/year with variations made in planning horizon and cropping management alternatives. Since the underlying relationships for Farm 1 and Farm 2 were very similar, only the results of Farm 3 were presented. When all cropping systems were considered, the optimal farm plans included primarily soybeans-wheat double-crop and no-till corn for all the various planning horizons (one to 40 years). No-till corn dominated at 166 acres over all planning horizons.

Removal of soybeans-wheat double-crop as a cropping alternative resulted in no-till corn dominating all cropping systems for the various planning horizons. Net returns were reduced by approximately 2 percent in each planning horizon.

When soybeans-wheat double-crop and no-till corn were excluded as cropping options, corn conventional tillage on the contour dominated the land use in the optimal farm plan at the 1-year planning horizon. As the length of the planning horizon increased to five years and beyond, corn conventional tillage on the contour with terraces and no-till soybeans with terraces were major enterprises in the optimal systems. Removal of soybeans-wheat double-crop and no-till corn as enterprise options reduced net returns by 15-25 percent for the various planning horizons.

Removal of soybeans-wheat double-crop and all no-till options (soybeans and corn) resulted in corn conventional tillage and meadow dominating in the plan for the 1-year planning horizon. As the length of the planning horizon increased to five years and beyond corn conventional tillage on the contour with terraces were major enterprises in the optimal farm plans. At the 20- and 40-year planning horizons the farm organization included 105.4 acres of corn conventional tillage with terraces (about 40 percent of the cropland). Net returns were reduced 20-25 percent below the level attainable when all enterprises were considered.

III. Conclusion

Based upon the assumptions and results of this study, no-till and double-cropping systems could be used to reduce soil losses to no more than 10 tons/acre/year with little or no effect upon net returns. Considering the full range of crop management systems considered in this study, the 5-ton soil loss level could be achieved with only minor reductions in net returns on all three study farms (2-3 percent) utilizing a variety of conservation alternatives including particularly no-till but also contour cultivation and in some cases terracing if terracing could be done rather inexpensively.

If the use of no-till and double-cropping systems is not feasible on a given farm, achievement of soil losses at or near tolerance levels would not appear possible without a substantial change in production practices, a reduction in row crop acres, and a significant impact on net farm income. This would be particularly true for soils now used for row crops that have slopes of 5 percent or greater. To achieve a 5-ton soil loss level would likely result in income reduction of 25-30 percent.

Results also indicated that to achieve the 5-ton soil loss level, when no-till options were excluded, net returns were reduced more on Farms 1 and 3 (20-30 percent) which were predominantly upland farms than on Farm 2 (10-20 percent) which had 81.2 acres of bottomland. This would indicate that a uniform policy to restrict soil loss would likely create certain inequities. Some farms would need to make major adjustments in cropping systems to achieve specific soil loss standards while the adjustments on others would be less drastic. The financial consequences in terms of income could be significantly greater on predominantly upland farms, farms producing row crops on slopes greater than 5 percent, and farms unable to successfully implement double-crop and no-till systems.

Based upon the assumptions and basic data used for this study, the production of no-till corn was the predominant cropping system in the optimal organizations developed for each of the study farms when all cropping systems were considered. In terms of crops currently produced in the area soybeans is by far the predominant enterprise. While the use of no-till systems is expanding in acreage, conventional tillage systems are most common. It should be noted that the enterprise budgets indicate relatively small differences in net returns between corn and soybeans.

As compared to corn, soybeans have somewhat lower investment requirements and tend to be less risky since yield variability is lower over time.

IV. Future Research

The 208 Water Quality Plan as prepared by the Tennessee Department of Public Health has recommended that soil loss stay within tolerance limits. The tolerance level refers to the maximum amount of soil loss that can be tolerated and yet achieve the degree of conservation needed for sustained economic production in the foreseeable future. These tolerance values are estimates based upon subjective judgments and conventional wisdom of scientists familiar with the physical and biological aspects of the erosion process and crop production. These values do not necessarily represent the optimum level of soil loss from the viewpoint of the individual farmer or that achieving them will be sufficient to maintain water quality.

In the Water Quality Plan for Tennessee (28) the soil tolerance level was set at five tons for Memphis soils, three tons for slightly and moderately eroded Grenada and Lexington, and two tons for severely eroded Grenada and Lexington. In the present study soil losses were limited to five tons/acre/year. Thus, this 5-ton level met the tolerance limit for Memphis but not for Grenada or Lexington. Further research is needed to determine more precisely the relationship between the level of soil losses, sediment control and water quality, and the effect upon cropping systems and net returns if soil loss tolerance levels were achieved for all soils.

The impact of soil loss constraints on income and cropping systems depends considerably on the unit to which the constraint is applied. In the present study, the soil loss constraint was imposed on a field basis as the average soil loss per acre rather than a farm basis or individual acre basis. If a 5-ton limit were set, in fields containing both bottomland and upland soil losses in excess of five tons on the upland soils could be offset by the bottomland soils, with no measurable soil loss. Additional research is needed to examine more thoroughly the effects upon cropping systems and net returns when soil loss was restricted on an individual acre basis or a farm basis.

The present study assumed that no-till systems could be used over an extended period and that yields were the same for no-till systems as for conventional tillage. The study did not examine insect, weed, or germination problems or pesticide buildup in the soil that might result from no-till systems. Future research is needed to more fully evaluate no-till crop production management systems from an economic standpoint with particular attention to chemical, labor, fuel, and machinery requirements, and risk involved in no-till systems and the obstacles to more widespread use.

The relationship between erosion and yields is an important factor in determining the economics of soil conservation. The effect of topsoil loss on yield is not well known. For some soils loss of topsoil may bring about a reduction in yields within a short time period. For other deep loess derived soils where the subsoil may be as productive as the topsoil, there may be no appreciable yield reduction due to erosion. On many soils potential yield reductions may be offset by increased fertilization or masked by technological improvements in input use. Future research needs to be done to evaluate the expected long-term consequences of soil erosion on yields on different soils with different climatic regimes.

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