ECONOMICS OF REDUCED TILLAGE TECHNOLOGY ON SOIL CONSERVATION AND RISK ANALYSIS FOR EASTERN OKLAHOMA FARMERS

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CHAPTER I

INTRODUCTION

General Problem

For the last 50 years, soil erosion has been a subject of interest due to the adverse effects of soil loss on soil productivity and the agricultural land base. In the 1950's and 1960's, there was less concern for the conservation of soil due to a number of factors, including technological development in agricultural production.

> . . .it appears that the economics of soil conservation had been a neglected subject in agricultural economics during the last two or three decades except as it relates to stream pollution and externalities. The most obvious reason for this apparent lack of interest in the subject is the view that advances in technology have made soil resources per se of less consequence for agricultural production (15, p. 83).

Recently, soil erosion has again come to be viewed by many as a severe problem and as a threat to agricultural production in the United States. Further, there is a growing concern for the adverse water quality impacts resulting from soil erosion.

Soil erosion has two main effects on the environment. One effect of soil erosion is the loss of soil productivity through removal of soil, plant nutrients, and other organic matter, an onsite effect of the farming activity.

> The loss of the topsoil lowers the amount of nitrogen and other nutrients available to growing crops. Erosion also diminishes the ability of the soil to absorb water, which reduces the moisture available in the soil to dissolve nutrients required by plants (22, p. 1).

The second effect of soil erosion is water pollution, an offsite effect. Soil erosion results in sediment, nutrients and pesticides polluting the waterways.

Accurate data on the relationship between soil productivity and soil erosion are essential to make agricultural policy decisions. It is known that soil erosion eventually depletes soil productivity of the remaining land base, but the relationship between erosion and productivity is not well defined (52, 72, 81, 99, 100).

A 1981 study stated:

> until the relationship between erosion and productivity is adequately developed, selecting management strategies to maximize long-term crop production will be impossible. Poor decisions can easily result in serious damage to soil resources; productivity may approach zero in many severely eroded areas of the United States (72, p. 82).

It has been argued that it is very difficult to detect the erosion-productivity problem. Erosion reduces productivity so slowly that land is not suitable any more for growing crops at the time the productivity reduction is recognized (52, 72). Furthermore, improved technology (e.g., fertilizer application) makes the detection of erosion-productivity more difficult as it masks the reduction in productivity (49, 72).

In the early 1970's, water pollution from agricultural sources received more attention. The Federal Water Pollution Control Act Amendments of 1972 (PL 92-500) recognized agriculture as a major source of water pollution. The objective of that law is the restoration and maintenance of the quality of the nation's water (22). Water pollution caused by soil erosion has occurred in 68 percent of the river basins in the United States (18). The Soil and Water Resources Conservation Act and the Rural Clean Water Program, both enacted in 1977, urge soil and water resource conservation in the United States.

For more than 40 years, the Soil Conservation Service (SCS) and other agencies have been working on the problem of controlling soil erosion. It would seem, after such a long-term effort, that the soil would be "tied down" in the entire country and that the land would be erosion free.

Soil and water conservation programs, however, have not been very effective in some areas in the United States. Widespread observations of soil erosion are confirmed by the quantification of soil loss and other consequences of land misuse. Agricultural lands and soils are being lost in the United States at an unacceptable rate (70).

The 1977 National Resource Inventory showed a loss that year from sheet, rill, and wind erosion of more than 5.3 million tons of soil (71). Recent estimates indicate that 23.5 percent of all cropland in the U.S. is being eroded at a rate of 5 tons or more per acre each year (48).

In Oklahoma, soil and water conservation programs have been relatively effective and the loss from sheet, rill and wind erosion is not very high compared to other areas in the states. This does not suggest that there is no concern about the soil erosion in Oklahoma. On the contrary, wind and water erosion are dominant problems on 19.4 million and 34.1 million acres, respectively, in the Southern Great Plains (Kansas, New Mexico, Oklahoma and Texas). Of these 53.5 million acres, 37.2 million acres still need treatment for erosion control

(110). Therefore, Oklahoma farmers need to adopt best management practices[1] such as reduced tillage technology[2] that protects the soil resource and reduces soil erosion that otherwise would have an adverse impact on soil productivity and water quality.

Soil conservation practices include minimum tillage, no-tillage, terraces, crop rotations, contour farming, strip-cropping, cover-establishment, grassed waterways and other practices.

Reduced tillage technology in this study refers to both minimum tillage and no-tillage.

> Minimum tillage refers to tillage systems that do not use the moldboard plow, that leave enough crop residue on the soil surface to reduce erosion significantly, and rely primarily on herbicides for weed control (87, p. 4).

No-tillage refers to tillage systems that accomplish weed control with chemicals and the soil is not tilled.

> No-tillage has been concisely defined as placing the crop seed or seed transplant into the soil by a device that opens a trench or slot through the sod or previous crop residue only sufficiently wide and deep to receive the seed or transplant roots and to provide satisfactory seed or root coverage. No other soil manipulation is required. Weeds are controlled by herbicides, crop rotation, and plant competition (121, p. 219).

Many factors undoubtedly affect the adoption of reduced tillage technology as an erosion control practice. However, the overriding factor is economics. Reduced tillage technology practices that improve net returns have been, and will continue to be, adopted. Those

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[1]"Best management practices (BMP's) are practices of tilling, cultivating, or harvesting crops that help reduce soil erosion and water pollution. These include conservation tillage systems, supporting practices, less intensive crop rotations, and/or combinations of each" (85, p. 22).

[2]Reduced tillage technology, soil conservation practices, conservation tillage and reduced tillage systems will be used interchangeably in this study.

practices that do not improve net returns likely will not be adopted. If the choice is between losing the farm to its mortgage holder or losing a few inches of topsoil, most, if not all, will choose the latter. Farmers are well aware of the agronomic benefits of adoption of reduced tillage technologies to protect the soil resource. However, they tend to adopt only those which are economical.

The level of soil erosion and water quality, the present and future productivity of Oklahoma farmland, and other important issues associated with Oklahoma agriculture are significantly influenced by the various management practices used by Oklahoma farmers.

The education, training, and experience of farmers play an important role in determining their management practices. In addition, the levels of risk and uncertainty that farmers attach to the various management practices also influence their adoption of reduced tillage technology. The farmers' perceptions, attitudes and ability to take risks also play an important role in farm management decisions and in formulating public policy on reduced tillage technology. For example, if a farmer is averse to risk taking, he may reject a more profitable reduced tillage technology in favor of a less profitable and less risky conventional tillage system. One reason for this is that risk averse farmers will be reluctant to invest in reduced tillage technology or soil conservation practices to the extent that they suffer financial failure in the short run. In addition, those averse to risk will be less willing to forego short run returns for long-term and uncertain productivity benefits.

Soil conservation practices often require long-term investments such as tillage equipment and terraces. Because many of the benefits of soil conservation practices may not be realized for many years, sufficient incentives may not exist for many farmers to use or adopt soil conservation practices. In most cases farmers are interested in the short-term profitability of reduced tillage technology.

> Given the economic realities of high land prices, high interest rates, growing expenses, etc., many farmers believe that they must concentrate on short-run profits and cash flows or be forced out of farming (85, p. 1)

Another factor to be considered is that the adoption of reduced tillage technology might have an adverse impact on farmers' incomes in early stages, at least in the short run, due to the fact that this new technology is not used appropriately or/and due to the lack of appropriate management practices in conjunction with the technology package.

One reason that more progress has not been made in controlling or reducing soil erosion may be that many conservation practices are more costly than conventional practices, at least in the short-run. Higher costs may result from installing and maintaining terraces, contour plowing, or using more herbicides in reduced tillage farming.

Specific Problem

The 1977 Oklahoma Resources Inventory estimated that average annual sheet and rill erosion for all cultivated cropland is 3.73 tons per acre or 41,833,000 tons per year. The cultivated cropland erosion rates ranged from an average of 3.25 tons per acre per year for the better croplands (capability classes I-III), 5.04 tons per acre per year for the marginal croplands (capability classes IV-V) to 8.02 tons per acre per year for capability class VI lands that are considered best suited for a permanent grass cover. Soil loss on cultivated cropland due to wind erosion averages 3.5 tons per acre per year. The wind erosion estimates were made on soils in the 43 western counties where wind erosion problems are significant (78). Soil erosion and its effect on water quality and on agricultural productivity should be a major concern for the future of Oklahoma agriculture and for the Oklahoma economy.

To reduce soil erosion caused by farming with conventional tillage systems, best management practices (BMP's) such as reduced tillage technology must be adopted at the farm level. By determining the attitudes of farmers towards the adoption of reduced tillage technology and its impact on the farm, farm income and soil erosion situation, appropriate policy measures can be made to help farmers and to induce them to adopt reduced tillage technology. Educational and cost-sharing programs and tax incentives are common policy measures.

Objectives of the Study

This study deals with reduced tillage technology as a conservation practice to reduce soil erosion, farmers' attitudes toward this new technology, and the risk factors involved or related to this technology adoption process.

The objectives of this study are as follows:

1. to examine the effect of soil loss on current net returns from farming.
2. to examine the effect of soil loss on future net returns from farming.
3. to identify farmers' characteristics and adoption rates of reduced tillage technology and to examine some socio-economic factors which explain the adoption of this new technology.

4. to evaluate tillage systems with special emphasis on double cropping.
5. to estimate the impact of the reduced tillage (tillage systems) technology on the crop yields in relationship to soil erosion (soil loss).
6. to examine risk factors that affect the adoption of reduced tillage technology.

Hypotheses of the Study

The following hypotheses will be tested:

1. Short-run farm income decreases as a result of the adoption of reduced tillage technology.
2. Long-run farm income increases as a result of the adoption of reduced tillage technology.
3. Reduced tillage technology reduces soil loss so that crop production can be sustained in future years without depleting the soil resource.
4. Personal characteristics of the farmer such as age, education, experience in farm management and in reduced tillage technology, and health status influence adoption rates.
5. The number of soil conservation practices used by a farmer is a function of the number of tillable acres on the farm, the type of soils on the farm, and the age, education, and the farmer's experience in farm management.
6. Risk aversion and the perception of farmers that the costs of reduced tillage technology may exceed their benefits result in non-adoption of reduced tillage technology.

Selection of Study Area

The region selected for this study is eastern Oklahoma (northeast, eastcentral and southeast). The area selected includes Craig, LeFlore, Okmulgee, Ottawa, and Wagoner Counties (Figure 1).

This area was selected because there is a need for research on adoption of reduced tillage technology in eastern Oklahoma and because of the increasing importance of this area to total Oklahoma agricultural production. These five counties were selected because they represent the area with a combination of reduced tillage technology (minimum- and no-till) and double cropping soybeans after wheat.

Minimum tillage and no-tillage double-crop system of soybeans after wheat are growing rapidly in eastern Oklahoma. Farmers adopted the double-cropping system to increase agricultural incomes. For example, they may harvest 20 bushels of soybeans per acre from land that has already produced 40 or 50 bushels of wheat. Instead of growing one crop and plowing the soil the rest of the year, two crops are grown and harvested from the same acre in one year.

Soil erosion is a serious soil management problem in soybean production. Many commonly used soybean tillage and cropping systems result in high soil losses per acre per year on some soils. Double-cropping of wheat and soybeans is an excellent soil erosion control and water conservation system, because of the nearly year-round cover on the soil surface.

The effectiveness of double-cropping as a soil erosion control and water conserving practice is enhanced if the soybeans are no-till or minimum till planted into the standing wheat stubble. Another benefit of planting no-till or minimum till soybeans into wheat stubble is that it allows an earlier planting date.

Organization of Remainder of Thesis

The remainder of the thesis is organized into six chapters. The literature review is presented in Chapter II. Methodology and the analytical models utilized in estimating economic impact of soil loss, examining socio-economic factors which explain the adoption of reduced tillage technology, and examining risk in farm planning by using the three tillage systems and taking into consideration wheat-soybeans double-cropped are presented in Chapter III. The survey results, secondary data and development of enterprise budgets are presented in Chapter IV. The impact of soil erosion on crop yields is presented in Chapter V. Results of the study are presented in Chapter VI. The summary and conclusions, and potentials for future research are presented in Chapter VII.

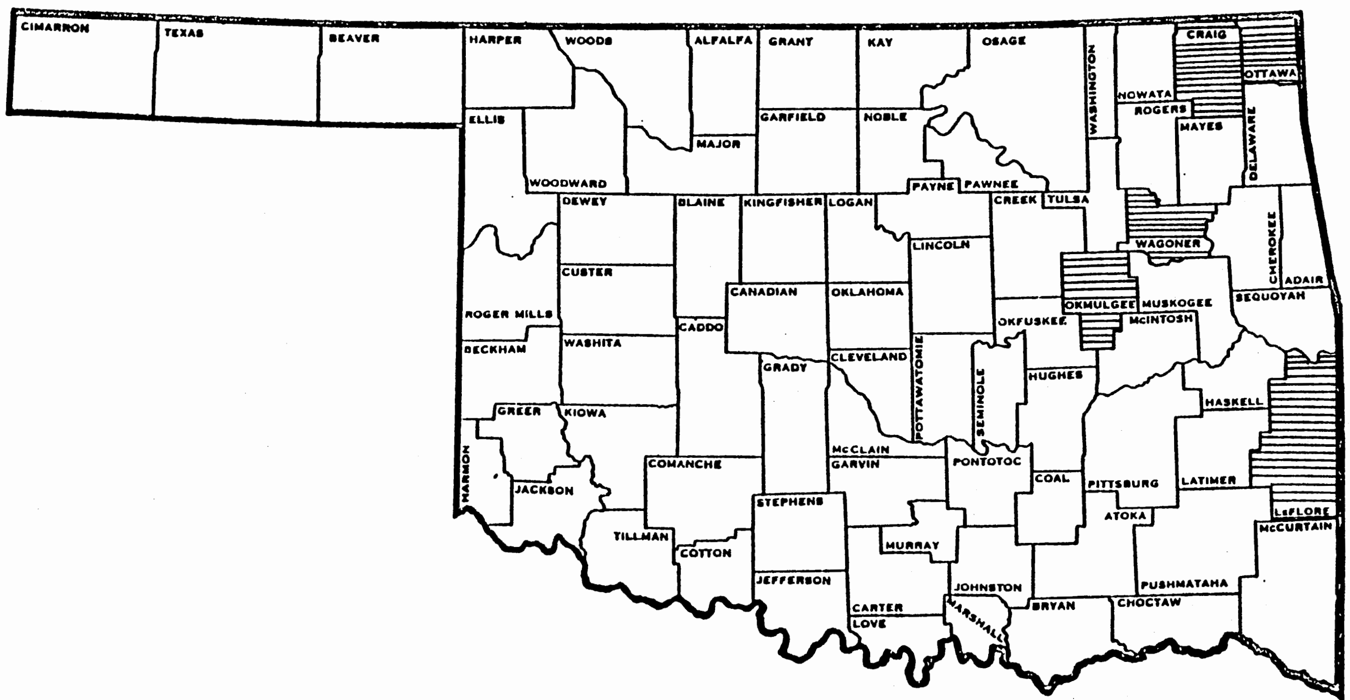

Figure 1. Map of Study Area in Eastern Oklahoma

CHAPTER II

LITERATURE REVIEW

The economics of soil and water conservation practices and the impact of alternative soil conservation policies on individual farmers, soil erosion and water quality have been evaluated at the national, regional, state, watershed and farm levels.

The United States Department of Agriculture (USDA) adopted national priorities to guide its soil and water conservation activities in the future. The first priority is to reduce excessive soil erosion on crop, range, pasture and forest lands. In response to provisions of the Soil and Water Resources Conservation Act of 1977 (RCA) (Public Law 95-192) USDA is required to appraise the condition of the soil, water, and related resources on the non-federal lands of the nation and to develop a national soil and water conservation program to guide its future conservation activities on those lands.

Since the problems for which people need USDA assistance vary in different parts of the nation, the program allows for local and state priorities as a foundation for local and state conservation programs.

National Studies

At the national level, several studies concerning the economic effects of controlling soil loss have been conducted. Nicol, Heady and

Madsen (74) in 1974 used a linear programming model to simulate changes in national and regional variables relating to agricultural production resulting from soil erosion controls. Major agricultural commodities were incorporated in the model which determined the pattern of production in 223 production areas. The production of alternative crops was allocated to those areas which had an economic advantage and were compatible with restraints of soil loss. The results of the study indicated that agriculture can meet present and expanded levels of demand at soil loss levels below 5 tons per acre per year.

A 1976 study by Wade, Nicol and Heady (114) used a linear programming model which incorporated all major regions, commodity markets, resources, and transportation networks in the U.S. to determine the effects of reducing agricultural pollution on gross farm income. They found that total farm income will increase even though production costs increase, with soil erosion controls of five tons per acre per year at the national level. The study also showed that increased farm income will result in changes in the distribution of farm income and an increase in consumer prices.

A study conducted by Vocke et al. (111) in 1977 used an interregional linear programming model of U.S. agriculture to analyze policies aiming at controlling pollution caused by agricultural production. The study concluded that the U.S. agriculture has the capacity to meet pollution control policies and satisfy demand for farm products.

In a 1980 study conducted by English and Heady (23), impacts on U.S. agriculture from imposing soil loss control programs were measured. The study used a national interregional linear programming model to examine soil loss decreases of 10, 20, and 30 percent from a 1985 model and 10, 20, 30, 40 percent from a long-term or 2000 model. The results of the study indicated that as soil loss is reduced in both models, the trend toward modern and improved conservation practices will lead to reductions of soil erosion from agricultural land. Another result of the study was that as soil loss is reduced, the more erosive land leaves agricultural production and is left idle.

A 1980 study conducted by Daines and Heady (20) analyzed and compared three soil conservation policies: (1) a tax on soil loss; (2) reductions in soil loss to 5 tons or less per acre per year; and (3) a tax to encourage soil conservation practices. The study used a large-scale linear programming model. The model minimized the cost of producing and transporting the most important commodities in the United States. The results indicated significant reductions in soil loss can be obtained through applying each of the three policies.

Crosson (19) in 1981 tried to compare conservation tillage with conventional tillage. The study indicates that the costs of conservation tillage for corn, sorghum, wheat, soybeans, and cotton, based on 1979 prices and other conditions, were 5 to 10 percent less than those of conventional tillage.

In a 1976 study, Wade and Heady (113) evaluated national sediment control policies and the cost of reducing pollution from agricultural resources. They used an interregional linear programming model taking into consideration erosion, water quality and land management. The model minimized the cost of erosion control and the cost of producing and transporting agricultural commodities. They concluded that the minimum sediment reduction alternative requires extreme changes in the production system and significantly increases total production costs. Also the study found that erosion from non-cropland sources exceeds that from cropland sources. Cropland remains a major source of sediment, and cropland management offers a means for improvement in water quality.

Another study concluded by Wade and Heady (112) in 1976 evaluated possible environmental policies. Five alternatives were analyzed for stream sediment loads, agricultural land use, crop production patterns, and total social cost. The study used an interregional linear programming model which provides flexibility in the agricultural sector for meeting stream water quality standards. This analysis concluded that less erosion control can be obtained at a small total cost through the reorganization of the production technologies and crops.

In a 1977 study, Saygideger, Vocke and Heady (89) analyzed the trade-offs between efficiency and soil loss control in U.S. agriculture. They found that at a very high level of soil loss, a reduction in soil erosion can be obtained without substantial cost to society. But when soil losses are at relatively low levels, further reductions are very expensive. As the total amount of soil loss is reduced on U.S. cropland, the costs rise sharply to achieve further reductions.

In a 1980 study conducted by Lee (54), the impact of landownership factors on soil conservation was examined on a national and regional basis. The study used dummy variables in a regression model to test for differences in average erosion rates among different organizational structures. A second weighted regression model with dummy variables was used to examine average erosion rates on cultivated cropland among income and tenure variables. The study concluded that there is more need for research concerning the landownership impacts on soil conservation. The study also found that there are no significant differences in average rates of erosion on cropland owned by different types of organization units such as sole proprietor, family ownership, family and non-family corporation. Another result of the study was the existence of regional differences in controlling soil erosion at least with respect to income and tenure variables.

Heady et al. (38) in 1976 analyzed the national markets and the impacts of state land use and environmental programs. For this purpose a linear programming model was specified and used. The study found that imposition of soil loss limits reduces profitability of Iowa farming relative to the rest of the nation, as both income and costs change. Net farm income in Iowa decreases as a result of the imposition of soil loss restrictions, whereas farming in the rest of the country becomes more profitable. In the case of exports at a very high level, income in both Iowa and the rest of the country increases.

Lee and Stewart (56) in 1982 analyzed the relationships between landownership and the adoption of minimum tillage with a logit model. The results of the study indicate that adoption of minimum tillage was lowest among full-owner operators. Nationally, about 44 percent of full-owner operators adopted minimum tillage on cultivated cropland as opposed to 52 percent of part-owner operators and 51 percent of non-operator landlords. The latter do not operate any land, but rent their land to others. With respect to size of farm, the results of the study confirmed the hypothesis that small farm size may inhibit adoption of soil conservation practices on cropland. In addition, minimum tillage is more likely to be adopted on non-erosive land than on erosive land in some regions.

A study by the National Soil Erosion - Soil Productivity Research Planning Committee (72) in 1981 examined the soil erosion effects on soil productivity. A mathematical modeling approach was used to predict accumulated erosion, annual crop yields, nutrient losses, annual fertilizer application rates, offsite sediment deposition and energy requirements for tillage and maintenance. Accumulated erosion can be related to declining crop yields and the costs of soil loss can be determined through reduced yields, increased fertilizer and energy requirements, and downstream damages.

Regional and Watershed Studies

Several regional and watershed studies concern the impact on a region or a watershed of imposing pollution control policies. Lee et al. (55) in 1974 tried to determine the average soil loss and average income per acre resulting from seven crop rotations used in a watershed in Brown County in Illinois. Various tillage systems and conservation practices also were considered in the study. The study found that farmers could increase their present income by 41 percent and at the same time decrease soil loss from eight tons per acre to less than two tons per acre by using conservation practices.

In 1977, Taylor and Frohberg (103) examined the partial welfare effects of alternative erosion control methods, banning insecticides, banning herbicides, and limiting nitrogen fertilizer in the Corn Belt. The study used a linear programming model of the production and marketing of corn, soybeans, wheat, oats, hay, and pasture in the Corn Belt. This model incorporated stepped demand functions for corn and soybeans. Controls on soil erosion were also evaluated. The results of the study indicated that a soil loss tax ($4, $2, $1 and $0.50 per ton) was the least costly method for achieving soil loss reductions. The study also found that a per acre restriction (2, 3, 4 and 5 tons per acre) was only slightly more costly than a tax for achieving up to 50 percent reduction in soil erosion. A terrace subsidy policy was found to be less efficient than the other policies.

A 1978 study conducted by Swanson (100) was designed to provide information to the Illinois Pollution Control Board (IPCB) concerning soil erosion and water quality. Six watersheds were selected for this purpose. For each of the six watersheds, a twenty-year horizon was used. However, a 100-year planning horizon was examined in one watershed. The main objective of the study was to provide information on the erosion-sedimentation problem and compare the productivity loss and the sedimentation damage. The study used a relationship between depth of topsoil and yields to derive a cost of soil loss. The study concluded that the planning horizon is significant and the longer the horizon is, the more profitable the erosion control policies will be.

A 1981 study conducted by Burt (15) applied control theory to study the economics of soil conservation in the Palouse Area of the Northwest. The study used a dynamic programming model to maximize the present value of net returns from the land resource over an infinite planning horizon. The results of the study indicated that intensive wheat production with appropriate cultural and fertilization practices is economically justified in the long run, as well as for immediate net returns.

A 1981 study conducted by Shortle (94) examined the management problems arising as a consequence of cropland erosion. The study used a dynamic programming model of soil management in the Four Mile Creek

Watershed in Iowa. The results of the study indicated the importance of dynamic analysis in examining the issues in cropland erosion control. The study also found that there were some net social gains to be expected as a result of efficient erosion control strategies.

Hudson (43) in 1981 estimated the cost per acre of conventional versus no-tillage corn and soybeans in Tennessee. The estimated production costs of no-tillage corn and soybeans were about $17.00 per acre less than conventional tillage of corn and soybeans. Seed and chemical costs were higher for no-tillage compared to conventional tillage; however, lower labor, fuel and machinery costs for no-tillage more than offset the increased seed and chemical costs. Also, no-tillage corn and soybean yields were as high or higher than conventional tillage on well-drained soils. No-tillage corn yield averaged about seven percent higher than conventional tillage in that study.

Allen et al. (2) in 1977 discussed the conservation tillage systems and their impacts on energy use at Bushland and at other locations in the Great Plains, Midwest and East Central farming regions. Energy requirements and production costs in Kansas have been reported for selected tillage systems. Tillage costs for conventional, minimum tillage and no-till systems were $15.11, $15.90 and $13.40 per acre, respectively. These figures were based on 1974 prices. Minimum tillage and no-till reduced the energy requirements to 62 and 70 percent of conventional tillage.

Forster and Becker (28) in 1979 analyzed the net economic impacts of restrictions on soil loss, taxes on soil loss, and subsidies for reducing soil loss. Results of the linear programming study indicate that total net revenue of farmers in the Honey Creek watershed can be increased if soil loss reducing practices (e.g. minimum tillage and no-tillage) are adopted.

Choi (16) in 1979 found that about 37% of farmers considered labor savings to be the most important attribute of no-tillage. Only 19 percent considered erosion control the most important contribution of reduced tillage systems.

Hemmer and Forster (40) in 1979, analyzed farmer experiences with alternative tillage practices in the western Lake Erie Basin. Results of the study support the economic feasibility of reduced tillage systems. Both yields and net incomes were slightly higher for reduced tillage systems than for conventional tillage. However, the difference in net incomes and yields was not significant for most reduced tillage systems.

Forster and Stem (29) in 1979 tried to identify the rate of adoption of conservation practices, particularly reduced tillage practices, in the Lake Erie Basin. Also, factors which explain the adoption of reduced tillage and other conservation practices were examined. The results indicated that minimum tillage was used on about 21 percent of row crop acreage, whereas no-tillage was used on about 2 percent of the row crop acreage. Larger acreage farmers and better educated farmers tend to have high reduced tillage adoption rates.

Downs (21) discussed the Lo-till farming and Lo-till planters in Oklahoma. The study shows that minimum tillage results in reduced fuel consumption, less labor, fewer field operations and reduced field compaction. Moisture and soil conservation have been considered the most significant advantages of Lo-till practices. Results indicate that the overall cost of the Lo-till system was about the same as conventional systems.

Stiegler et al. (98) in 1982 discussed Lo-till farming in Oklahoma. It has been argued that with Lo-till, increased net returns should be possible through the effect of moisture and top soil conservation, reduced fuel consumption, less labor and the timeliness of farming operations. Also, the study showed that there were no yield penalties for no-till wheat compared to conventional tillage. By using two pounds of Surflan alone the yield of wheat was 30.6 bushels/acre. Two pounds of Surflan plus 3/4 pounds of Roundup increased the yield to 34.7 bushels/acre. As new chemicals and better ways of using them become available, reduced tillage systems become more favorable.

Naderman and Neumann (67) in 1981 examined the cost differences and erosion implications of no-till and conventional tillage. Cost estimates and comparisons between tillage systems were made for three cases with different locations. While estimated costs and fuel use per acre of chisel/disc were higher than those of no-till corn and soybeans in North Carolina in Cases A and B, the estimated costs and fuel use per acre of chisel/disc were lower than those of no-till corn and soybeans in Case C.

Logan and Adams (58) in 1981 examined the effects of conservation tillage (primarily no-till) versus conventional tillage on surface runoff, soil loss and phosphorus loss. The results of the study indicated that no-till reduces soil loss (> 90% reduction) compared to conventional plow systems. In addition, no-till increases run-off compared to conventional tillage on soil with poor drainage, while no-till decreases run-off on soils that are more permeable. Another finding of the study was that no-till reduced run-off of total particulate P by about 89 percent. No-till increased soluble P losses compared to conventional tillage.

Ervin (26) in 1982 analyzed perceptions, attitudes, and risk that relate to soil conservation practices. A general decision making model was used. The study found that personal variables were most important in determining the diversity of soil conservation practices. Education, perception of an erosion problem on the farm, risk aversion, and physical and economic factors also were important in explaining erosion rate variations.

Walker (115) in 1982 developed an erosion damage function to evaluate alternative tillage systems for controlling soil erosion. In addition to the long-run damage function, sensitivity analysis was used. Results of the study indicate that the model was highly sensitive to rate of discount and yield penalty with conservation tillage. The study showed that the adoption of conservation tillage ranged from year 62 with a two percent real private rate of discount to year 196 with an eight percent rate of discount. As expected, higher discount rates postponed the profitability of the conservation practice and resulted in greater soil depletion. Also, a lower yield penalty for the conservation practice reduced the current profit advantage of the conventional system and increased the future yield damage from conventional tillage erosion. Also, it has been found that conservation tillage does not pay on deeper soils. However, there is an incentive to increase conservation tillage as topsoil is lost through erosion and yields decline increases. Conservation tillage is more profitable in the long-run on steeper slopes where erosion and yield damage are greater.

Miranowski (63) in 1982 examined the overlooked variables in BMP implementation. The overlooked variables are risk attitudes, perceptions and human capital characteristics. A linear probability model of tillage choice was developed and used in this analysis. Results of the study indicate that farmers' risk attitudes are not homogenous and vary from risk averse to risk loving. Also, it has been found that economic characteristics of farmers may be important in best management practices (BMP) adoption and utilization. Human capital, scale, tenure and environmental factors seemed to affect the choice of tillage practice. Nowak and Wagener (75) in 1982 analyzed risk and social position in explaining the adoption of soil conservation practices. The study found that it is important to know an individual's risk orientation, but only when the individual's position within a community of reference is also known. In addition, an individual's rationality is not fixed and it varies by the stage of the adoption process and available information.

In 1974, Jacobs and Timmons (45) developed a linear programming model to estimate the costs to farmers of reducing soil and phosphorus losses. They also estimated the benefit of reduced soil losses to a municipal water supply and to recreational uses. This study was applied to the Nishnabotna River Basin in Southwestern Iowa. The results indicated that agricultural production practices can be effective in reducing soil and phosphorus losses only at substantial costs to farmers.

Nagadevara, Heady and Nicol (68) in 1975 used a cost-minimizing linear programming model to examine the impact of soil loss in Iowa. In addition, spatial variation in commodity requirements were taken into consideration. They concluded that production costs increased and income for Iowa farmers decreased as a result of policies aiming at controlling soil loss and pollution caused by agricultural production. The results confirm the findings of Heady and Vocke (39) and Nicol et al. (74).

A 1976 study conducted by Kasal (47) examined the trade-off between farm income and pollution control. A linear programming model was developed to maximize profits subject to resource and environmental constraints. Policies made to control pollution accounted for restrictions on soil loss, fertilizer, land use, and different combinations of these policies. The results indicated that farm income decreased as a result of imposing more restrictions on pollution control policies.

A 1977 study by Alt and Heady (3) examined the impacts of erosion restraints on crop production in the Iowa River Basin. The objective of the study was to evaluate several alternative policies aimed at reducing soil erosion and sedimentation in the Iowa River Basin area. The study used a linear programming model to simulate crop production in the Iowa River Basin. The objective function minimized the costs of crop production with respect to the environmental and other restraints specified in the model. The study results indicated that crop production costs would be increased if soil erosion control policies were imposed in the Iowa River Basin.

Other studies conducted by Taylor, Frohberg and Seitz (104) in 1977, by Taylor, Frohberg and Seitz (105) in 1978, and by Seitz, Osteen and Nelson (92) in 1978 in the Corn Belt also analyzed the economic impacts of soil erosion control policies using linear programming models. Osteen and Seitz (80) in 1978 estimated the spatial economic impacts of some alternative policies to control erosion and sedimentation. A linear programming model was used to investigate policies to control nonpoint sources of pollution. The model was applied to 17 Land Resource Areas. The objective function in the model was producers' and consumers' surpluses from the production of corn and soybeans minus the costs of production. This function was maximized subject to land restrictions and environmental controls. The results of the study indicated relatively small social costs as a result of soil loss restrictions. The price effects and costs of erosion controls caused relatively large decreases in expenditures to consumers. The study also found that economic incentives would encourage farmers to adopt conservation practices that reduce soil loss.

Taylor, Reneau and Harris (107) examined the economics of soil conservation using different pollution control policies. The 1978 study used planning horizons of 10, 100 and 200 years. In the study, the loss of crop productivity was related to loss of soil.

Marsh and Parvin (61) in 1979 calculated costs and returns of different cropping systems in the Delta area of Mississippi. The study examined the impact of Section 208, PL 92-500 and compared net returns with and without implementation of Section 208. The results of the study indicated that the implementation of Section 208 planning controls would have an adverse effect on farm income in the area.

A 1979 report by Seitz et al. (93) summarized the results of several studies whose objectives were to assess the economic impacts of soil erosion control policies in the Corn Belt. The analyses were carried out with several linear programming models of the production and marketing of corn, soybeans, wheat, oats, hay, and pasture in the Corn

Belt. A 100-year time horizon was selected for this purpose. The study indicated that improvements in soil erosion control can be achieved without severe impacts on the agricultural sector. However, the improvements would result in additional costs to society reflected in higher food prices. The study concluded that an effective policy to control soil losses prevents the loss of A-horizon soil within a 100-year period. Also, a reasonable soil erosion control policy would lead to an increase in land values and high costs to consumers. However, a more effective soil erosion control policy would be in the social interest.

A 1980 study conducted by Badger, Lawler and Mapp (5) presented and evaluated the farmers' attitudes on participation in water quality improving conservation practices and their impacts on their net farm incomes in the Little Washita River Watershed in Oklahoma. The study used a linear programming model to maximize total returns for the Little Washita River Watershed subject to resource and erosion control policies constraints. The results of the study indicated that farm income decreased as erosion control policies became restrictive.

Ogg and Heimlich (76) in 1980 examined how soil conservation plans can incorporate potential changes in market prices of crops. The Chowan-Pasquotank River Basin in eastern Virginia and North Carolina including 26 counties was selected for this study. A linear programming model was used to allocate land uses to soil groups with similar erosion and yield characteristics. The objective was to compare alternative profit maximizing soil conservation strategies. The study found that net returns and row crop acreage were reduced and acreages treated with soil conservation practices were increased as erosion constraints became more restrictive. Also, it was found in the study that flexible strategies based on market prices could continue to meet food needs and protect soil and water resources.

Bergland and Michalson (9) in 1981 estimated the cost of controlling soil erosion from cropland in the Cow Creek Watershed in Latah County, Idaho. A linear programming model was used to estimate the impact of adopting the soil erosion control program. The study found that the adoption of a soil conservation plan would decrease farm income in the Cow Creek Watershed.

Ervin and Washburn (27) in 1981 analyzed the profitability of soil conservation practices in Missouri. The study estimated the magnitude of private economic incentives for selected conservation practices on some common Missouri soils and analyzed the sensitivities of these incentives to different discount rates, planning periods, and cost-sharing levels. The study used a capital budgeting model to determine the profitabilities of selected cropping activities, including crop rotation, tillage systems and conservation practices. Net present values were calculated for cropping activities in Monroe County in Missouri. The results of the study indicated that the benefits of soil conservation practices resulted from increased crop yields over time. The costs included direct application costs, such as terrace construction charges, and the opportunity costs for crop rotations with lower returns.

Baron (7) in 1981 examined the landownership characteristics and investment in soil conservation practices in the Southern Plains, Delta, Corn Belt, and Northern Plains. Logit regression analyses of 1978 Resource Economic Survey data were used. The study concluded that landlords in the Southern Plains, Delta and Corn Belt Regions who are part-time operator or share-rent landlords invest more in conservation than full-time nonoperator cash-rent landlords.

In the Northern Plains Region there were no differences in soil conservation investments between operator and nonoperator landlords, or between share-rent landlords and cash-rent landlords. The study also found in all four regions that there was a positive correlation between investment in conservation and education levels and total acreage owned, but a negative correlation with age.

Taylor and Young (106) in 1982 examined the cost-sharing, price supports, and taxes which equated the discounted summed net income from conventional tillage and no-tillage for different planning horizons and interest rates. A break even analysis was developed and used in this study. The results of the study indicate that unless the three policies discussed are continued indefinitely (50 years or more), farmers would have an incentive to go back to heavy tillage as soon as the policy was discontinued.

Logan (57) in 1981 analyzed pesticide use in the Lake Erie Basin and the impact of accelerated conservation tillage on pesticide use and run-off losses. Results of the study indicate that a shift to more no-till and other conservation tillage systems meant increased use of paraquat and glyphosate, but, in general, pesticide usage will not change markedly with a shift to conservation tillage. Also, runoff losses of pesticides in the Lake Erie basin do not change markedly with a shift to conservation tillage.

In a 1977 study, Swanson and Taylor (102) analyzed the potential impact of increased energy costs on the location of crop production in the corn belt. A mathematical model and input costs for 1974 as a base were used in this analysis. The study found that generally soil losses decreased as a result of higher energy costs, as did the use of agricultural chemicals. In addition, it has been found that both consumers and producers were worse off as a result of the energy price increases. Consumer's surplus declined $971 million and producer's surplus declined $867 million or about $8 an acre.

Farm Studies

At the farm level, Olson (79) in 1977 examined restoring the productivity of a glacial till soil after topsoil removal. Three soil removal treatments and six fertility treatments on a Beadle silty clay loam were applied to determine the impact of topsoil loss on corn yields. The study found that removal of 30 to 45 centimeters (12 to 18 inches) of topsoil caused significant corn yield reduction, although high rates of nitrogen fertilizer and zinc offset the yield losses somewhat. Once the topsoil has been removed, the remaining soil must be treated to restore its full productivity. When topsoil cannot be replaced, a good fertility program must be undertaken.

Jones et al. (46) in 1969 analyzed the effects of conventional tillage, no-tillage, and mulch on soil water and plant growth. The results of the study indicated that the surface mulch conserves soil water, reduces the runoff, and increases grain yield by 1,932 kg/ha.

Triplett et al. (109) in 1968 examined the effect of corn stover mulch on no-tillage corn yield and water infiltration. Results from experiments of the study indicated that mulch is necessary to maintain no-tillage corn grain yields on Wooster silt loam. In addition, mulch increases soil moisture.

Epplin et al. (24) in 1982 examined the impacts of reduced tillage on operating inputs and machinery requirements. A simulation model to estimate field work days and an integer programming model to select least-cost machinery were used in the study. The results of the study indicate that the reduced tillage systems (experimental two-till, one-till, and zero-till) require 69 to 80 percent less machinery labor, 50 to 82 percent less tractor fuel, and 27 to 34 percent less machinery investment than the conventional (plow) system. However, these reduced tillage systems require more annual operating capital and more herbicides than the plow system. Total operating costs were four to 22 percent greater for the reduced tillage systems. But, they require 26 to 33 percent less machinery fixed costs than the plow system. The total operating plus machinery costs were estimated to be 2.6 percent less than that for the plow system. Zero-till system costs 12 percent more than the plow system. However, the zero-till can reduce the annual hours of equipment use to complete field operations substantially.

Langdale et al. (51) in 1979 showed that run-off was reduced 47 percent with no-tillage compared to conventional tillage and erosion was reduced 98 percent over a four year period.

Beale et al. (8) in 1955 showed that no-till corn in winter cover mulch averaged 3.11 inches less water run-off per year and 2.38 tons/acre less soil erosion per year. The study also found that yields were equal to or greater than those of the conventional unmulched corn. Because of the mulch cover, more water is available in the soil for plant use.

Handke (32) in 1982 evaluated reduced tillage wheat production systems as compared to conventional methods of producing wheat in Oklahoma. For this purpose, 22 wheat production systems were defined, ranging from conventional tillage (plow) to zero-tillage systems. An integer programming model was used in the analysis. The results of the study indicate that on a total cost basis, several reduced tillage systems are very competitive with conventional wheat tillage systems. Reduced tillage systems become more favorable as prices of fuel and labor increase.

Bhide et al. (10) in 1982 tried to analyze economically optimal levels of soil loss from an individual farmer's viewpoint and in a multi-period framework. The study found that a reduction in soil loss from the current levels in Iowa can be achieved without reducing the associated net returns. A control theory model was used to relate net returns per acre to the level of soil loss per acre and technological progress, change in net returns to the soil depth in A-horizon and technological progress, and soil loss to soil depth. The results of the study show that the soil loss levels under a multi-period framework are below the T-limit when the planning period is only one year. In addition, soil loss on more eroded soils are lower than on soils with higher soil depth. The study also found that when soil loss is restricted to the T-limit, the reductions in net returns decrease for more eroded soils.

A 1982 study by Rahm and Huffman (86) examined the effect of human capital investments on the adoption of reduced tillage practices by Iowa farm firms. A conceptual model was used. This model assesses the impact of human investments on the probability of adopting a single production technology. Probabilities from linear, logit and probit models were estimated. Results of the study indicate that investments in education and health increase the probability of adopting a reduced tillage practice. In addition, the soil type, cropping system and the scale of operation were the major determinants of the economic feasibility of a reduced tillage practice.

Rowell et al. (88) in 1977 examined the effects in a long-term trial of minimum and reduced cultivation on wheat yields. The experiment was continued for seven years and the results of the study indicate that herbicides can successfully substitute for mechanical weed control. The difference in yield was not significant. The results also indicate that neither minimum nor reduced cultivation increased the requirement for nitrogen fertilizer.

Wittmuss et al. (120) in 1975 examined the energy requirements for conventional versus minimum tillage. The study indicates that substantial fuel savings are possible nationally by using minimum tillage practices. It has been shown that use of minimum tillage practices can reduce the energy input for production of corn and sorghum as much as 83 percent.

Gebhardt (30) in 1981 tried to evaluate the effectiveness of combinations of herbicides applied preemergence and postemergence, with and without cultivation, for controlling weeds in soybeans. The study found that weeds were controlled best by using Alachlor and Linuron applied as preemergence, and glyphosate applied as postemergence, followed by one cultivation. The highest soybean yields were obtained when Alachlor and Linuron applied as preemergents were followed by cultivation, Bentazon applied postemergence, Bentazon applied postemergence and a cultivation, or Glyphosate applied postemergence and a cultivation. Results indicate that a cultivation in addition to the preemergence and postemergence treatments improved both weed control and soybean yield.

Erbach and Lovely (25) in 1975 examined the effect of plant residue on herbicide performance in no-tillage corn. Field and greenhouse experiments were used for this purpose. Results of the study indicate that plant residue did not significantly affect weed control when herbicides were applied at recommended rates but had an increased influence on control as herbicide rates were reduced.

Azlin and McWhorter (4) in 1981 examined the Johnson grass control in soybeans with Metriflufen applied postemergence. Results of the study indicate that excellent Johnson grass control was excellent following applications of Metriflufen at 1.7 and 2.2 kg/ha without soybean injury and with increased soybean yields.

Bandel et al. (6) in 1975 examined the N-behavior under no-till versus conventional corn farming. Results of the study indicate that the optimal level of applied N for grain dry matter yields did not differ with tillage method.

Harrold (34) in 1960 had a three year soil loss test of minimum tillage as compared to conventional tillage in Ohio. Results showed a total loss from a cornfield to be 8 tons per acre for conventional tillage versus a 1.23 ton per acre loss from the minimum tilled field.

Meyer et al. (62) in 1970 found that a mulch of only 1/4 ton per acre reduced soil erosion to about 30 percent of unmulched soil. Also, reduced tillage reduced erosion and maintained or increased yields on sloping soil.

Harrold et al. (33) in 1971 measured the sediment yield for conventional tillage versus no-tillage. The study found that a conventional field with good management practices yielded 6,430 pounds of sediment per acre, compared to a no-till field which yielded only 63 pounds per acre.

Schmidt and Triplett (91) in 1967 examined the soil loss with conventional tillage versus no-tillage from a cornfield. Results of the study showed 130 tons per acre of soil lost from conventional tillage as compared to only two tons per acre from no-tillage during one severe windstorm.

Schmidt and Kroetz (90) in 1969 found that soil losses for fall plowed, spring plowed and no-tilled fields were 2,605, 848 and 119 grams, respectively. Also, they found that no-tillage reduced wind erosion on sandy textured soils.

Blevens (11) in 1970 concluded that early planting of corn with no-tillage is not as critical as early planting under the conventional tillage system. If the planting is delayed, reduced yields will occur in conventional tillage, but not in the no-tillage system.

Swanson and Harshberger (101) in 1964 analyzed the economic effects of soil loss on crop yields on Swygert silt loam to silty clay loam in north-eastern Illinois. The present value of discounted net returns of cropping plans over 50 years was used. These returns were estimated by a budgeting procedure. The study concluded that soil conservation does not pay for the individual farmer. Another result was that a farmer on Swygert soils would sacrifice income if he wanted to maintain the T-limit level of soil losses.

Narayanan and Swanson (69) in 1972 examined the trade-offs between sedimentation and farm income. The study used a linear programming model to maximize farm income with respect to various sediment levels. The results of the study indicated that there was a trade-off between reduction in sedimentation levels and farm income, i.e., a decrease in sedimentation level would lead to a decrease in farm income.

Boggess et al. (12) in 1979 evaluated the impact of soil loss controls on individual farm firms. The study used a linear programming model to analyze two representative farms, a cash grain farm and a livestock farm. The model maximized after-tax cash income rather than net taxable income and compared the effects of direct regulations , taxes, and subsidies. The results of the study indicated that there was no unique policy to restrict soil loss and the effect of soil loss controls varied among soil types, farm enterprise organizations, and initial financial situations of the farms. The results also indicated that soil loss could be reduced to 5 tons or even to 2 tons per acre per year with only 10 to 15 percent reductions in net farm income after taxes.

Hurt and Reinschmied (44) in 1979 estimated the economic impact of non-point source pollution regulations on Mississippi agriculture. They evaluated the effect on net farm income that would result if soil loss limits were equal or less than the tolerance level in the study area. The results of the study indicated that the reduction of soil erosion to tolerance levels would have a severe economic impact on agriculture in Mississippi, i.e., reductions of soil erosion would lead to reductions in net income of between $22 and $67 per acre.

A 1980 study conducted by Mitchell, Brach and Swanson (64) examined the costs and benefits of terraces from erosion control to determine if terrace systems could be economically justified from the farmers' standpoint solely. This economic justification was investigated on several sloping soils in Illinois, taking into consideration soil productivity, management level, erosion potential, kind of topsoil, and terrace installation costs. The findings of the study were that most farmers would lose income if only the direct benefits were considered. Terracing increased income only in the case of using terrace system on highly erodible soils with unfavorable subsoils and the management level is high.

White and Partenheimer (117) in 1980 used a linear programming model to evaluate the effects of implementation of erosion control plans in Pennsylvania. They examined 12 dairy farms as case studies and concluded that net income would be reduced on 10 of the farms as a result of soil erosion control, especially in the short run. The analysis suggested a flexible approach to erosion and sedimentation control planning without adherence to absolute soil loss limits.

Eddings (22) in 1981 analyzed the economic impact of restricting soil erosion at the farm level in Southwestern Oklahoma using a linear programming model. A 40-year planning horizon was assumed. To examine the impacts of adopting conservation practices on annual production costs, enterprise budgeting was used. The study found that adopting soil conservation practices would increase annual production costs with one exception of the use of minimum tillage to produce grain sorghum in Grady County. Another finding of the study was that the impact of restricting soil erosion is not uniform, i.e., it varies from farm to farm.

Walker and Timmons (116) in 1980 evaluated alternative policies to reduce soil erosion and sediment discharge from agricultural land. The policies were: (1) a ban on fall plowing, (2) a soil loss tax of 10 cents to 20 cents per ton per acre per year, (3) a subsidy for minimum tillage, and (4) a dual ban on fall plowing and straight-row cultivation on slopes. A linear programming model was used in this analysis. Results of the study indicate that one group of erosion control policies was effective in reducing soil loss to an average of about 10 tons per acre. Another group of erosion control policies was effective in reducing soil loss to an average of about 2 tons per acre. In addition, the most cost-effective policy was the dual ban on fall plowing and straight-row cultivation on slopes. However, all erosion control policies resulted in an income penalty of 9.5 percent or less.

Triplett et al. (108) in 1973 found that continuous no-till corn growth on poorly drained soils has resulted in a yield reduction of 10-20 percent compared to continuous corn planted in fall-plowed soil.

Pope III et al. (85) in 1982 tried to examine the economics of soil and water conservation practices in Iowa. Linear programming models for 18 representative farms were used. The study explained the general methodology, documentation of the data collection and model building activities. The study has no results because a second volume for results is still under preparation.

Boggess et al. (13) in 1980 used a multiple goal analysis to examine the relationship between sediment damage and farm production costs. The results of the study quantify the trade-offs between production cost and sediment damage. The study indicated that on 940,000 acres, a reduction in sedimentation of approximately 850,000 tons could be achieved at modest costs, but to move beyond this point would result in rapidly increasing costs.

In a 1975 study, Moschler et al. (65) examined the residual fertility in soil continuously field cropped top corn by conventional tillage and no-tillage methods. Results of the study indicate that both methods had received the same amount of lime and fertilizer. More P and more N were recovered with no-tillage corn than with conventionally tilled soil. In addition, more Mg and less K were recovered from no-tillage soil than from conventionally tilled soil.

Hazel (37) in 1971 proposed the MOTAD (minimization of total absolute deviations from the mean) as a linear alternative to quadratic and semivariance programming for farm planning under uncertainty. This alternative (expected income-mean absolute deviation) was proposed because the quadractic programming must frequently be performed on time series or cross-sectional sample data. The MOTAD criterion leads to a linear model that can be solved by parametric linear programming yet retains many of desired features of dynamic programming and the income-variance criterion.

Brink et al. (14) in 1978 examined the trade-off between expected return and risk among Cornbelt farmers. An attempt was made to determine if risk consideration in the model helps predict actual farmer behavior in terms of crop acreage chosen or whether explicit risk-aversion should be included in an operational farm planning model. The decision criterion used measured risk as total negative deviation from an expectation. A MOTAD model was developed and used in the analysis. Risk-aversion coefficients were derived for thirty-eight farmers individually and as a group. The study concluded that risk aversion may play a smaller role in Cornbelt crop farming than in many other types of farming. This result indicated that risk-aversion was not, in general, an important factor in selecting crop acreage by farmers.

Adams (1) in 1949 found yield reductions of 34 to 40 percent for non-leguminous crops (cotton, corn and oats) and 22 percent for a legume crop (vetch) on Southern Piedmont soils where water had eroded the top 6 inches.

Olson in 1977, tried to determine the effects of topsoil loss on crop yields in the western Corn Belt. He applied three soil removal treatments and six fertility treatments on a Beadle silty clay loam. He found that removal of 12 to 18 inches of topsoil reduced corn yields significantly. However, the supply of high rates of N fertilizer and zinc decrease the yield losses somewhat (79).

The studies discussed have generally shown farmers may benefit from soil loss controls imposed and enforced at the national or regional level. The farm level studies show a wide variation in the effect of different levels of control of sediment and soil loss. Most of these studies do show that soil loss could be reduced substantially with very little effect on farm income. The effect, however, is not uniform.

CHAPTER III

METHODOLOGY

The Sample Survey

The data used to analyze the attitudes on adoption of reduced tillage technology by farmers in eastern Oklahoma were obtained by personal interviews conducted in the summer of 1982. The counties in the study area are in eastern Oklahoma: Craig, LeFlore, Okmulgee, Ottawa and Wagoner. After consultations with SCS personnel, county extension directors and farm management specialists in the area, survey forms were designed and pre-tested. A copy of the survey form is found in Appendix A.

The survey consisted of four parts: (1) general information about the operator and the farming operation; (2) information about reduced (minimum and no till) tillage; (3) summary on reduced tillage; and (4) information on inputs (seeds, fertilizer, herbicides and labor) for different crops. The sample of farmers to be interviewed was obtained with the help of county extension specialists and SCS personnel in the study area. Randomness of the sample was assumed to the extent that interviews were limited to those using or planning to use reduced tillage technology which promises the greatest chance of economic success in the study area.

A total of 55 farmers were interviewed in the five counties. The number of farmers interviewed and the average size of farm in each county are presented in Table I. Because these reduced tillage technologies, and especially no-till technologies, are new in Oklahoma, almost all farmers in the sample were using more than one tillage system. Often various tillage systems were tried because of the farmers' interest in comparing for themselves the results of several tillage systems on their farms.

Development of Representative Farms

Three representative farms were selected for the analysis from the five counties where the survey was conducted. It was decided that these three representative farms could adequately represent the different soils and cropping situations in eastern Oklahoma and still be manageable in terms of the constraints of this study. The selection of these three representative farms was based on characteristics such as soil type, slope steepness, slope length, land capability class, and the soil association. Based on these characteristics and on types of crops and cropping pattern, Representative Farm 1 was selected to represent Craig, Ottawa and Wagoner Counties. Similarly, Representative Farm 2 was selected to represent LeFlore County because of different soil characteristics and cropping pattern. For the same reason Representative Farm 3 was selected to represent Okmulgee County.

Soil Loss Data and Development of Two Soil Cases

Soil loss under a given management system was approximated by using the Universal Soil Loss Equation (USLE). The formulations of the

TABLE I

NUMBER OF FARMS INTERVIEWED AND SIZE OF FARMS IN THE REDUCED TILLAGE TECHNOLOGY STUDY, BY COUNTY[a], 1982

COUNTY	FARMERS INTERVIEWED	SMALLEST	LARGEST	AVERAGE
		ACRES		
Craig	19	170	4,000	1,292[b]
LeFlore	9	658	2,500	1,504
Okmulgee	8	660	2,300	1,589
Ottawa	9	340	2,400	1,061
Wagoner	10	750	6,000	1,671[c]

[a] The size of farm includes the acres owned, the acres rented in and operated by the farmer, and the acres rented out to others to operate.

[b] Average includes two farms of 3,000 and 4,000 acres. Excluding these farms, the largest farm is 1,917 acres and the average is 1,032 acres.

[c] Average includes one farm of 6,000 acres. Excluding this farm, the largest farm is 2,000 acres and the average is 1,190 acres.

equation and the estimation procedure of soil loss coefficients are presented in Chapter V. Two cases were used for each of the three representative farms: (1) an unrestricted soil erosion case and (2) a restricted soil erosion case related to SCS recommended T-values or soil loss limits. These T-values are determined by the soil types.

In this study three models were developed and used: (1) a linear programming (LP) model, (2) a multiple regression model, and (3) a MOTAD model which incorporates the risk factors into a linear programming (LP) model.

Linear Programming Model

A linear programming (LP) model was built for each of the three representative farms. Three components of a linear programming model are: an objective function; the restrictions which typically take the form of limited amounts of resources; and, a large number of alternative combinations of these resources in production processes. A linear programming problem maximizes or minimizes an objective function subject to certain constraints. Since this study deals with a maximization problem, a linear programming model may be written in a general form as:

$$\text{maximize } Z = C_1X_1 + C_2X_2 + \ldots + C_nX_n \tag{1}$$

subject to the input-output relationships and the resource levels:

$$\begin{aligned} a_{11}X_1 + a_{12}X_2 + \ldots + a_{1n}X_n &\leq b_1 \\ a_{21}X_1 + a_{22}X_2 + \ldots + a_{2n}X_n &\leq b_2 \\ \vdots \qquad \vdots \qquad &\vdots \\ a_{m1}X_1 + a_{m2}X_2 + \ldots + a_{mn}X_n &\leq b_m \end{aligned} \tag{2}$$

$$X_1 \geq 0,\ X_2 \geq 0,\ \ldots,\ X_n \geq 0 \tag{2.1}$$

In the case of restricted soil erosion, the following restriction should be added:

Soil loss S_i, $A_{i1}X_1 + A_{i2}X_2 + \ldots + A_{ij}X_j \leq B_i$ (2.2)

In a compact form the problem can be rewritten as:

$$\text{maximize } Z = \sum_{j=1}^{n} C_j X_j \tag{1a}$$

$$\sum_{j=1}^{n} a_{ij} X_j \leq b_i \tag{2a}$$

$$X_j \geq 0 \text{ for all } j \tag{2.1a}$$

$$\sum_{j=1}^{n} A_{ij} X_j \leq B_i \tag{2.2a}$$

where $i = 1, 2, \ldots, m$; and $j = 1, 2, \ldots, n$

Z = the objective function,

C_j = per unit prices, net incomes, or costs of associated activities (the objective function values for each of the n activities or the net income and/or costs of the associated activities),

X_j = the possible alternative activities or the level of activities,

a_{ij} = the requirements of resource i per unit of activity j, and

b_i = denotes the resource availabilities of the m resources (activity restrictions).

S_i is the soil series, A_{ij}'s are the soil loss coefficients for soil series i used in production of j, and B_i is the SCS recommended soil loss limit (tons per acre per year) for the acres of the soil series under study.

For a large number of restrictive resources and many alternative enterprises, linear programming provides a more precise and more efficient solution than budgeting techniques. In this analysis, the IBM MPSX linear programming package has been used to solve the LP model.

Data needed to solve the linear programming model are discussed in the next chapter. Those include the alternative enterprises, the net returns or costs associated with each enterprise, the input-output coefficients for each enterprise considered, and the amount or level of each resource restriction.

The alternative crop enterprise activities include wheat, soybeans, grain sorghum and wheat-soybeans double-cropped. Also, improved pasture and cow-calf operations for improved pasture are included. Production costs for each enterprise are discussed in the next chapter. The cj values were calculated as follows:

$$C_j = P_j Q_j - K_j \tag{3}$$

where Cj is as previously defined, Pj is the price per unit of output j, Qj is the quantity of j produced and Kj are the production costs of producing j. The 1982 product prices used are presented in Table II. The initial crop yields are presented in the next chapter. The crop yields decrease over time due to soil erosion which has an adverse effect on soil productivity, assuming no advances in technology to offset the loss in soil productivity. Reductions in yields for different crops and tillage systems are discussed in Chapter V.

The resource requirements were estimated and are presented in the next chapter. Soil erosion coefficients were calculated using the Universal Soil Loss Equation (ULSE) and are discussed in Chapter V.

The amount of land available by soil series for each representative farm, labor, and capital are presented in Chapter IV. To examine the long-run impact of soil erosion on the farm income, a time period of 40

TABLE II

PRICES USED FOR CALCULATING C_j VALUES IN THE LP MODELS FOR THE THREE REPRESENTATIVE FARMS[a]

PRODUCT	PRICE
Wheat	$ 4.00 per bushel
Soybeans	$ 5.75 per bushel
Grain Sorghum	$2.44 per bushel
Steer	$87.00 per cwt.
Heifer	$77.00 per cwt.
Cull Cow	$55.00 per cwt.
Aged Bull	$58.00 per cwt.
Hay	$50.00 per AUM

[a]Prices were those used by the OSU Enterprise Budget Generator adjusted by those received by interviewed farmers during 1982.

years was used for this study. A time period of 40 years was used to represent a generation or lifetime of the farmer. Age of 20 or 25 years was thought to be the time when a farmer starts farming and the age of 60 or 65 years to be the time when a farmer quits farming and the farm is handed down to one of his children. Two cases have been discussed for each representative farm: the unrestricted soil erosion case and the restricted soil erosion case.

Linear programming Tableaus for the representative farms are presented in Appendix B. The abbreviations used in the linear programming Tableaus for the three representative farms are presented in Appendix C.

Assumptions

A linear programming problem arises because the number of constraints (equations) is not equal to the number of variables and because there are inequalities in the constraints.

Assumptions of a linear programming problem are:

1. Additivity of resources and activities. This assumption means that the sum of resources used by different activities must equal the total quantity of resources used by each activity for all the resources, individually and collectively (no interaction among the activities of the resources).

2. Linearity of the objective function. This assumption implies that the output response to a proportionate increase of all inputs is constant.

3. Nonnegativity of the decision variables. In economics, we usually deal with positive activities and decision variables.

4. Divisibility of activities and resources. This assumption means that the use of inputs and the production of outputs could be achieved in fractional quantities or units. This assumption implies continuity of resources and output, and the use of factors in fractional units such as .74 acres of land, .95 hours of labor, or 66.5 bushels of wheat.

5. Finiteness of the activities and resource restrictions. An infinite number of alternative activities and resource restrictions cannot be programmed or an optimal solution achieved.

6. Proportionality of activity levels to resources. This assumption implies linear relationships between activities and resources. Doubling the output would simply require doubling the inputs or resources.

7. Single-valued expectations. this assumption means that resource supplies, input-output coefficients and prices of resources and activities are known with certainty.

Limitations

Linear programming allows one to test a wide range of alternative adjustments and to analyze their consequences cheap and fast with a small input of managerial time. However, it is unable to estimate input-output relationships. Programming can only specify the type and quantity of data needed. The planner must supply estimates of the amount and distribution of inputs to produce output. Estimates of this type are difficult to make, especially on farms where record keeping has been neglected. Another limitation of linear programming is that it cannot help the planner or manager in formulating price expectations.

The process can only indicate the best way to use resources once a judgment has been made as to future prices.

Also, programming does not take into account the risk preferences of the farm operator. It assumes that the price and input-output expectations that have been formulated are equally reliable for all farm products. This implies that all enterprises are treated as though they were equally without risk.

Another consideration is that restrictions are sometimes difficult to specify. It is certainly very difficult to know how much labor or capital will be available during the coming season. Linear programming assumes that each additional unit of output requires the same quantity of input. This conflicts with diminishing marginal returns in farm production. For example, the amount of crop output per unit of fertilizer declines as more fertilizer is used per acre. Finally, activities that involve decreasing costs cannot be treated adequately with linear programming models because of the assumption of linear production coefficients.

Multiple Regression Model

To examine and explain the adoption of reduced tillage technology as a soil conservation practice, a multiple regression model was used. A multiple regression model can be written in a general form as follows:

$$Y_t = \beta_1 + \beta_2 X_{t2} + \beta_3 X_{t3} + \ldots + \beta_k X_{tk} + U_t \qquad (4)$$

where Y denotes the dependent variable, the X's denote the explanatory variables, and u is a stochastic disturbance. The subscript t refers to the t^{th} observation; the second subscript used in describing the explanatory variables identifies the variable in equation. The number of the explanatory variables is K-1, so that for K = 2 equation (4) reduces to a simple regression equation. An alternative way of writing (4) is

$$Y_t = \beta_1 X_{t1} + \beta_2 X_{t2} + \ldots + \beta_k X_{tk} + U_t \qquad (4a)$$

where $X_{t1} = 1$ for all t = 1, 2, . . ., n. Writing X_{t1} for 1 as the multiplication factor of β_1 makes the regression equation look symmetric without bringing about any real change. Similarly, a second multiple regression equation was used to test the relationship between soil conservation practices other than reduced tillage technology and certain socio-economic factors such as tillage acres, age and education. The regression equation can be written in a general form as follows:

$$C_t = a_1 + a_2 D_{t2} + a_3 D_{t3} + \ldots + a_k D_{t4} + \varepsilon_t \qquad (5)$$

or,

$$C_t = a_1 D_{t1} + a_1 D_{t2} + \ldots + a_k D_{tk} + \varepsilon_t \qquad (5a)$$

Adoption of reduced tillage technology has occurred on 42 percent of the acres cropped according to survey participants. Obviously, labor and fuel cost reductions, soil loss reductions, moisture saving and timeliness associated with reduced tillage technology are important considerations in adopting this technology. Hence, the potential net returns from reduced tillage technology were expected to partially explain reduced tillage adoption.

Also, the number of acres cropped were thought to be an important factor in reduced tillage adoption. Those with larger row crop acres tend to favor reduced tillage technology since labor efficiency is improved during the critical planting period. Tenure of the farm operator was thought to be another partial explanation for adoption of reduced tillage technology. Landlords might be more hesitant to have a relatively new technology employed on their farms. Furthermore, tenants might not be as concerned with soil conservation as owner operators. Also, some personal characteristics of the farmer were thought to be important factors. Age, education, experience in farm management and in reduced tillage technology and health status were expected to influence adoption rates. These relationships were tested statistically. For this purpose, the following multiple regression model was specified and used:

$$Y = \beta_o X_{ot} + \beta_1 X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} + \beta_4 X_{4t} + \beta_5 X_{5t} + \beta_6 X_{6t} + \beta_7 X_{7t} + \beta_8 X_{8t} + \beta_9 X_{9t} + \beta_{10} X10t \qquad (6)$$

where: $\beta_o X_{ot}$ = the intercept term,

Y = the farmer's cropped acreage on which reduced tillage technology was used in 1982,

X_1 = the number of cropped acres,

X_2 = the farmer's years of farm management experience,

X_3 = the farmer's years of experience in reduced tillage technology,

X_4 = the farmer's years of education,

X_5 = the farmer's years of age,

X_6 = the tillable acres being rented in,

X_7 = a dummy variable which has a value of one (1) if the farmer's health was good or excellent, or it has a value of zero (0) if it was fair or poor,

X_8 = a dummy variable which has a value of one (1) if the farmer used OSU extension services sometimes or frequently, or equal to zero (0) if never or seldom,

X_9 = a dummy variable which has a value of one (1) if the farmer used SCS services sometimes or frequently, or equal to zero (0) if never or seldom,

X_{10} = the soil type expressed in average land price in 1982.

Other soil conservation practices, such as terraces, grassed waterways, and cover establishments are widely used in eastern Oklahoma. Most farmers use one or more of these practices to control soil erosion. It was hypothesized that the number of soil conservation practices used by a farmer is a function of the number of tillable acres on the farm, the type of soils on the farm, and the age, education, and the farmer's experience in farm management. To test this relationship, the following multiple regression model was specified and used:

$$C = a_o D_{ot} + a_1 D_{1t} + a_2 D_{2t} + a_3 D_{3t} + a_4 D_{4t} + a_5 D_{5t} \quad (7)$$

where:

$\alpha_o D_{ot}$ = the intercept term

C = the number of soil conservation practices on the farm,

D_1 = the number of tillage acres (acres operated),

D_2 = the farmer's years in farm management experience,

D_3 = the farmer's years of age,

D_4 = the farmer's years of education, and

D_5 = the soil type(s) on the farm or the land value in U.S. dollars in 1982.

Assumptions

Assumptions for the classical multiple linear regression model are:

1. The disturbance term (ut) is normally distributed.

2. The expected value of each disturbance is zero: Eut = o for t = 1....T, where t is observation number and T is the total number of observations on the independent variables and the dependent variables.

3. The disturbances have a common variance and are not correlated with one another: $EU^2_t = \delta^2$, and $EU_tU_s = 0$

4. The explanatory variables are uncorrelated with the disturbances: $EX'U = 0$

5. The independent variables are fixed in repeated samples: X is non-stochastic.

6. No exact linear relation exists among the independent variables. This assumption states that none of the explanatory variables is perfectly correlated with any other explanatory variable or with any linear combination of other explanatory variables.

7. The number of observations (T) exceeds the number of coefficients (K) to be estimated.

Limitations

Given the assumptions discussed earlier, it can be shown that the least squares estimates of the regression parameters have all the desirable properties. However, when any one of the basic assumptions is violated, the properties of the least squares estimators are affected. If the assumption that the disturbance (Ut) is normally distributed is dropped, the least squares estimators of the regression coefficients are still BLUE (Best Least Unbiased Estimator), but they can no longer be claimed to be efficient. Also, the least squares estimators are no longer maximum likelihood estimators since the likelihood function, based on the assumptions of normality, no longer applies.

The second assumption, i.e., the expected value of each disturbance is zero, is made in accordance with the specification that the regression line is:

$$E(Y_t) = \alpha + \beta_{xt} \qquad (8)$$

If the expected value of the disturbance is not zero but, say, λ, then:

$$E(Y_t) = \alpha + \beta_{xt} + \lambda t \quad (9)$$

The implications of this depend on the nature of λt. One must distinguish between the case where λt has the same value for all observations and the case where λt may vary. In the first case $\lambda t = \lambda$, and the regression line is

$$E(Y_t) = \alpha + \lambda + \beta_{xt} \quad (10)$$

or

$$E(Y_t) = \alpha^* + \beta_{xt} \quad (11)$$

While the least squares estimator of β is unaffected, the least squares formula for estimating the intercept gives an estimation of α^* and not of α. There is no way to estimate α and λ separately and get unbiased or at least consistent estimates. In the second case where λt is not a constant, the intercept becomes $(\alpha + \lambda t)$; that is, the relationship between Xt and Yt has not been correctly specified.

When the assumption of homoskedasticity does not hold, the least squares estimators of the regression coefficients are not BLUE. This means that the least squares estimators do not have the smallest variance in a class of unbiased estimators, and, therefore, that they are not efficient. To use these estimators for testing hypotheses or constructing confidence intervals, requires not only that the estimators themselves be unbiased, but also that their estimated variances by unbiased. Otherwise, the tests are invalid and the constructed confidence intervals incorrect.

If the non-autoregression assumption - $E(UtUs) = o$ $(t=s)$ - is not violated; that is, when the disturbances are autoregressive, the least squares estimators of the regression coefficients are unbiased and consistent, but they are not efficient or asymptotically efficient. Thus, in using the least squares formulas when the disturbances are autoregressive, the resulting estimators will still have some desirable properties. However, to use these estimators for testing hypotheses or constructing confidence intervals, requires unbiasness not only of the estimators themselves, but also of their estimated variances.

In the case of violating the fifth assumption discussed earlier, X is nonstochastic and values of X are fixed in repeated samples - the desirable properties of least squares estimators are not changed if X is independent of the disturbance (Ut).

If the sixth assumptions - no exact linear relation exists among the independent variables - is violated, there is a multicollinearity problem. A high degree of multicollinearity is harmful in the sense that the estimates of the regression coefficients are highly imprecise. The imprecision arises because of the large variances of the least squares estimators.

MOTAD Model

Increasingly, risk considerations are necessary in whole-farm-planning models. In the search for operational methods of tackling the whole-farm planning problem, linear programming has been very popular. The farm planning problem is to determine the optimal farm plans.

In linear programming, it is assumed that the input-output coefficients (aij), the resource constraints (bi), and the per unit net revenue of the j^{th} activity (cj) are all known constants - an assumption that is fully justified when all the planning coefficients are known for certain. If this assumption is relaxed, i.e., if risk and uncertainty are to be introduced in whole-farm planning, then linear programming is an inappropriate technique and its usefulness is limited. The limitations or deficiencies of the linear programming model can be overcome to some extent by various extensions of the technique.

There are different approaches that take explicit account of risk in mathematical programming formulations of the whole-farm planning problem. Examples of these are quadratic risk programming, simulation models, the MOTAD model, and incorporation of game theory criteria into a linear programming formulation. The higher costs and the computational complexities of quadratic risk programming favor the use of the MOTAD model. MOTAD is minimization of total absolute deviations.

Hazell (37) developed a model, referred to as MOTAD, which minimizes total absolute deviation rather than variance. In using the MOTAD model there is no need for a nonlinear programming algorithm, an advantage which MOTAD has over the quadratic programming model.

In this study, risk is measured in terms of negative deviation from an expectation. This MOTAD model was used to address an enterprise choice problem involving high-level, medium-level, and low-level technology. These enterprise alternatives differ substantially in average net return and income variability. The MOTAD approach was found useful for handling such risk in an explicit manner. The efficiency frontiers and accompanying farm plans permit a farm decision maker to evaluate the trade-offs between return and risk.

To introduce risk and uncertainty in whole-farm planning, a MOTAD model was developed and used in this study. Mathematically, the MOTAD model can be written as follows:

$$\text{Minimize} \quad L\bar{y} \qquad (12)$$

$$\text{subject to } AX \leq B, \qquad (13)$$

$$DX + I\bar{y} \geq o, \qquad (14)$$

$$C'X = \lambda, \qquad (15)$$

and

$$X, \bar{Y}, \lambda \geq o \qquad (16)$$

where X, A, B and C represent activity levels, resource uses, resource availabilities and expected net returns (gross margins expectations), respectively. D is a deviation matrix representing the difference between the net return observed and the expected net return in a particular year. The vector, $\bar{y}$, represents yearly total negative deviations summed over all risky activities. The elements of $\bar{y}$ are summed over t years by L, a row vector of ones, to give a measure of summed total negative deviation over all years. An t X t identity matrix is shown as I. The risk aversion coefficient, λ, is used to show the expected income constraint level. $L\bar{y}$ is transformed into an estimate of standard deviation by multiplication by the constant K. Brink and McCarl (14) calculated K as follows:

$$K = \frac{2}{t}\sqrt{\frac{t \cdot \pi}{2(t-1)}} \qquad (17)$$

where t = number of years in the series

π = 3.1429 (a mathematical constant)

$$\text{Mean Absolute Deviation} = \text{MAD} = \frac{2}{t} \cdot L\bar{y} \qquad (18)$$

$$\text{Standard Deviation} = K \, . \, L\bar{y} \qquad (19)$$

The MOTAD model minimizes the summed total negative deviation over all years, subject to technical constraints. This sum is transformed into an estimate of standard deviation by multiplication by the constant K.

Assumptions

The linear programming assumptions 1-6 discussed earlier, still hold for the MOTAD model. However, the seventh assumption which states that the input-output coefficients (aij), the resource constraints (bi), and the per unit net revenue of the j^{th} activity (cj) are all known constraints, is relaxed for the MOTAD model. The MOTAD model incorporates risk and uncertainty in the whole-farm planning.

Tableaus

The MOTAD model initial tableau in a general form is presented in Table III. Initial tableaus for conventional tillage, minimum tillage, and no-tillage are presented in Appendix D.

Limitations

Compared to conventional linear programming which is used extensively in farm planning analyses, the MOTAD model has been useful and successful because it accommodates risk and uncertainty in farm planning analyses. In spite of that, it is not without limitations.

Historical yield and price data are needed for the MOTAD model to capture the risk associated with the alternative enterprises. These data must be carefully inventoried. Also, the similarity among alternative enterprises must be carefully evaluated.

The decision criteria used in the analysis measures risk as total negative deviation from an expectation. The arbitrariness with which such risk measures have to be postulated raises questions about how farmers perceive risk and what measure of risk is appropriate in this

TABLE III

INITIAL TABLEAU FOR THE MOTAD MODEL (GENERAL FORM)

RESOURCE RESTRICTIONS	DECISION VARIABLES X_1	X_2	X_3	. . .	X_n	y_1	y_2	y_3	. . .	y_t	CONSTRAINTS
OBJECTIVE FUNCTION						1	1	1	. . .	1	MINIMIZE
Resource 1	a_{11}	a_{12}	a_{13}	. . .	a_{1n}						$\leq B_1$
Resource 2	a_{21}	a_{22}	a_{23}	. . .	a_{2n}						$\leq B_2$
Resource 3	a_{31}	a_{32}	a_{33}	. . .	a_{3n}						$\leq B_3$
⋮	⋮	⋮	⋮	⋮							⋮
Resource m	a_{m1}	a_{m2}	a_{m3}	. . .	a_{mn}						$\leq B_m$
Year 1	D_{11}	D_{12}	D_{13}	. . .	D_{1n}	1					≥ 0
Year 2	D_{21}	D_{22}	D_{23}	. . .	D_{2n}		1				≥ 0
Year 3	D_{31}	D_{32}	D_{33}	. . .	D_{3n}			1			≥ 0
⋮	⋮	⋮	⋮	⋮					⋱		⋮
Year t	D_{t1}	D_{t2}	D_{t3}	. . .	D_{tn}					1	≥ 0
Income	C_1	C_2	C_3	. . .	C_n						$= \lambda$

type of farm planning application. Also the question arises as to whether risk is adequately measured by deviation from expectations and how are expectations formed. The mean of the series of gross margins is often used as the expectation. Because of the relatively long series of gross margins, the mean appeared to be an unrealistic measure of farmer expectation. Thus, an unweighted three-year moving average was used in this analysis as the gross margin expectation. Gross margin here is crop price times yield minus variable costs of production.

How to choose the appropriate weights of the three-year moving average is another limitation of the MOTAD model. A three-year moving average was used with weights of 0.5 for the most recent year and 0.3 and 0.2 for the two previous years. Moreover, the choice of the appropriate length of the historical series of yields and prices data is not easy.

The 1958-1982 crop yields and average prices received for all Okmulgee County farmers for three crops (wheat, soybeans and grain sorghum) were used over a period long enough to include changes in cropping practices, weather variations, etc.

Each decision maker or each farmer can then choose a farm enterprise plan and return-risk situation which is consistent with his risk preference and goals.

Development of Yield Scenarios for the LP Model

Three yield scenarios were used for the analysis of the LP model. The yield scenarios are : (1) yields of minimum and no-tillage systems and conventional tillage were the same; (2) yields of minimum and no-tillage systems were three bushels/acre/year less than those of conventional tillage; and (3) yields of minimum and no-tillage systems were three bushels/acre/year more than those of conventional tillage.

A planning horizon of 40 years and a discount rate of four percent were used in the LP analysis. Also, two cases were used for each of the three representative farms: (1) an unrestricted soil erosion case and (2) a restricted soil erosion case to the SCS recommended levels depending on the different soil types involved in the study.

Development of Two Yield Scenarios for MOTAD Model

Based on review of literature on reduced tillage versus conventional tillage, several studies show reduced tillage yields are less while other studies show that reduced tillage yields are higher than conventional tillage. Therefore, it was decided that a range of six bushels/acre/year would be representative of the yield differences for reduced tillage versus conventional tillage in the risk analysis. Two scenarios for the yield differences were used: (1) yields of minimum and no-tillage systems were three bushels/acre/year less than those of conventional tillage; and (2) yields of minimum and no-tillage systems were three bushels/acre/year more than those of conventional tillage.

CHAPTER IV

SURVEY RESULTS AND DEVELOPMENT OF BUDGETS

Reduced Tillage Technology Survey Results in Eastern Oklahoma

Characteristics of those interviewed are shown in Table IV. On the average, farmers in the survey are about 44 years of age, have completed high school, have been farming most of their lives, and have been using reduced tillage technology in the last three years. They farm an average of nearly 1,405 tillage acres, of which about 41 percent is owned and the remaining 59 percent is rented in from others. The average acres cropped were about 853. Total acres operated and cropped are shown in Table V. Eighteen percent of the total acres cropped are double-cropped. As far as the type of farm organization is concerned, 24 percent of the interviewed farmers have a partnership with family members, 45 percent are sole proprietors, 27 percent have a family ownership, and only four percent are family corporations (Table VI). In addition, 95 percent of the farmers in the survey are part-owner operators and only five percent are cash rent or crop-share rent operators. Ninety-one percent of those interviewed considered themselves as full-time farmers and the remaining nine percent as part-time farmers (Table VII).

Most of the farmers interviewed (82 percent) had 100 percent of family incomes from the farm. The type of operation for almost all

TABLE IV

CHARACTERISTICS OF FARMERS INTERVIEWED IN THE REDUCED TILLAGE TECHNOLOGY SURVEY, 1982

	CHARACTERISTIC	MEAN	STANDARD DEVIATION
1.	Age (yrs)	44	9.4
2.	Education (yrs)	13	2.7
3.	Experience (yrs)		
	in farm management	24	9.6
	in reduced tillage technology	3.3	3.2
4.	Years associated with operating or owning this farm	17	7.8
5.	owned and operated	413	384.8
	A. Acre owned and operated		
	B. Acres rented in and operated		
	cash lease	340	422.6
	share lease	645	814.8
	other	6	44.5
	C. Acres owned and rented out to others		
	cash lease	1	5.9
	share lease	0.1	0.7
	other	0.0	0.0
	TOTAL ACRES (A+B-C) =	1,405	965.0
6.	Acres Cropped	853	834.0

TABLE V

TOTAL ACRES OPERATED AND CROPPED FOR REDUCED TILLAGE TECHNOLOGY SURVEY, BY COUNTY, 1982

COUNTY	ACRES OPERATED				TOTAL ACRES CROPPED
	OWNED +	RENTED IN -	RENTED OUT =	TOTAL	
Craig	8,544	15,995	5	24,544	11,825
LeFlore	4,923	8,637	20	13,540	8,820
Okmulgee	2,317	10,503	0	12,820	5,990
Ottawa	3,909	5,641	0	9,550	6,835
Wagoner	3,015	13,695	39	16,671	13,471
Total	22,718	54,471	64	77,125	46,941

TABLE VI

TYPE OF FARM ORGANIZATION FOR REDUCED TILLAGE TECHNOLOGY SURVEY BY COUNTY, 1982

County	PARTNERSHIP WITH FAMILY MEMBERS		SOLE PROPRIETOR		FAMILY OWNERSHIP		FAMILY CORPORATION		TOTAL	
	No.	%	No.	%	No.	%	No.	%	No.	%
Craig	4	7.3	9	16.0	5	9.0	1	2.0	19	34.0
LeFlore	4	7.3	4	7.3	1	1.8	0	0.0	9	17.0
Okmulgee	0	0.0	3	5.4	5	9.0	0	0.0	8	14.0
Ottawa	2	4.0	4	7.3	3	5.4	0	0.0	9	17.0
Wagoner	3	5.4	5	9.0	1	1.8	1	2.0	10	18.0
Total	13	24.0	25	45.0	15	27.0	2	4.0	55	100.0

TABLE VII

TYPE OF TENANCY CONDITIONS FOR REDUCED TILLAGE TECHNOLOGY SURVEY, BY COUNTY, 1982

COUNTY	CASH AND CROP SHARE RENT OPERATOR		PART-OWNER OPERATOR		TOTAL		PART-TIME FARMER		FULL-TIME* FARMER	
	No.	%	No.	%	No.	%	No.	%	No.	%
Craig	0	0.0	19	35.0	19	35.0	2	3.6	17	31.0
LeFlore	0	0.0	9	16.0	9	16.0	1	1.8	8	14.5
Okmulgee	1	2.0	7	13.0	8	15.0	1	1.8	7	13.0
Ottawa	0	0.0	9	16.0	9	16.0	1	1.8	8	14.5
Wagoner	2	3.0	8	15.0	10	18.0	0	0.0	10	18.0
Total	3	5.0	52	95.0	55	100.0	5	9.0	50	91.0

*Full-time farmer refers to a farmer who works 200 days or more each year.

farms interviewed was beef cattle, pasture and some crops, particularly wheat, soybeans and grain sorghum. Peanuts were found only in Okmulgee County and spinach only in LeFlore County. Ninety percent of the interviewed farms were involved in beef cattle with an average size of 180 head per farm. Thirty-nine percent of the total acres operated were in pasture. Of the total acres cropped, there were 45, 39 and eight percent in soybeans, wheat, and grain sorghum, respectively.

Different crop rotations were used by farmers. Based on the personal interviews and the different areas in this study, the following crop rotations were identified:

W	(continuous wheat)
BWA	soybeans (one year) - wheat (one year) - alfalfa (4-5years)
WWBB$\overline{BW}$B	wheat-wheat-soybeans-soybeans-soybeans-soybeans-and wheat double-cropped
WBWC	wheat-soybeans-wheat-corn
BGBP$\overline{G}$B	soybeans-grain sorghum-soybeans-peanuts-grain sorghum soybeans double-cropped
WBPGP	wheat-soybeans-peanuts-grain sorghum-peanuts
GW	grain sorghum-wheat
WPWB	wheat-peanuts-wheat-soybeans
WPWG	wheat-peanuts-wheat-grain sorghum
WBWG	wheat-soybeans wheat-grain sorghum
PCWB	peanuts-corn-wheat-soybeans
GBWB	grain sorghum-soybeans-wheat-soybeans
GWB	grain sorghum-wheat-soybeans
CCCBBB	corn-corn-corn-soybeans-soybeans-soybeans
GBO	grain sorghum-soybeans-oats
RWGW	greens-wheat-grain sorghum-wheat
WRWSRH	wheat-greens-wheat-peas-greens-spinach
ABWHS	alfalfa (4-5 years)-soybeans-wheat-spinach-peas
T	permanent pasture

where:
W = wheat
B = soybeans
C = corn
G = grain sorghum
P = peanuts
O = oats
R = greens

A = alfalfa
S = peas
H = spinach
T = permanent pasture
$\overline{WB}$ = double cropping of soybeans after wheat
$\overline{GB}$ = double cropping of soybeans after grain sorghum.

Respondents were asked about capital expenditures during the last three years (1980-1982) for soil and water conservation practices, other than reduced tillage technology, used on farmland that they owned and/or rented. More than half of the respondents use terraces, grass waterways and cover establishments as soil conservation practices and also have participated in an ACP cost-sharing program with a federal cost-sharing rate of 50 to 75 percent.

An average value per acre of cropland (without mineral rights) of $1,038 was given by the interviewed farmers in the survey. To answer the question, "What should Oklahoma State University (OSU) and the Soil Conservation Service (SCS) be doing in the area of reduced tillage technology", farmers' responses were as follows: OSU should be doing education, demonstrations and field days. Also, showing good results on reduced tillage technology and the economics of it was seen by farmers as part of OSU's responsibilities. More information on spraying equipment and chemicals and their application for good weed control were listed as what OSU should be doing to help farmers adopt reduced tillage technology. In addition, farmers needed information on seeding rate and depth, checking different types of soils and new adaptive seeds.

In the area of reduced tillage technology, farmers felt that SCS, in addition to their technical and economic services on other soil conservation practices (terraces, grass waterways, cover establishment), should have cost-sharing programs on herbicides and equipment and an educational program also. Such a cost-sharing program was started in October 1982 in two counties in Oklahoma, namely Craig and Caddo Counties with a cost-sharing rate of 50 percent. Another thing farmers thought that SCS should be doing was to lease reduced tillage drilling equipment to farmers for reasonable prices.

About 40 percent of the respondents had capital expenditures during the last three years (1980-82) for reduced tillage technology. Over 90 percent of those farmers preferred to buy no-till planters, rather than no-till drills. Conventional tillage was being used on 58 percent of the respondents' crop acreage in the study area, of which 28, 26, and four percent was for moldboard plow, chisel plow, and other (e.g., disk), respectively. Reduced tillage was being employed on 42 percent of the acres cropped, with minimum-tillage being the predominant form of reduced tillage system (Table VIII).

Interviewed farmers' reasons for adopting reduced tillage technology agree with the concept that reduced tillage technology is labor and fuel cost reducing and soil conserving. Farmers' rankings of reasons for adopting reduced tillage technology were: (1) reduces labor cost; (2) reduces fuel cost; (3) reduces soil erosion; (4 and 5) timeliness and conserves moisture, with the same ranking; (6) conserves future soil productivity; (7) reduces equipment cost; and, (8) increases yield (Table IX). Those who have not adopted reduced tillage technology identified weed control problems, type of soil not conducive to reduced tillage technology, and higher equipment costs as being the most important reasons for non-adoption of reduced tillage technology.

Fifty-six percent of the interviewed farmers considered June 1 to June 14 as good time to harvest wheat if they plan to double crop with

TABLE VIII

ADOPTION RATES OF ALTERNATIVE TILLAGE SYSTEMS FOR REDUCED TILLAGE TECHNOLOGY SURVEY, 1982

PRACTICE[a]	PROPORTION OF ACRES CROPPED	PERCENT OF ACRES DOUBLE-CROPPED
Conventional tillage		
moldboard plow	28	5
chisel plow	26	3
other	4	1
Sub total	58	9
Reduced Tillage		
minimum-till	40	8
no-till	2	1
Sub total	42	9
Total	100	18

[a] Conventional tillage refers to traditional moldboard plow, chisel plow and other (e.g. disk plow). Minimum tillage does not use the moldboard plow, leaves residue on the surface of the soil and uses more chemicals and less tillage operations than conventional tillage. With no-tillage, weed control is accomplished completely with chemicals and without tilling the soil. Reduced tillage refers to either minimum tillage or no-tillage or both.

TABLE IX

REASONS FOR ADOPTING REDUCED TILLAGE TECHNOLOGY IN EASTERN OKLAHOMA, 1982

REASONS	MEAN (Scale: 1 to 5 where 5 is strongly agree = SA and 1 is strongly disagree = SD)
1. Reduces labor cost	4.33
2. Reduces fuel cost	4.31
3. Reduces soil erosion	4.29
4. Farming operation done faster (timeliness)	4.22
5. Conserves moisture	4.22
6. Conserves future soil productivity	4.07
7. Reduces equipment cost	3.65
8. Increases yield	2.89

soybeans. Thirty-eight percent of them chose June 15 to June 30 to be a good time and only six percent decided for July 1 to July 15. Sixty percent of the farmers agreed with the notion that conventional tillage causes soil loss, but 91 percent of them disagreed with the notion that farming with conventional tillage has a negative impact on the sale value of their farms.

In general, there was no problem with wind erosion in eastern Oklahoma. However, there was a general consensus among interviewed farmers that reduced tillage technology helps reduce soil loss from water (run-off).

Secondary Data

Secondary data also were used in this analysis. Budgets developed by the Agricultural Economics Department at Oklahoma State University were used. Cost and returns estimates for all farm enterprises for the conventional tillage systems were adopted from those budgets. Publications by the Soil Conservation Service in Stillwater were also used to compute the soil erosion coefficients using the Universal Soil Loss Equation (USLE) (96). Published Soil Surveys of the five counties in the study area, namely, Craig, LeFlore, Okmulgee, Ottawa and Wagoner also were used. Those soil surveys contain information on soil types, yield data by soil types, slope, and land capability. In addition, agricultural statistics compiled by the Oklahoma Crop and Livestock Reporting Service also were used in this analysis (77).

Secondary data also were collected for one of the three Representative Farms (Okmulgee County) to represent the farm situation in Eastern Oklahoma as a whole. These data were needed to measure the variations in net returns of the different technology levels or tillage systems discussed in this study and their impact on risk-efficient farm plans in a MOTAD framework. Okmulgee County (Representative Farm 3) was selected for the risk analysis because of the higher proportion of cropped acres used in reduced tillage technology.

Time series data for the time period from 1958-1982 on crop yields per acre and the Oklahoma season prices were obtained from Oklahoma Agricultural Statistics (77). These data were needed to compute net returns for crops. Net returns were obtained by taking, for instance, price of a crop times yield minus total variable costs of production. The OSU 1982 crop budgets for Eastcentral Oklahoma was used to extrapolate total variable costs (TVC) for different activities back to 1958. For the derivation of total variable costs the Index of Prices Paid by farmers was used.

Historic yields per acre and net returns for the different crops and tillage systems in Okmulgee County (Eastcentral Oklahoma) for the time period from 1958-1982 are presented in Tables X-XV, respectively. The farm situation in Eastcentral Oklahoma for the risk analysis deals only with four cropping activities, namely wheat, soybeans, grain sorghum, and wheat-soybeans double-cropped, because budgets are available only for these crops and for all three tillage systems. Out of 1,200 acres of the Representative Farm 3, only 594 acres of land was used for the MOTAD analysis because of the use of one type of soil only. The total hours of annual labor available are 1,168 of which 372 hours are available from January-March, 256 hours in April-June, 391 hours in July-September, and 149 hours in October-December. Additional labor can be hired at $4.00 an hour. Annual capital of $19,685 and intermediate

TABLE X

HISTORIC CROP YIELDS PER ACRE FOR OKMULGEE COUNTY
EASTCENTRAL OKLAHOMA, 1958-1982

YEAR	WHEAT (bu/acre)	SOYBEANS (bu/acre)	GRAIN SORGHUM (bu/acre)
1958	19.8	22.5	24.0
1959	18.6	18.0	30.0
1960	24.7	20.0	31.3
1961	25.2	19.5	26.1
1962	22.4	16.7	20.0
1963	22.4	9.6	24.2
1964	24.7	14.9	17.6
1965	23.8	12.8	30.1
1966	20.3	16.8	28.1
1967	23.3	20.6	37.4
1968	22.3	18.7	32.9
1969	24.0	13.2	21.5
1970	24.0	19.8	32.9
1971	25.0	24.0	26.8
1972	26.7	18.1	21.6
1973	25.0	23.6	34.5
1974	17.0	21.4	24.3
1975	18.5	21.8	45.6
1976	34.0	20.4	45.7
1977	37.2	19.5	31.0
1978	28.8	12.4	37.5
1979	37.2	22.0	49.0
1980	33.7	10.0	17.8
1981	38.1	24.9	45.5
1982	38.4	28.0	49.3

Source: Oklahoma Agricultural Statistics, Oklahoma Crop and Livestock Reporting Service, Oklahoma City, Oklahoma, 1958-1982.

TABLE XI

NET RETURNS FOR DIFFERENT CROPS USING CONVENTIONAL TILLAGE IN OKMULGEE COUNTY, EASTCENTRAL OKLAHOMA, 1958-1982 .

YEAR	WHEAT ($/acre)	SOYBEANS ($/acre)	GRAIN SORGHUM ($/acre)	WHEAT-SOYBEANS Double-Cropped ($/Acre)
1958	13.87	20.62	3.72	31.0
1959	12.91	15.07	8.70	24.0
1960	22.37	16.64	4.04	35.0
1961	24.43	24.63	4.84	45.0
1962	24.45	15.73	-2.00	36.0
1963	21.07	1.04	3.17	19.0
1964	14.33	14.23	-2.29	24.0
1965	10.57	11.52	9.91	17.0
1966	10.95	26.95	8.47	34.0
1967	11.42	33.27	15.90	40.0
1968	5.05	24.16	9.57	25.0
1969	5.75	9.59	0.30	11.0
1970	6.56	30.68	15.15	32.0
1971	9.82	47.51	3.48	43.0
1972	17.76	50.12	3.54	62.0
1973	55.62	93.39	47.77	142.0
1974	29.92	102.44	33.93	124.0
1975	21.90	57.02	69.26	70.0
1976	50.52	89.48	49.60	131.0
1977	40.72	60.72	13.83	92.0
1978	37.83	31.44	29.88	59.0
1979	88.77	75.57	60.58	153.0
1980	66.18	13.22	-7.57	66.0
1981	79.47	77.63	40.29	144.0
1982	83.70	101.12	52.28	171.0

TABLE XII

NET RETURNS FOR DIFFERENT CROPS USING MINIMUM TILLAGE IN OKMULGEE COUNTY, EASTCENTRAL OKLAHOMA, BASED ON LOWER YIELDS THAN CONVENTIONAL TILLAGE, 1958-1982[a]

YEAR	WHEAT ($/acre)	SOYBEANS ($/acre)	GRAIN SORGHUM ($/acre)	WHEAT-SOYBEANS Double-Cropped ($/Acre)
1958	8.90	14.10	-0.37	18.70
1959	7.73	8.25	4.73	11.69
1960	17.40	10.11	0.64	23.26
1961	19.30	16.79	0.87	31.46
1962	18.61	8.59	-5.00	22.01
1963	15.66	-7.15	-0.95	3.46
1964	10.25	5.97	-6.65	11.30
1965	6.78	2.79	5.73	4.55
1966	6.28	17.02	4.11	17.84
1967	7.32	24.34	11.78	26.49
1968	1.61	15.62	5.60	12.29
1969	2.38	0.99	-4.09	-1.63
1970	2.99	21.03	9.58	18.59
1971	5.91	37.54	-0.82	36.99
1972	13.03	35.87	-1.84	40.93
1973	45.39	75.39	39.66	111.40
1974	17.95	81.23	23.05	88.05
1975	12.17	41.47	59.94	44.20
1976	42.77	68.23	41.39	98.96
1977	34.38	42.28	6.04	65.27
1978	29.40	9.69	21.49	26.51
1979	77.81	55.10	51.32	119.92
1980	55.53	-11.62	-20.08	28.62
1981	68.82	56.83	30.15	112.27
1982	72.64	79.68	41.88	137.92

[a]Assuming that yields of minimum tillage system were 3 bushels/acre/year less than those of conventional tillage.

TABLE XIII

NET RETURNS FOR DIFFERENT CROPS USING NO-TILLAGE IN OKMULGEE COUNTY, EASTCENTRAL OKLAHOMA, BASED ON LOWER YIELDS THAN CONVENTIONAL TILLAGE, 1958-1982[a]

YEAR	WHEAT ($/acre)	SOYBEANS ($/acre)	GRAIN SORGHUM ($/acre)	WHEAT-SOYBEANS Double-Cropped ($/Acre)
1958	5.74	12.10	-0.37	16.70
1959	4.55	6.25	4.73	9.69
1960	14.23	8.11	0.64	21.26
1961	16.12	14.79	0.87	29.46
1962	15.38	6.59	-6.00	20.01
1963	12.39	-8.15	-0.95	1.46
1964	6.94	3.97	-6.65	9.30
1965	3.47	0.79	5.73	2.55
1966	2.82	15.02	4.11	15.84
1967	3.85	22.34	11.78	24.49
1968	-1.86	13.62	5.60	10.29
1969	-1.24	-1.01	-5.09	-4.63
1970	-0.75	19.03	9.58	15.59
1971	1.98	35.51	-2.18	34.99
1972	8.83	33.87	-2.84	38.93
1973	40.32	73.39	38.66	108.40
1974	12.19	78.23	22.05	84.05
1975	5.85	38.47	58.94	40.20
1976	36.08	64.23	41.39	93.96
1977	27.45	39.28	5.04	61.27
1978	21.88	5.69	20.49	21.51
1979	69.19	51.10	50.32	113.92
1980	45.97	-16.62	-20.08	22.62
1981	58.60	51.83	29.15	105.27
1982	62.01	74.21	40.66	130.44

[a]Assuming that the yields of no-tillage system were 3 bushels/acre/year less than those of conventional tillage.

TABLE XIV

NET RETURNS FOR DIFFERENT CROPS USING MINIMUM TILLAGE IN OKMULGEE COUNTY, EASTCENTRAL OKLAHOMA, BASED ON HIGHER YIELDS THAN CONVENTIONAL TILLAGE, 1958-1982[a]

YEAR	WHEAT ($/acre)	SOYBEANS ($/acre)	GRAIN SORGHUM ($/acre)	WHEAT-SOYBEANS Double-Cropped ($/Acre)
1958	19.40	24.90	5.81	40.00
1959	18.65	19.95	10.67	34.31
1960	27.90	21.09	5.44	44.74
1961	30.10	30.53	6.81	56.00
1962	30.85	21.55	1.00	47.21
1963	27.06	6.35	5.29	28.36
1964	19.01	20.07	0.07	34.16
1965	14.94	17.97	12.09	27.89
1966	16.24	34.42	10.83	45.20
1967	16.14	40.48	18.02	51.45
1968	9.11	30.38	11.54	34.55
1969	9.76	13.24	2.69	18.00
1970	10.79	37.47	16.72	42.83
1971	14.43	54.94	5.78	62.91
1972	23.23	61.25	6.92	76.51
1973	66.75	107.25	53.88	164.62
1974	41.65	120.11	40.81	150.63
1975	32.75	68.11	74.58	91.420
1976	59.45	106.93	53.81	154.34
1977	48.30	74.38	17.62	111.29
1978	47.58	47.79	34.27	82.79
1979	101.27	90.50	65.84	179.08
1980	78.51	32.42	-1.06	95.64
1981	91.92	91.03	44.43	169.57
1982	96.64	115.68	56.88	197.92

[a]Assuming that the yields of minimum tillage system were three bushels/acre/year more than those of conventional tillage.

TABLE XV

NET RETURNS FOR DIFFERENT CROPS USING NO-TILLAGE IN OKMULGEE COUNTY, EASTCENTRAL OKLAHOMA, BASED ON HIGHER YIELDS THAN CONVENTIONAL TILLAGE, 1958-1982[a]

YEAR	WHEAT ($/acre)	SOYBEANS ($/acre)	GRAIN SORGHUM ($/acre)	WHEAT-SOYBEANS Double-Cropped ($/Acre)
1958	16.24	22.90	5.81	38.00
1959	15.47	17.95	10.67	32.31
1960	24.73	19.09	5.44	42.74
1961	26.92	28.53	6.81	54.00
1962	27.62	19.55	1.00	45.21
1963	23.79	5.35	5.29	26.16
1964	15.70	18.07	0.07	32.16
1965	11.63	15.97	12.09	25.89
1966	12.78	32.42	10.83	43.20
1967	12.67	38.48	18.02	49.45
1968	5.64	28.38	11.54	32.55
1969	6.14	11.24	1.69	15.00
1970	7.05	35.47	16.72	39.83
1971	10.50	52.91	4.78	60.91
1972	19.03	59.91	4.78	60.91
1973	61.68	105.25	52.88	161.62
1974	35.89	117.11	39.81	146.63
1975	26.43	65.11	73.58	87.42
1976	52.76	102.93	53.81	149.34
1977	41.37	71.38	16.62	107.29
1978	40.06	43.79	33.27	77.79
1979	92.65	86.50	64.84	173.08
1980	68.95	27.42	-1.06	89.64
1981	81.70	86.03	43.43	162.57
1982	86.01	110.21	55.66	190.44

[a]Assuming that the yields of no-tillage system were three bushels/acre/year more than those of conventional tillage.

capital of $62,000 are available. Additional capital can be borrowed at 16.0 percent annually.

Enterprise Budgets

Cost and returns estimates for different crops, livestock, or any other farm enterprise are presented in budgets. The enterprise budget is a tool for measuring costs and returns for each unit of a given enterprise. These budgets, which are statements of expected revenues from and expenses incurred in the production of a crop or livestock enterprise, provide information on the input-output coefficients. They may not provide all the information needed. However, they have been found useful in farm planning and analysis. Budgets for three Representative Farms for different crops and livestock in Eastern Oklahoma have been developed. Budgets for conventional tillage have been developed by the Agricultural Economics Department at Oklahoma State University.

Budgets for minimum tillage and no-tillage were developed with the help of farmers' personal interviews, OSU agronomists, area farm management and agronomy extension specialists and OSU agricultural economists. Production costs for the Representative Farms are shown in Appendix E. The following crops were considered in this study: pasture, wheat, soybeans and grain sorghum.

Representative Farms

It is difficult to find a farm that can be viewed as typical or representative of a given area. However, the three Representative Farms developed in Chapter III represent the situation fairly well because of the similarities of soils and farming practices in the area. The farm descriptions of the three Representative Farms are summarized in Tables XVI-XVIII. Number of acres of by soil series and expected crop yields of the three Representative Farms are presented in Tables XIX-XXI.

TABLE XVI

DESCRIPTION OF THE REPRESENTATIVE FARM 1
FOR NORTHEASTERN OKLAHOMA

Principal Soil Association: Dennis-Parsons-Taloka
Verdigris-Radley-Lightning

Location: Welch
County: Craig
Farm Size: Acres operated: 1,500
Acres cropped: 900
Pasture land: 600
Beef cattle: 100 mother cows,
90 calves,
3 bulls
Hours of Labor Available: 2,400
Annual Capital: $50,000
Intermediate Capital: $200,000

SOIL TYPE NAME	SLOPE STEEPNESS (%)	SLOPE LENGTH (FEET)	CAPABILITY CLASS	ACRES OF OPERATED FARM LAND	% OF OPERATED FARM ACRES
Dennis silt loam (DSL)	2	200	I-1	150	10.0
Parsons silt loma (PSL)	3	300	I+IIIe	150	10.0
Taloka silt loam (TSL)	2	100	IIw	150	10.0
Osage silt clay loam (OSCL)	2	300	II+IIIe	450	30.0
Verdigris silty clay loam (VSCL)	4	300	VIs	600	40.0
TOTAL				1,500	100.0

TABLE XVII

DESCRIPTION OF THE REPRESENTATIVE FARM 2
FOR SOUTHEASTERN OKLAHOMA

Principal Soil Association: Oklared
Miller-Lonoke
Pope-Atkins

Location: Braden
County: LeFlore
Farm Size: Acres operated: 658
Acres cropped: 555
Pasture land: 103[a]
Hours of Labor Available: 1,800
Annual Capital: $40,000
Intermediate Capital: $200,000

SOIL TYPE NAME	SLOPE STEEPNESS (%)	SLOPE LENGTH (FEET)	CAPABILITY CLASS	ACRES OF OPERATED FARM LAND	% OF OPERATED FARM ACRES
Oklared fine sandy loam (OF)	2	300	I+IIw	110	17.0
Miller clay (MC)	1	400	I+IIw	155	23.0
Lonoke silty clay loam (LS)	2	300	I+IIIe	140	21.0
Pope very fine sandy loam (PV)	2	200	I+IIIw	150	23.0
Atkins silt loam (AS)	3	300	I+IVw	103	16.0
TOTAL				658	100.0

[a] Sells hay from pasture land.

TABLE XVIII

DESCRIPTION OF THE REPRESENTATIVE FARM 3 FOR EASTCENTRAL OKLAHOMA

Principal Soil Association: Bates-Parsons
Taloka
Okemah-Woodson

Location: Okmulgee
County: Okmulgee
Farm Size: Acres operated: 2,000
Acres cropped: 1,200
Pasture land: 800
Beef cattle: 150 cows, 140 calves, 6 bulls
Hours of Labor Available: 5,500
Annual Capital: $125,000
Intermediate Capital: $350,000

SOIL TYPE NAME	SLOPE STEEPNESS (%)	SLOPE LENGTH (FEET)	CAPABILITY CLASS	ACRES OF OPERATED FARM LAND	% OF OPERATED FARM ACRES
Okemah silt loam (OKA)	1	300	I-1	160	8.0
Okemah silt loam (OKB)	2	250	I-1	290	14.0
Taloka silt loam (TKA)	2	400	I+IIe	614	31.0
Bates loam (BAB)	3	250	IIIw	136	7.0
Bates loam (BAC)	4	150	IIIw	800	40.0
TOTAL				2,000	100.0

TABLE XIX

NUMBER OF ACRES BY SOIL SERIES AND EXPECTED CROP YIELDS FOR THE REPRESENTATIVE FARM 1[a]

SOIL SERIES	ACRES	WHEAT (bu)	SOYBEANS (bu)	GRAIN SORGHUM (bu)	BERMUDA (AUM)
		------------YIELD PER ACRE------------			
Dennis silt loam (DSL)	150	30	23	54	7.0
Parsons silt loam (PSL)	150	33	24	50	5.5
Taloka silt loam (TSL)	150	34	25	58	6.0
Osage silt clay loam (OSCL)	450	25	22	47	6.0
Verdigris silty clay loam (VSCL)	600	-	-	-	8.0

[a]Yield estimates are from the Soil Survey of Craig County, Oklahoma (73).

TABLE XX

NUMBER OF ACRES BY SOIL SERIES AND EXPECTED CROP YIELDS FOR THE REPRESENTATIVE FARM 2[a]

SOIL SERIES	ACRES	WHEAT (bu)	SOYBEANS (bu)	GRAIN SORGHUM (bu)	BERMUDA (AUM)
		----------- YIELD PER ACRE			-----------
Oklared fine sandy loam (OF)	65	34	25	58	7.0
Miller clay (MC)	155	28	21	50	7.0
Lonoke silty clay loam (LS)	140	33	24	52	7.0
Pope very fine sandy loam (PV)	195	32	23	56	7.0
Atkins silt loam (AS)	103	25	19	48	5.0

[a]Yield estimates were not available in the Soil Survey of LeFlore County, Oklahoma. They were obtained by consultations with farmers.

TABLE XXI

NUMBER OF ACRES BY SOIL SERIES AND EXPECTED CROP YIELDS FOR THE REPRESENTATIVE FARM 3[a]

SOIL SERIES	ACRES	WHEAT (bu)	SOYBEANS (bu)	GRAIN SORGHUM (bu)	BERMUDA (AUM)
		YIELD PER ACRE			
Okemah silt loam (OKA)	136	32	24	50	7.5
Okemah silt loam (OKB)	290	28	22	46	7.0
Taloka silt loam (TKA)	614	32	22	47	6.0
Bates Loam (BAB)	160	27	20	42	7.0
Bates loam (BAC)	800	24	16	37	6.5

[a]Yield estimates are from the <u>Soil Survey of Okmulgee County, Oklahoma</u> (97).

CHAPTER V

IMPACT OF SOIL EROSION ON CROP YIELDS

Farmers are under intense pressure to produce more food and fiber for domestic consumption and export. At the same time, the agricultural production capacity of the soil is affected negatively because of continuing damage from soil erosion, pollution, flooding, conversion of farmland to other uses, and shortages of water.

Undoubtedly, soil erosion affects crop production by reducing nutrient supply, water infiltration, and soil water-holding capacity. However, the effects of soil erosion on crop yield is not easily estimated. The loss of soil productivity expressed in terms of per unit crop yield because of soil erosion is included among numerous variables on which the crop yields depend. Examples are the climatic conditions, management practices, diseases, insects, hail, crop varieties, and rotations, planting data, type and dates of tillage, rainfall amounts and distribution, slope, fertilizer rates, and soil texture. It is very difficult to separate or isolate the effects of soil erosion on crop yields from those of the other variables mentioned above. Furthermore, improved technology often masks the reduction in productivity or the per unit crop yield. Although some eroded soils respond well to heavy fertilizer application and low crop yields can partially be compensated, production costs would increase.

Soil erosion reduces crop yields by: (1) loss of plant-available soil water capacity; (2) contributing to plant-nutrient losses; (3) degrading soil structure, and (4) non-uniform removal of soil within a field (72).

Several studies in the United States between 1935 and 1950 documented a trend of reducing crop yields through soil erosion. These studies indicated that as a result of the loss of topsoil the supply of N and P was drastically reduced and crop yields declined. Crop yields on severely eroded soil were reduced 20 to 50 percent where the depths of the topsoil were less than 30 cm (1, 17, 35, 53, 66, 95, 118).

Research has been done to examine the impacts of 95 soil factors on corn yield using multiple regression analysis in 17 Iowa counties. The researcher found that plant-available water-holding capacity of the soil was highly correlated with corn yields and soil erosion had a negative impact on yields (41).

Because of increasing crop yields caused by new technologies during the past 30 years in the United States, the declining soil productivity due to soil erosion is very difficult to detect. In other words, technology advancements have masked soil productivity to soil erosion.

According to Langdale and Shrader, only two research methods have been used to measure the effects of soil erosion on soil productivity during the past 30 years. The first method is the cut and fill method and the second approach is multiple regression analyses applied to random samples to measure the effects of soil erosion on crop yields. The researchers characterized these two approaches as being less than desirable to measure adequately the effects of soil erosion on crop yields (52).

Crop yields estimates associated with various levels of soil erosion in southeastern and midwestern United States are shown in Tables XXII and XXIII. It has been shown that soybean yields were improved with minimum tillage on Southern Piedmont soils (50). Also, no-tillage reduced soil erosion and in some cases improves crop yields on lands that are highly erodible (51, 82).

In Missouri, the 10-year average corn yield on a desurfaced plot of Shelby silt loam was 47 percent of that on a control plot (95). The 10-year average cotton yield on a desurfaced plot of sandy clay soil in East Texas was 32 percent of that on a control plot (84). Field trials in some parts of the States showed that grain yields on severely eroded soils were about 65 to 75 percent of those on slightly eroded land (36). Winter wheat-fallow rotations were tested on Palouse soils with a 30 percent slope and the wheat yield on desurfaced plots was found to be 40 percent of that on control plots (42). Several studies have related crop yields to soil thickness. Estimates of yield reductions were made and they were .2 bushel per acre for corn and .1 bushel per acre for wheat, soybeans, grain sorghum, and oats (59, 60, 83).

Although numerous studies have been conducted to examine the relationship between soil erosion and productivity, the relationship is not adequately developed yet. Additional research with a combination of field experiments and mathematical models is needed to permit the prediction of accumulated soil erosion, nutrient losses, and annual crop yields, that can be related to soil erosion mathematically. Research of this type requires field experiments and data for many years. The necessary components (erosion-sedimentation, nutrient cycling, tillage, crop growth, etc.) should be included and linked to the appropriate

TABLE XXII

CROP YIELDS ESTIMATES ASSOCIATED WITH VARIOUS LEVELS OF SOIL EROSION IN SOUTHEASTERN UNITED STATES

DEGREE OF EROSION	CROP YIELD CORN	SOYBEANS	COTTON	SMALL GRAINS	FORAGE
	q/ha[a]				
	Memphis silt loam (Typic Hapludalfs), 2-5% slope				
None	69	27	9.52	36	76
Eroded	65	24	9.24	35	76
Severe	60	22	8.40	32	72
	Grenada silt loam (Glossic Fragiudalfs), 0-5% slope				
None	60	27	8.40	36	72
Eroded	53	20	7.84	31	67
Severe	44	16	6.72	27	60
	Brandon silt loam (Typic Hapludults), 2-12% slope				
None	50	20	7.28	33	65
Eroded	44	13	6.72	32	60
Severe	28	11	4.76	26	49
	Cecil sandy clay (Typic Hapludults), 2-10% slope				
Deposition (Local alluvium)	62	--	--	--	--
Eroded	58	21 to 31	13.89	24	174
Severe	19	15 to 24	8.66	16	137

[a]Quintals/hectare.
1 quintal = 220.46 pounds (1 metric ton = 2,204.6 pounds)
1 hectare = 2.471 acres

Source: Langdale, G. W. and W. D. Schrader, "Soil Erosion Effects on Soil Productivity of Cultivated Cropland," In Determinants of Soil Loss Tolerance, American Society of Agronomy, Madison, Wisconsin, 1981.

TABLE XXIII

CROP YIELDS ESTIMATES ASSOCIATED WITH VARIOUS LEVELS OF SOIL EROSION IN MIDWESTERN UNITED STATES

DEGREE OF EROSION	CROP YIELD			
	CORN	SOYBEANS	SMALL GRAINS	FORAGE
	q/ha[a]			
	Seymour silt loam (Aquic Argiudolls), 2.5-6.0% slope			
None	--	--	--	--
Slight	52	22	16	78
Moderate	43	17	13	63
	Marshall clay loam (Typic Hapludoll), 2.5-6.0% slope			
None	--	--	--	--
Slight	67	28	22	90
Moderate	62	26	20	63
	Monoma silt loam (Typic Hapludoll), 2.5-6.0% slope			
None	--	--	--	--
Slight	62	25	25	83
Moderate	56	23	23	76
	Ida silt loam (Typic Udorthents), 6.0-9.0% slope			
None	--	--	--	--
Slight	52	22	21	69
Moderate	43	17	17	58

[a]Quintals/hectare.
1 quintal = 220.46 pounds (1 metric ton = 2,204.6 pounds)
1 hectare = 2.471 acres

Source: Langdale, G. W. and W. D. Schrader, "Soil Erosion Effects on Soil Productivity of Cultivated Cropland," In Determinants of Soil Loss Tolerance, American Society of Agronomy, Madison, Wisconsin, 1981.

mathematical model to examine the soil-erosion-crop yield relationship. A considerable effort has been made by Hagen and Dyke to examine such a relationship at the national level (31).

Since soil erosion depletes soil productivity, the relationship between erosion and productivity should be well defined. Accurate estimates of future soil productivity are essential to make agricultural policy decisions, and to select land use plans and management strategies to maximize the long-run crop production. Poor policy decisions can easily lead to serious soil damage and consequently to a reduction in productivity. In addition, poor policy decisions can lead to under use of soil resources, loss of incomes to the producers, and a smaller supply of food and fiber to the consumers. Field experiments needed to examine the relationship between soil erosion and crop yields are costly and time consuming. For this reason and because of other constraints, the only feasible approach to be used in this analysis is to use the Universal Soil Loss Equation (USLE) in determining the annual soil loss that can be related to crop yields.

Estimating Soil Loss Coefficients for Different Types of Soils

The Universal Soil Loss Equation (USLE) is:

$$A = R \cdot K \cdot L \cdot S \cdot C \cdot P \qquad (20)$$

where A is the predicted average annual soil loss expressed in tons per acre. R is the rainfall-erosion factor. K is a soil erodibility factor, expressed in tons per acre per unit of rainfall-erosion index. L is a length of slope factor; S is a steepness of slope factor. C is a cropping management factor which takes into account the effects of crops, crop sequences, and various management practices. P is a factor for mechanical and structural erosion control practices.

For example, the estimated average annual soil loss for conventionally tilled wheat grown on Parsons silt loam in Craig County is 14.78 tons per acre, calculated as follows:

$$A = (260)\ (0.49)\ (0.40)\ (0.29) = 14.78 \qquad (21)$$

For Craig County, the rainfall factor (R) is 260 (96, p.3). The soil erodibility factor (K) is 0.49 for Parsons silt loam (96, p.11). Assuming a slope length (L) of 300 feet and a slope steepness (S) of 3 percent, the LS factor is 0.40 (96, p.16). The cropping management factor (CP) for continuous wheat using conventional tillage is 0.29 (96, p.4).

The USDA has assigned a soil loss tolerance (T) value to most of the soils mapped in the United States. The T-value is defined by Wischmeier and Smith (119) to mean the maximum level of soil erosion that will permit a high level of crop productivity to be maintained economically and indefinitely.

Estimated average annual soil loss coefficients and T-values (Tolerance level) for the three representative farms are presented in Tables XXIV-XXVI.

Reduction of Yields Due to Soil Loss

The estimated annual soil loss can be converted to inches of soil removed and the corresponding loss in crop yield can be estimated. Soil data and annual soil loss estimates of the three representative farms were used for this purpose.

TABLE XXIV

ANNUAL SOIL LOSS COEFFICIENTS OF REPRESENTATIVE FARM 1

Cropping and Tillage Systems	R (1)	K (2)	LS (3)	CP (4)	A (1)(2)(3)(4)	T-Values
1. CONVENTIONAL						
IMPPVSCL	260	.37	0.62	0.02	1.19	5
WDSL	260	.43	0.25	0.29	8.11	5
WPSL	260	.49	0.40	0.29	14.78	4
WTSL	260	.49	0.20	0.29	7.39	5
WOSCL	260	.43	0.28	0.29	9.08	5
SBDSL	260	.43	0.25	0.52	14.53	5
SBPSL	260	.49	0.40	0.52	26.50	4
SBTSL	260	.49	0.20	0.52	13.25	5
SBOSCL	260	.43	0.28	0.52	16.28	5
GSDSL	260	.43	0.25	0.42	11.74	5
GSPSL	260	.49	0.40	0.42	21.40	4
GSTSL	260	.49	0.20	0.42	10.70	5
GSOSCL	260	.43	0.28	0.42	13.15	5
W/SBDSLDC	260	.43	0.25	0.30	8.39	5
W/SBPSLDC	260	.49	0.40	0.30	15.29	5
W/SBTSLDC	260	.49	0.20	0.30	7.64	5
W/SBOSCLDC	260	.43	0.28	0.30	9.39	5
2. MINIMUM-TILL						
WDSL	260	.43	0.25	0.18	5.03	5
WPSL	260	.49	0.40	0.18	9.17	4
WTSL	260	.49	0.20	0.18	4.59	5
WOSCL	260	.43	0.28	0.18	5.63	5
SBDSL	260	.43	0.25	0.30	8.39	5
SBPSL	260	.49	0.40	0.30	15.29	4
SBTSL	260	.49	0.20	0.30	7.64	5
SBOSCL	260	.43	0.28	0.30	9.39	5
GSDSL	260	.43	0.25	0.24	6.71	5
GSPSL	260	.49	0.40	0.24	12.23	4
GSTSL	260	.49	0.20	0.24	6.12	5
GSOSCL	260	.43	0.28	0.24	7.51	5
W/SBDSLDC	260	.43	0.25	0.16	4.47	5
W/SBPSLDC	260	.49	0.40	0.16	8.15	4
W/SBTSLDC	260	.49	0.20	0.16	4.08	5
W/SBOSCLDC	260	.43	0.28	0.16	5.01	5
3. NO-TILL						
WDSL	260	.43	0.25	0.09	2.52	5
WPSL	260	.49	0.40	0.09	4.59	4
WTSL	260	.49	0.20	0.09	2.29	5
WOSCL	260	.43	0.28	0.09	2.82	5
SBDSL	260	.43	0.25	0.13	3.63	5
SBPSL	260	.49	0.40	0.13	6.62	4
SBTSL	260	.49	0.20	0.13	3.31	5
SBOSCL	260	.43	0.28	0.13	4.07	5
GSDSL	260	.43	0.25	0.11	3.07	5
GSPSL	260	.49	0.40	0.11	5.61	4
GSTSL	260	.49	0.20	0.11	2.80	5
GSOSCL	260	.43	0.28	0.11	3.44	5
W/SBDSLDC	260	.43	0.25	0.08	2.24	5
W/SBPSLDC	260	.49	0.40	0.08	4.08	4
W/SBTSLDC	260	.49	0.20	0.08	2.04	5
W/SBOSCLDC	260	.43	0.28	0.08	2.50	5

TABLE XXV

ANNUAL SOIL LOSS COEFFICIENTS OF REPRESENTATIVE FARM 2

Cropping and Tillage Systems	R (1)	K (2)	LS (3)	CP (4)	A (1)(2)(3)(4)	T-Values
1. CONVENTIONAL						
IMPPAS	320	0.43	0.40	0.02	1.10	5
WOF	320	0.28	0.28	0.29	7.28	5
WMC	320	0.43	0.20	0.29	7.98	5
WLS	320	0.24	0.23	0.29	5.12	5
WPV	320	0.28	0.25	0.29	6.50	5
SBOF	320	0.28	0.28	0.52	13.05	5
SBMC	320	0.43	0.20	0.52	14.31	5
SBLS	320	0.24	0.23	0.52	9.19	5
SBPV	320	0.28	0.25	0.52	11.65	5
GSOF	320	0.28	0.28	0.42	10.54	5
GSMC	320	0.43	0.20	0.42	11.56	5
GSLS	320	0.24	0.23	0.42	7.42	5
GSPV	320	0.28	0.25	0.42	9.41	5
W/SBOFDC	320	0.28	0.28	0.30	7.53	5
W/SBMCDC	320	0.43	0.20	0.30	8.26	5
2. MINIMUM-TILL						
WOF	320	0.28	0.42	0.18	6.77	5
WMC	320	0.43	0.20	0.18	4.95	5
WLS	320	0.24	0.23	0.18	3.18	5
WPV	320	0.28	0.25	0.18	4.03	5
SBOF	320	0.28	0.42	0.30	11.29	5
SBMC	320	0.43	0.20	0.30	8.26	5
SBLS	320	0.24	0.23	0.30	5.30	5
SBPV	320	0.28	0.25	0.30	6.72	5
GSOF	320	0.28	0.42	0.24	9.03	5
GSMC	320	0.43	0.20	0.24	6.60	5
GSLS	320	0.24	0.23	0.24	4.24	5
GSPV	320	0.28	0.25	0.24	5.38	5
WSBOFDC	320	0.43	0.20	0.16	6.02	5
WSBMCDC	320	0.43	0.20	0.16	4.40	5
3. NO-TILL						
WOF	320	0.28	0.42	0.09	3.39	5
WMC	320	0.43	0.20	0.09	2.48	5
WLS	320	0.24	0.23	0.09	1.59	5
WPV	320	0.28	0.25	0.09	2.02	5
SBOF	320	0.28	0.42	0.13	4.89	5
SBMC	320	0.43	0.20	0.13	3.58	5
SBLS	320	0.24	0.23	0.13	7.30	5
SBPV	320	0.28	0.25	0.13	2.91	5
GSOF	320	0.28	0.42	0.11	4.14	5
GSMC	320	0.43	0.20	0.11	2.03	5
GSLS	320	0.24	0.23	0.11	1.94	5
GSPV	320	0.28	0.25	0.11	2.46	5
WSBOFDC	320	0.28	0.42	0.08	3.01	5
WSBMCDC	320	0.43	0.20	0.08	2.20	5

TABLE XXVI

ANNUAL SOIL LOSS COEFFICIENTS OF REPRESENTATIVE FARM 3

Cropping and Tillage Systems	R (1)	K (2)	LS (3)	CP (4)	A (1)(2)(3)(4)	T-Values
1. CONVENTIONAL						
IMPPBAC	280	0.37	0.47	0.02	0.97	3
WOKA	280	0.43	0.18	0.29	6.28	5
WOKB	280	0.43	0.27	0.29	9.43	5
WTKA	280	0.49	0.31	0.29	12.33	5
WBAB	280	0.37	0.39	0.29	11.42	3
SBOKA	280	0.43	0.18	0.52	11.27	5
SBOKB	280	0.43	0.27	0.52	16.90	5
SBTKA	280	0.49	0.31	0.52	22.12	5
SBBAB	280	0.37	0.38	0.52	20.47	3
GSOKA	280	0.43	0.18	0.42	9.10	5
GSOKB	280	0.43	0.27	0.42	13.65	5
GSTKA	280	0.49	0.31	0.42	17.86	5
GSBAB	280	0.37	0.38	0.42	16.53	3
WSBOKBDC	280	0.43	0.27	0.30	9.75	5
2. MINIMUM-TILL						
WOKA	280	0.43	0.18	0.18	3.90	5
WOKB	280	0.43	0.27	0.18	5.85	5
WTKA	280	0.49	0.31	0.18	7.66	5
WBAB	280	0.37	0.38	0.18	7.09	3
SBOKA	280	0.43	0.18	0.30	6.50	5
SBOKB	280	0.43	0.27	0.30	9.75	5
SBTKA	280	0.49	0.31	0.30	12.76	5
SBBAB	280	0.37	0.38	0.30	11.81	3
GSOKA	280	0.43	0.18	0.24	5.20	5
GSOKB	280	0.43	0.27	0.24	7.80	5
GSTKA	280	0.49	0.31	0.24	10.21	5
GSBAB	280	0.37	0.38	0.24	9.45	3
WSBOKBDC	280	0.43	0.27	0.16	5.20	5
3. NO-TILL						
WOKA	280	0.43	0.18	0.09	1.95	5
WOKB	280	0.43	0.27	0.09	2.93	5
WTKA	280	0.49	0.31	0.09	3.83	5
WBAB	280	0.37	0.38	0.09	3.54	3
SBOKA	280	0.43	0.18	0.13	2.82	5
SBOKB	280	0.43	0.27	0.13	4.23	5
SBTKA	280	0.49	0.31	0.13	5.53	5
SBBAB	280	0.37	0.38	0.13	5.12	3
GSOKA	280	0.43	0.18	0.11	2.38	5
GSOKB	280	0.43	0.27	0.11	3.58	5
GSTKA	280	0.49	0.31	0.11	4.68	5
GSBAB	280	0.37	0.38	0.11	4.33	3
WSBOKBDC	280	0.43	0.27	0.08	2.60	5

The estimates of inches of soil loss were obtained by dividing the estimated soil loss per acre per year by the weight (the bulk density) of an acre-inch of a soil.

The average weight of an acre-inch of a soil in Oklahoma is 136.125 tons acre inch, calculated as follows:

Soils weigh ± 75 lbs. per cubic foot
43,560 square feet = 1 acre
X 1 foot depth
43,560 cubic feet
X 75 lbs/cubic foot
3,267,000 lbs. in 1 acre 1 foot thick

$$\frac{3,267,000}{2,000} = 1,633.5 \text{ tons per acre for } 12''$$

$$\frac{1,633.5}{12} = 136.125 \text{ tons per acre inch}$$

How the annual soil loss is converted to inches of soil removed and how many years are required to lose 10 inches, is shown in the following example:

Erosion Class	Topsoil Remaining (Inches)	Bulk Density (Tons per acre inch)
1	10.0	130
2	5.0	136
3	1.5	136

Rate of Soil Loss Erosion Class 1 (Tons per acre)	Converted Soil Loss Into Inches of Soil/Year	Years Required To Lose Ten Inches (No Soil Formation)
5	0.0385	260 years
10	0.0769	130 years
50	0.385	26 years

5 tons of soil loss per acre per year = $\frac{5}{130}$ = 0.0385 inch of soil/year.

$$\frac{130}{5} = 26 \text{ years required to lose 1 inch of soil.}$$

Assuming that the loss of five percent of the topsoil reduces the yield of wheat by one bushel per acre, then one could say that these would be a reduction of 2 bushels of wheat for instance every 26 years, based on 5 tons of soil loss per acre per year. Based on 50 tons soil loss per acre per year, we would have a reduction of 2.0 bushels every 2.6 years, i.e., about 0.77 bushel per acre every year.

The conversion of the estimated soil losses per acre per year into inches of soil per year and the yield reductions associated with them are given in Tables XXVII-XXIX for the three representative farms.

TABLE XXVII

ANNUAL SOIL LOSS COEFFICIENTS, YIELD REDUCTIONS DUE TO SOIL LOSS AND YEARS REQUIRED TO LOSE ONE INCH OF SOIL FOR REPRESENTATIVE FARM 1

Cropping & Tillage Systems	Annual Soil Loss Coefficients (Tons/Acre/Yr)	Converted Soil Loss Into Inches Of Soil Per Year*	Yield Reductions Due To Soil Loss Per Year (bu)**	Years Required To Lose 1 Inch Of Soil
1. CONVENTIONAL				
IMPPVSCL	1.19	0.0087	----	114
WDSL	8.11	0.0596	0.11	17
WPSL	14.78	0.1086	0.22	9
WTSL	7.39	0.0543	0.11	18
WOSCL	9.08	0.0667	0.11	15
SBDSL	14.53	0.1067	0.19	9
SBPSL	26.50	0.1947	0.39	5
SBTSL	13.25	0.0973	0.19	10
SBOSCL	16.28	0.1196	0.20	8
GSDSL	11.74	0.0862	0.16	12
GSPSL	21.40	0.1572	0.31	6
GSTSL	10.70	0.0786	0.16	13
GSOSCL	13.15	0.0966	0.16	10
WSBDSLDC	8.39	0.0616	0.11	16
WSBPSLDC	15.29	0.1123	0.22	9
WSBTSLDC	7.64	0.0561	0.11	18
WSBOSCLDC	9.39	0.069	0.12	14
2. MINIMUM-TILL				
WDSL	5.03	0.0370	0.07	27
WPSL	9.17	0.0674	0.13	15
WTSL	4.59	0.0337	0.07	30
WOSCL	5.63	0.0414	0.07	24
SBDSL	8.39	0.0616	0.11	16
SBPSL	15.29	0.1123	0.22	9
SBTSL	7.64	0.0561	0.11	18
SBOSCL	9.39	0.0690	0.12	14
GSDSL	6.71	0.0493	0.09	20
GSPSL	12.23	0.0898	0.18	11
GSTSL	6.12	0.0450	0.09	20
GSOSCL	7.51	0.0552	0.09	18
WSBDSLDC	4.47	0.0328	0.06	30
WSBPSLDC	8.15	0.0599	0.12	17
WSBTSLDC	4.08	0.0300	0.06	33
WSBOSCLDC	5.01	0.0368	0.06	27
3. NO-TILL				
WDSL	2.52	0.0185	0.03	54
WPSL	4.59	0.0377	0.08	30
WTSL	2.29	0.0168	0.03	59
WOSCL	2.82	0.0207	0.04	48
SBDSL	3.63	0.0267	0.05	37
SBPSL	6.62	0.0486	0.10	21
SBTSL	3.31	0.0243	0.05	41
SBOSCL	4.07	0.0299	0.05	33
GSDSL	3.07	0.0226	0.04	44
GSPSL	5.61	0.0412	0.08	24
GSTSL	2.80	0.0206	0.04	49
GSOSCL	3.44	0.0253	0.04	40
WSBDSLDC	2.24	0.0165	0.03	61
WSBPSLDC	4.08	0.0520	0.10	33
WSBTSLDC	2.04	0.0150	0.03	67
WSBOSCLDC	2.50	0.0184	0.03	54

* Assuming a bulk density of 136.125 tons acre inch.

** Assuming a loss of five percent of topsoil reduces the yield of wheat by one bushel. Adjustments were made for yields of other crops to be comparable with wheat yield reduction.

TABLE XXVIII

ANNUAL SOIL LOSS COEFFICIENTS, YIELD REDUCTIONS DUE TO SOIL LOSS AND YEARS REQUIRED TO LOSE ONE INCH OF SOIL FOR REPRESENTATIVE FARM 2

Cropping & Tillage Systems	Annual Soil Loss Coefficients (Tons/Acre/Yr)	Converted Soil Loss Into Inches Of Soil Per Year*	Yield Reductions Due To Soil Loss Per Year (bu)**	Years Required To Lose 1 Inch Of Soil
1. CONVENTIONAL				
IMPPAS	1.10	0.0081	----	124
WOF	10.91	0.0801	0.18	12
WMC	7.98	0.0586	0.12	17
WLS	5.12	0.0376	0.08	27
WPV	6.50	0.0478	0.10	21
SBOF	19.57	0.1438	0.32	7
SBMC	14.31	0.1051	0.21	10
SBLS	9.19	0.0675	0.15	15
SBPV	11.65	0.0856	0.17	12
GSOF	15.81	0.1161	0.26	9
GSMC	11.56	0.0849	0.17	12
GSLS	7.42	0.0545	0.12	18
GSPV	9.41	0.0691	0.14	14
WSBOFDC	11.29	0.0829	0.18	12
WSBMCDC	8.26	0.0607	0.12	16
2. MINIMUM-TILL				
WOF	6.77	0.0497	0.11	20
WMC	4.95	0.0364	0.07	27
WLS	3.18	0.0234	0.05	43
WPV	4.03	0.0296	0.06	34
SBOF	11.29	0.0829	0.18	12
SBMC	8.26	0.0607	0.12	16
SBLS	5.30	0.0389	0.09	26
SBPV	6.72	0.0494	0.10	20
GSOF	9.03	0.0633	0.14	15
GSMC	6.60	0.0485	0.10	21
GSLS	4.24	0.0311	0.07	32
GSPV	5.38	0.0395	0.08	25
WSBOFDC	6.02	0.0442	0.10	23
WSBMCDC	4.40	0.0323	0.06	31
3. NO-TILL				
WOF	3.39	0.0249	0.05	40
WMC	2.48	0.0182	0.04	55
WLS	1.59	0.0117	0.03	86
WPV	2.02	0.0148	0.03	67
SBOF	4.89	0.0359	0.08	28
SBMC	3.58	0.0264	0.05	38
SBLS	2.30	0.0169	0.04	59
SBPV	2.91	0.0214	0.04	47
GSOF	4.14	0.0304	0.07	33
GSMC	3.03	0.0223	0.04	45
GSLS	1.94	0.0143	0.03	70
GSPV	2.46	0.0181	0.04	55
WSBOFDC	3.01	0.0221	0.05	45
WSBMCDC	2.20	0.0162	0.03	62

* Assuming a bulk density of 136.125 tons acre inch.

** Assuming a loss of five percent of topsoil reduces the yield of wheat by one bushel. Adjustments were made for yields of other crops to be comparable with wheat yield reduction.

TABLE XXIX

ANNUAL SOIL LOSS COEFFICIENTS, YIELD REDUCTIONS DUE TO SOIL LOSS AND YEARS REQUIRED TO LOSE ONE INCH OF SOIL FOR REPRESENTATIVE FARM 3

Cropping & Tillage Systems	Annual Soil Loss Coefficients (Tons. Acre/Yr)	Converted Soil Loss Into Inches Of Soil Per Year*	Yield Reductions Due To Soil Loss Per Year (bu)**	Years Required To Lose 1 Inch of Soil
1. CONVENTIONAL				
IMPPBAC	0.97	0.0071	----	140
WOKA	6.28	0.0462	0.10	22
WOKB	9.43	0.0693	0.15	14
WTKA	12.33	0.0907	0.18	11
WBAB	11.42	0.0840	0.17	12
SBOKA	11.27	0.0829	0.18	12
SBOKB	16.90	0.1243	0.27	8
SBTKA	22.12	0.1626	0.33	6
SBBAB	20.47	0.1505	0.30	7
GSOKA	9.10	0.0669	0.15	15
GSOKB	3.65	0.1004	0.22	10
GSTKA	17.86	0.1313	0.26	8
GSBAB	16.53	0.1215	0.24	8
WSBOKBDC	9.75	0.0716	0.16	14
2. MINIMUM-TILL				
WOKA	3.90	0.0287	0.06	35
WOKB	5.85	0.0430	0.09	23
WTKA	7.66	0.0563	0.11	18
WBAB	7.09	0.0521	0.10	19
SBOKA	6.50	0.0478	0.11	21
SBOKB	9.75	0.0717	0.16	14
SBTKA	12.76	0.0938	0.19	11
SBBAB	11.81	0.0868	0.17	12
GSOKA'	5.20	0.0382	0.08	26
GSOKB	7.80	0.0574	0.13	17
GSTKA	10.21	0.0751	0.15	13
GSBAB	9.45	0.0695	0.14	14
WSBOKBDC	5.20	0.0382	0.08	26
3. NO-TILL				
WOKA	1.95	0.0143	0.03	70
WOKB	2.93	0.0215	0.05	46
WTKA	3.83	0.0282	0.06	36
WBAB	3.54	0.0260	0.05	38
SBOKA	2.82	0.0207	0.05	48
SBOKB	4.23	0.0311	0.07	32
SBTKA	5.53	0.0407	0.08	25
SBBAB	5.12	0.3768	0.08	27
GSOKA	2.38	0.0175	0.04	57
GSOKB	3.58	0.0263	0.06	38
GSTKA	4.68	0.0344	0.07	29
GSBAB	4.33	0.0318	0.06	31
WSBOKBDC	2.60	0.0191	0.04	52

* Assuming a bulk density of 136.125 tons acre inch.

** Assuming a loss of five percent of topsoil reduces the yield of wheat by one bushel. Adjustments were made for yields of other crops to be comparable with wheat yield reduction.

CHAPTER VI

RESULTS OF THE STUDY

Scenario 1 Programming Results

The linear programming model was used to examine the effect of soil loss on current and future net returns from farming for the three representative farms. Three scenarios for yields were used in the linear programming models for the three Representative Farms.

Scenario 1 assumed that yields were the same for conventional, minimum and no-tillage systems.

Representative Farm 1

The results of the programming model for the Representative Farm 1 are presented in Tables XXX-XXXII. In year one, farm income for the unrestricted soil erosion is \$51,769 (Table XXX). Farm income decreases due to reductions in yields from soil erosion. Annual income falls from \$51,769 in year one to \$37,530 in year 40, a decrease of 28 percent. The present value of the income stream is \$912,890, using a discount rate of four percent. It was decided to use a discount rate of four perecnt as the difference between the prime rate of 10.5 percent and Consumer Price Index of 6 to 6.5 percent.

The salvage value of the farm in year 40 is calculated as:

$$V_f = \frac{E}{r} \qquad (22)$$

TABLE XXX

RETURNS TO LAND, LABOR, RISK AND MANAGEMENT FOR REPRESENTATIVE FARM 1 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING SAMES YIELDS FOR ALL TILLAGE SYSTEMS[a]

YEARS	ANNUAL INCOME UNRESTRICTED SOIL EROSION	ANNUAL INCOME RESTRICTED SOIL EROSION[b]
1	$ 51,769	$ 48,465
2-5	50,115	48,465
6-10	48,167	48,465
11-15	46,220	48,465
16-20	44,272	48,465
21-25	42,324	48,465
26-30	40,476	48,465
31-35	39,003	48,465
36-40	37,530	48,465
Total Income (Not Discounted)[c]	$1,769,715	$1,938,600
Present Value of Income Stream Discounted @ 4 Percent	912,890	959,254
Salvage Value of Farm in Year 40	938,250	1,211,625
Present Value of the Farm's Salvage Value	195,428	252,369
Net Present Value of Representative Farm 1	$1,108,318	$1,211,623

[a]It is assumed that yields were the same for conventional, minimum and no-tillge systems.

[b]Soil erosion restricted to SCS recommended levels.

[c]To obtain the total income, the income figures for the years 1 through 40 have been added together.

TABLE XXXI

THE OPTIMUM FARM ORGANIZATION OF REPRESENTATIVE FARM 1 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING SAME YILEDS FOR ALL TILLAGE SYSTEMS[a]

YEARS		UNRESTRICTED SOIL EROSION		RESTRICTED SOIL EROSION[b]
1-4	57	Cow-calf units	57	Cow-calf units
	549	Acres wheat (C)[c]	27	Acres wheat (C)
	51	Acres soybeans (MT)[d]	416	Acres wheat (MT)
	300	Acres wheat-soybeans double-cropped (MT)	2	Acres wheat (NT)
			182	Acres soybeans (NT)
			126	Acres wheat-soybeans double-cropped (MT)
			147	Acres wheat-soybeans double-cropped (NT)
5-27	57	Cow-calf units		No change from above
	523	Acres wheat (C)		
	77	Acres soybeans (NT)[e]		
	300	Acres wheat-soybeans double-cropped (MT)		
28-29	57	Cow-calf units		No change from above
	366	Acres wheat (C)		
	150	Acres wheat (MT)		
	84	Acres soybeans (NT)		
	300	Acres wheat-soybeans double-cropped (MT)		
30-40	57	Cow-calf units		No change from above
	468	Acres wheat (MT)		
	279	Acres soybeans (NT)		
	153	Acres wheat-soybeans double-cropped		

[a]It is assumed that yields were the same for conventional, minimum and no-tillage systems.

[b]Soil erosion is restricted to SCS recommended levels.

[c]C = Conventional Tillage.

[d]MT = Minimum Tillage.

[e]NT = No-Tillage.

TABLE XXXII

ANNUAL SOIL LOSS FROM REPRESENTATIVE FARM 1 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING SAME YIELDS FOR ALL TILLAGE SYSTEMS[a]

YEARS	SOIL SERIES	UNRESTRICTED SOIL EROSION Total	UNRESTRICTED SOIL EROSION Avg Tons Per Acre	RESTRICTED SOIL EROSION[b] Total	RESTRICTED SOIL EROSION[b] Avg Tons Per Acre
1-4	Dennis silt loam (DSL)	1,217	8.11	750	5.00
	Parsons silt loam (PSL)	1,198	8.00	600	4.00
	Taloka silt loam (YSL)	624	4.16	750	5.00
	Osage silt clay loam (OSCL)	4,102	9.12	2250	5.00
	Verdigris silty clay loam (VSCL)	4,102	9.12	2250	3.00
5-27	Dennis silt loam (DSL)	1,127	8.11	No change from above	
	Parsons silt loam (PSL)	1,198	8.00		
	Taloka silt loam (TSL)	624	4.16		
	Osage silt clay loam (OSCL)	3,699	8.22		
	Verdigris silty clay loam (VSCL)	714	1.19		
28-29	Dennis silt loam (DSL)	755	5.03	No change from above	
	Parsons silt loam (PSL)	1,198	8.00		
	Taloka silt loam (TSL)	624	4.16		
	Osage silt clay loam (OSCL)	3,667	8.15		
	Verdigris silty clay loam (VSCL)	714	1.19		
39-40	Dennis silt clay loam (DSL)	755	5.03	No change from above	
	Parsons silt loam (PSL)	1,348	9.00		
	Taloka silt loam (TSL)	624	4.16		
	Osage silt clay loam (OSCL)	2,099	4.66		
	Verdigris silty clay loam (VSCL)	714	1.19		

[a]It is assumed that yields were the same for conventional, minimum and no-tillage systems.

[b]Soil erosion is restricted to SCS recommended levels.

where V_f is the value of the farm, E is the expected future earning potential of the farm and r is the discount rate. As indicated in Table XXX, the salvage value of Representative Farm 1 in year 40 is $938,250 for the unrestricted soil erosion case (income of $37,530 in year 40 divided by the discount rate of four percent). Discounting this salvage value gives a present value of $195,428. The net present value of the farm is the sum of the present value of the income stream and the present value of the farm's salvage value. The net present value of Representative Farm 1 is $1,108,318 for the case of unrestricted soil erosion.

In the case of restricted soil erosion to SCS recommended levels, annual income stayed the same for all years at $48,465 (Table XXX). The SCS recommended soil loss level of the Representative Farm 1 is five tons per acre per year for three types of soil, four tons per acre per year for the fourth soil type, and three tons per acre per year for the fifth type of soil.

The income for the restricted soil erosion case does not change over the 40 year period because a high level of crop productivity is maintained economically and indefinitely according to the definition of the soil loss tolerance (T) value. The present value of the income stream for the restricted soil erosion case is $959,254. The present value of the farm's salvage value is $252,369 (Table XXX). The net present value of Representative Farm 1 is $1,211,623 when soil erosion is restricted.

With unrestricted soil erosion, the optimum farm plan in year one includes intensive crop production (Table XXXI). The farm plan includes 549 acres of wheat using conventional tillage, 51 acres of soybeans using minimum tillage (MT), 300 acres of wheat-soybeans double-cropped using minimum tillage (MT), and 57 cow-calf units raised on 600 acres of improved pasture. Because of the impact of soil erosion on per unit crop yield or productivity, the farm plan changes. In year five, it is more profitable to use reduced tillage technology. The acres of conventional wheat decreased and the acres of soybeans increased with a shift from minimum tillage to no-tillage which has less soil erosion. As the farm organization approaches the end of the 40 year planning horizon, a shift to reduced tillage technology (minimum- and no-till) occurs.

In the restricted soil erosion case, there is only one farm plan over the 40 year period. The farm plan included 27 acres of conventional tillage wheat, 416 acres of wheat using minimum tillage, 2 acres of wheat using no-tillage, 182 acres of soybeans using no-tillage, 126 acres of wheat-soybeans double-cropped using minimum tillage, 147 acres of wheat-soybeans double-cropped using no-tillage, and 57 cow-calf units. In the restricted soil erosion case, only a few acres of wheat were planted using conventional tillage. Minimum tillage and no-tillage dominate the farm plan. Restricting soil erosion to SCS recommended levels has no adverse impact on farm income in the long run for Representative Farm 1. The net present value of the farm increased 9 percent because of the soil loss restrictions. This result favors the adoption of reduced tillage technology as a soil conservation practice.

The annual soil losses are presented in Table XXXII. Soil erosion is highest for Osage silt clay loam, Dennis silt loam, and Parsons silt loam, which are in wheat and soybeans, and wheat and wheat-soybeans double-cropped, respectively. After five years, soil erosion for Osage silt clay loam decreased from 9.12 to 8.22 tons per acre per year. As the farm plan changes and the use of reduced tillage technology increases, soil erosion decreases and is no longer a major problem (Table XXXII). The SCS recommended levels (T-values) to which soil erosion is restricted are presented in Table XXXII.

Representative Farm 2

The results of the programming model for Representative Farm 2 are presented in Tables XXXIII-XXXV. In year one, farm income for the unrestricted soil erosion case is $52,872 (Table XXXIII). As a result of reductions in yields from soil erosion over time, farm income decreases. Annual income falls from $52,872 in year one to $45,633 in year 40, a decrease of 14 percent. The present value of the income stream is $991,119, using a discount rate of four percent. The salvage value of Representative Farm 2 in year 40 is $1,140,825. Discounting this salvage value gives a present value of $237,622. The net present value of the farm is the sum of the present value of the income stream and the present value of the farm's salvage value. The net present value of Representative Farm 2 is $1,228,741 for the case of unrestricted soil erosion.

The SCS recommended soil loss level (T-value) for Representative Farm 2 is five tons per acre per year for all types of soil. The annual income for the restricted soil erosion case was $51,496 which does not change over the 40 year period (Table XXXIII). The present value of the income stream for the restricted soil erosion case is $1,019,246. The present value of the farm's salvage value is $268,152 (Table XXXIII). The net present value of Representative Farm 2 is $1,287,398 when soil

TABLE XXXIII

RETURNS TO LAND, LABOR, RISK AND MANAGEMENT FOR THE REPRESENTATIVE FARM 2 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING SAME YIELDS FOR ALL TILLAGE SYSTEMS[a]

YEARS	ANNUAL INCOME: UNRESTRICTED SOIL EROSION	ANNUAL INCOME: RESTRICTED SOIL EROSION[b]
1	$ 52,872	$ 51,496
2-5	52,059	51,496
6-10	51,042	51,496
11-15	50,118	51,496
16-20	49,200	51,496
21-25	48,283	51,496
26-30	47,366	51,496
31-35	46,449	51,496
36-40	45,633	51,496
Total Income (Not Discounted)[c]	$1,965,547	$2,059,840
Present Value of Income Stream Discounted @ 4 Percent	991,119	1,019,246
Salvage Value of Farm in Year 40	1,140,825	1,287,400
Present Value of the Farm's Salvage Value	237,622	268,152
Net Present Value of Representative Farm 1	$1,228,741	$1,287,398

[a]It is assumed that yields were the same for conventional, minimum and no-tillge systems.

[b]Soil erosion restricted to SCS recommended levels.

[c]To obtain the total income, the income figures for the years 1 through 40 have been added together.

TABLE XXXIV

THE OPTIMUM FARM ORGANIZATION OF THE REPRESENTATIVE FARM 2 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING SAME YIELDS FOR ALL TILLAGE SYSTEMS[a]

YEARS		UNRESTRICTED SOIL EROSION		RESTRICTED SOIL EROSION[b]
1-10	103	Acres improved pasture	103	Acres improved pasture
	140	Acres wheat (C)[c]	131	Acres wheat (C)
	150	Acres grain sorghum(MT)[d]	9	Acres wheat (MT)
	68	Acres wheat-soybeans double-cropped (C)	130	Acres grain sorghum (MT)
			20	Acres grain sorghum (NT)
	197	Acres wheat-soybeans double-cropped (MT)	10	Acres wheat-soybeans double-cropped (C)
			218	Acres wheat-soybeans double-cropped (MT)
			37	Acres wheat-soybeans double-cropped (NT)
11-36	103	Acres improved pasture		No change from above
	140	Acres wheat (C)		
	150	Acres grain sorghum (MT)		
	265	Acres wheat-soybeans double-cropped (MT)		
37-40	103	Acres improved pasture		No change from above
	140	Acres wheat (C)		
	150	Acres grain sorghum (MT)		
	155	Acres wheat-soybeans double-cropped (MT)		
	110	Acres wheat-soybeans double-cropped (NT)[e]		

[a]It is assumed that yields were the same for conventional, minimum and no-tillage systems.

[b]Soil erosion is restricted to SCS recommended levels.

[c]C = Conventional Tillage.

[d]MT = Minimum Tillage.

[e]NT = No-Tillage.

TABLE XXXV

ANNUAL SOIL LOSS FROM THE REPRESENTATIVE FARM 2 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING SAME YIELDS FOR ALL TILLAGE SYSTEMS[a]

YEARS	SOIL SERIES	UNRESTRICTED SOIL EROSION Total	UNRESTRICTED SOIL EROSION Avg Tons Per Acre	RESTRICTED SOIL EROSION[b] Total	RESTRICTED SOIL EROSION[b] Avg Tons Per Acre
1-10	Oklared fine sandy loam (OF)	662	6.02	550	5.00
	Miller clay (MC)	946	6.10	775	5.00
	Lonoke silty clay loam (LS)	717	5.12	700	5.00
	Pope very fine sandy loam (PV)	807	5.38	750	5.00
	Atkins silt loam (AS)	113	1.10	309	5.00
11-36	Oklared fine sandy loam (OF)	662	6.02	No change from above	
	Miller clay (MC)	682	4.40		
	Lonoke silty clay loam (LS)	717	5.12		
	Pope very fine sandy loam (PV)	807	5.38		
	Atkins silt loam (AS)	113	1.10		
37-40	Oklared fine sandy loam (OF)	331	3.01	No change from above	
	Miller clay (MC)	682	4.40		
	Lonoke silty clay loam (LS)	717	5.12		
	Pope very fine sandy loam (PV)	807	5.38		
	Atkins silt loam (AS)	113	1.10		

[a]It is assumed that yields were the same for conventional, minimum and no-tillage systems.

[a]Soil erosion is restricted to SCS recommended levels.

erosion is restricted. With unrestricted soil erosion, the optimum farm plan in year one includes 103 acres of improved pasture, 140 acres of conventional wheat, 150 acres of grain sorghum using minimum tillage, 68 acres of wheat-soybeans double-cropped using conventional tillage, and 197 acres of wheat-soybeans double-cropped using minimum tillage (Table XXXIV). Since the soil erosion has an adverse impact on soil productivity, the farm plan changes over time which makes the use of reduced tillage technology more favorable and more profitable.

In year 40, the optimum farm plan includes 103 acres of improved pasture, 140 acres of conventional tillage wheat, 150 acres of grain sorghum using minimum tillage, 155 acres of wheat-soybeans double-cropped using minimum tillage, and 110 acres of wheat-soybeans double-cropped using no-tillage. A shift from erosive tillage systems and crops to less erosive tillage systems and crops can be seen.

In the restricted soil erosion case, in year one, the farm plan includes 103 acres of improved pasture, 131 acres of conventional wheat, 9 acres of minimum tillage wheat, 130 acres of grain sorghum using minimum tillage, 20 acres of grain sorghum using no-tillage, 10 acres of conventional wheat-soybeans double-cropped, 218 acres of wheat-soybeans double-cropped using minimum tillage, and 37 acres of wheat-soybeans double-cropped using no-tillage.

The annual soil losses are presented in Table XXXV. Soil erosion is highest for Oklared fine sandy loam (OF) and Miller clay (MC) which are in wheat-soybeans double-cropped. As the farm plan changes, and the use of reduced tillage technology is increasing, soil erosion becomes less. In the long run, restricting soil erosion to SCS recommended levels increases the annual farm income compared to the unrestricted soil erosion case, and reduced tillage technology becomes attractive.

Representative Farm 3

The results of the programming model for Representative Farm 3 are presented in Tables XXXVI-XXXVIII. In year one, farm income for the unrestricted soil erosion is $73,535 (Table XXXVI). Since soil erosion causes reduction in yields, annual farm income falls from $73,535 in year one to $52,080 in year 40, a decrease of 29 percent. The present value of the income stream is $1,257,691, using a discount rate of four percent. The salvage value of Representative Farm 3 in year 40 is $1,302,000. Discounting this salvage value gives a present value of $271,194. The net present value of the farm is the sum of the present value of the income stream and the present value of the farm's salvage value. The net present value of Representative Farm 3 is $1,528,885 for the case of unrestricted soil erosion.

In the case of restricted soil erosion to SCS recommended levels, annual income is $66,182 and does not change over the 40 year period. The present value of the income stream of the restricted soil erosion case is $1,309,921. The present value of the farm's salvage value is $344,626 (Table XXXVI). The net present value of Representative Farm 3 is $1,654,547 when soil erosion is restricted.

With unrestricted soil erosion, the optimum farm plan in year one included 614 acres of wheat using minimum tillage, 296 acres of soybeans using conventional tillage, and 290 acres of wheat-soybeans double-cropped using minimum tillage. In year eight, the farm plan includes 614 acres of wheat using minimum tillage, and 296 acres of

TABLE XXXVI

RETURNS TO LAND, LABOR, RISK AND MANAGEMENT FOR THE REPRESENTATIVE FARM 3 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING SAME YIELDS FOR ALL TILLAGE SYSTEMS[a]

YEARS	ANNUAL INCOME	
	UNRESTRICTED SOIL EROSION	RESTRICTED SOIL EROSION[b]
1	$ 73,535	$ 66,182
2-5	70,399	66,182
6-10	67,087	66,182
11-15	64,292	66,182
16-20	61,741	66,182
21-25	59,259	66,182
26-30	56,777	66,182
31-35	54,295	66,182
36-40	52,080	66,182
Total Income (Not Discounted)[c]	$2,473,589	$2,647,280
Present Value of Income Stream Discounted @ 4 Percent	1,257,691	1,309,921
Salvage Value of Farm in Year 40	1,302,000	1,654,550
Present Value of the Farm's Salvage Value	271,194	344,626
Net Present Value of Representative Farm 1	$1,528,885	$1,654,547

[a]It is assumed that yields were the same for conventional, minimum and no-tillge systems.

[b]Soil erosion restricted to SCS recommended levels.

[c]To obtain the total income, the income figures for the years 1 through 40 have been added together.

TABLE XXXVII

THE OPTIMUM FARM ORGANIZATION OF THE REPRESENTATIVE FARM 3 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING SAME YIELDS FOR ALL TILLAGE SYSTEMS[a]

YEARS	UNRESTRICTED SOIL EROSION	RESTRICTED SOIL EROSION[b]
1-4	614 Acres wheat (MT) 296 Acres soybeans (C)[c] 290 Acres wheat-soybeans double-cropped (MT)[d]	138 Acres wheat (MT) 540 Acres wheat (NT) 79 Acres soybeans (MT) 103 Acres soybeans (NT) 268 Acres wheat-soybeans double-cropped (MT) 22 Acres wheat-soybeans double-cropped (NT)
5-7	614 Acres wheat (MT) 181 Acres soybeans (C) 115 Acres soybeans (MT) 290 Acres wheat-soybeans double-cropped (MT)	No change from above
8-9	614 Acres wheat (MT) 296 Acres soybeans (MT) 290 Acres wheat-soybeans double-cropped (MT)	No change from above
10-16	614 Acres wheat (MT) 181 Acres soybeans (MT) 115 Acres soybeans (NT)[e] 290 Acres wheat-soybeans double-cropped (MT)	No change from above
17	614 Acres wheat (MT) 296 Acres soybeans (NT) 290 Acres wheat-soybeans double-cropped	No change from above
18-35	729 Acres wheat (MT) 181 Acres soybeans (NT) 290 Acres wheat-soybeans double-cropped (MT)	No change from above
36-40	729 Acres wheat (MT) 181 Acres soybeans (NT) 290 Acres wheat-soybeans double-cropped	

[a]It is assumed that yields were the same for conventional, minimum and no-tillage systems.

[b]Soil erosion is restricted to SCS recommended levels.

[c]C = Conventional Tillage.

[d]MT = Minimum Tillage.

[e]NT = No-Tillage.

TABLE XXXVIII

ANNUAL SOIL LOSS FROM THE REPRESENTATIVE FARM 3 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING SAME YIELDS FOR ALL TILLAGE SYSTEMS[a]

YEARS	SOIL SERIES	UNRESTRICTED SOIL EROSION Total	UNRESTRICTED SOIL EROSION Avg Tons Per Acre	RESTRICTED SOIL EROSION[b] Total	RESTRICTED SOIL EROSION[b] Avg Tons Per Acre
1-4	Okemah silt loam (OKA)	2,040	11.27	905	5.00
	Okemah silt loam (OKB)	1,508	5.20	1450	5.00
	Taloka silt loam (TKA)	4,703	7.66	3070	5.00
	Bates loam (BAB)	2,354	20.47	575	5.00
	Bates loam (BAC)	776	0.97	2400	3.00
5-7	Okemah silt loam (OKA)	2,040	11.27	No change from above	
	Okemah silt loam (OKB)	1,508	5.20		
	Taloka silt loam (TKA)	4,703	7.66		
	Bates loam (BAB)	1,358	11.81		
	Bates loam (BAC)	776	0.97		
8-9	Okemah silt loam (OKA)	1,177	6.50	No change from above	
	Okemah silt loam (OKB)	1,508	5.20		
	Taloka silt loam (TKA)	4,703	7.66		
	Bates loam (BAB)	1,358	11.81		
	Bates loam (BAC)	776	0.97		
10-16	Okemah silt loam (OKA)	1,177	6.50	No change from above	
	Okemah silt loam (OKB)	1,508	5.20		
	Taloka silt loam (TKA)	4,703	7.66		
	Bates loam (BAB)	589	5.12		
	Bates loam (BAC)	776	0.97		
17	Okemah silt loam (OKA)	510	2.82		
	Okemah silt loam (OKB)	1,508	5.20		
	Taloka silt loam (TKA)	4,703	7.66		
	Bates loam (BAB)	589	5.12		
	Bates loam (BAC)	776	0.97		
18-35	Okemah silt loam (OKA)	510	2.82		
	Okemah silt loam (OKB)	1,508	5.20		
	Taloka silt loam (TKA)	4,703	7.66		
	Bates loam (BAB)	815	7.09		
	Bates loam (BAC)	776	0.97		
36-40	Okemah silt loam (OKA)	510	2.82		
	Okemah silt loam (OKB)	754	2.60		
	Taloka silt loam (TKA)	4,703	7.66		
	Bates loam (BAB)	815	7.09		
	Bates loam (BAC)	776	0.97		

[a]It is assumed that yields were the same for conventional, minimum and no-tillage systems.

[b]Soil erosion is restricted to SCS recommended levels.

soybeans using minimum tillage, and 290 acres of wheat-soybeans double-cropped using minimum tillage. It can be seen that there is a shift towards reduced tillage technology over time which is less soil erosive than the conventional tillage system. In year 40, the optimum farm plan includes 729 acres of wheat using minimum tillage, 181 acres of soybeans using no-tillage, and 290 acres of wheat-soybeans double-cropped using no-tillage (Table XXXVII).

In the restricted soil erosion case, in year one the farm plan includes 188 acres of wheat using minimum tillage, 540 acres of wheat using no-tillage, 79 acres of soybeans using minimum tillage, 103 acres of soybeans using no-tillage, 268 acres of wheat-soybeans double-cropped using minimum tillage, and 22 acres of wheat-soybeans double-cropped using no-tillage. In the restricted soil erosion case, the farm plan in which reduced tillage technology dominates, does not change over the 40 year period (Table XXXVII).

The annual soil losses for Representative Farm 3 are presented in Table XXXVIII. For the unrestricted soil erosion case, soil erosion is highest for Okemah silt loam (OKA), Taloka silt loam (TKA), and Bates loam (BAB), which are all in soybeans. As the farm plan changes over time and there is a shift towards reduced tillage technology, soil erosion decreases and is no longer a serious problem (Table XXXVIII).

Scenario 1 Summary

Based on the assumption that the yields were the same for conventional, minimum and no-tillage systems, programming results suggest that restricting soil erosion results in an increase in the net present value of all three Representative Farms. In the case of

Representative Farm 1, the net present value of the farm for the restricted case is $1,211,623 which compares with $1,108,318 for the unrestricted case, an increase of nine percent. The profitability of less erosive crops makes reduced tillage technology attractive and more profitable for Representative Farm 1. However, restricting the soil to SCS recommended levels has a short-term negative income impact on the farm.

Restricting soil erosion on Representative Farm 2 increases the net present value of the farm five percent from $1,228,741 to $1,287,398. Restricting soil erosion on Representative Farm 3 increases the net present value of the farm eight percent from $1,528,885 to $1,654,547.

Based on the assumption that the farmer's objective was to maximize the net present value of the farm for a planning horizon of 40 years, incentives exist for the farmer to adopt reduced tillage technology. These incentives exist because restricting soil erosion increases the net present value of the farm. Since net present value of all three Representative Farms increased, these farms should adopt reduced tillage technology to reduce soil erosion. Again, these results are based on the assumption that yields are the same for all tillage systems.

Reduced tillage technology is a farming activity like any other tillage system and a soil conservation practice at the same time. Reduced tillage technology with its economic benefits and the advantage of reducing soil erosion is competitive with other tillage systems in the short-run, and is more profitable in the long-run.

Scenario 2 Programming Results

Scenario 2 assumed that yields of minimum and no-tillage systems were three bushels/acre/year less than the yields of the conventional tillage system.

Representative Farm 1

The results of the programming model for Representative Farm 1 are presented in Tables XXXIX-XLI. In year one, farm income for the unrestricted soil erosion case is $50,948 (Table XXXIX). Annual income falls from $50,948 in year one to $33,736 in year 40, a decrease of 34 percent. The present value of the income stream is $870,430. The salvage value of Representative Farm 1 in year 40 is $843,400. Discounting this salvage value gives a present value of $175,672. The net present value of Representative Farm 1 is $1,046,102 for the case of unrestricted soil erosion.

In the case of restricted soil erosion to SCS recommended levels, annual income stayed the same at $43,911 (Table XXXIX). The present value of the income stream for the restricted soil erosion case is $869,321. The present value of the farm's salvage value is $228,655 (Table XXXIX). The net present value of Representative Farm 1 is $1,097,976 when soil erosion is restricted.

With unrestricted soil erosion, the optimum farm plan includes 57 cow-calf units, 604 acres of conventional wheat, 70 acres of conventional soybeans, and 226 acres of wheat-soybeans double-cropped using conventional tillage. With the exception of wheat-soybeans double-cropped using minimum tillage which came in the final plan in

TABLE XXXIX

RETURNS TO LAND, LABOR, RISK AND MANAGEMENT FOR THE REPRESENTATIVE FARM 1 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING LOWER YIELDS FOR REDUCED TILLAGE SYSTEMS[a]

YEARS	ANNUAL INCOME	
	UNRESTRICTED SOIL EROSION	RESTRICTED SOIL EROSION[b]
1	$ 50,948	$ 43,911
2-5	48,759	43,911
6-10	46,759	43,911
11-15	43,809	43,911
16-20	41,694	43,911
21-25	39,705	43,911
26-30	37,715	43,911
31-35	35,726	43,911
36-40	33,736	43,911
Total Income (Not Discounted)[c]	$1,671,193	$1,756,440
Present Value of Income Stream Discounted @ 4 Percent	870,430	869,321
Salvage Value of Farm in Year 40	843,400	1,097,775
Present Value of the Farm's Salvage Value	175,672	228,655
Net Present Value of Representative Farm 1	$1,046,102	$1,097,976

[a]It is assumed that yields of minimum and no-tillge systems were three bushels/acre/year less than those of conventional tillage.

[b]Soil erosion restricted to SCS recommended levels.

[c]To obtain the total income, the income figures for the years 1 through 40 have been added together.

TABLE XL

THE OPTIMUM FARM ORGANIZATION OF THE REPRESENTATIVE FARM 1 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING LOWER YIELDS FOR REDUCED TILLAGE SYSTEMS[a]

YEARS	UNRESTRICTED SOIL EROSION		RESTRICTED SOIL EROSION[b]	
1-7	57	Cow-calf units	57	Cow-calf units
	604	Acres wheat (C)[c]	14	Acres wheat (C)
	70	Acres soybeans (C)	416	Acres wheat (MT)
	226	Acres wheat-soybeans double-cropped (C)	49	Acres soybeans (NT)[e]
			35	Acres wheat-soybeans double-cropped (C)
			239	Acres wheat-soybeans double-cropped (NT)
			147	Acres wheat-soybeans double-cropped (NT)
8-12	57	Cow-calf units		No change from above
	590	Acres wheat(C)		
	59	Acres soybeans (C)		
	153	Acres wheat-soybeans double-cropped (C)		
	98	Acres wheat-soybeans double-cropped (MT)[d]		
13-19	57	Cow-calf units		No change from above
	564	Acres wheat (C)		
	36	Acres soybeans (C)		
	8	Acres wheat-soybeans double-cropped (C)		
	292	Acres wheat-soybeans double-cropped (MT)		
20-40	57	Cow-calf units		No change from above
	540	Acres wheat (C)		
	57	Acres grain sorghum (C)		
	303	Acres wheat-soybeans double-cropped (MT)		

[a]It is assumed that yields of minimum and no-tillage systems were three bushels/acre/year less than those of conventional tillage system.

[b]Soil erosion is restricted to SCS recommended levels.

[c]CT = Conventional Tillage.

[d]MT = Minimum Tillage.

[e]NT = No-Tillage.

TABLE XLI

ANNUAL SOIL LOSS FROM THE REPRESENTATIVE FARM 1 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING LOWER YIELDS FOR REDUCED TILLAGE SYSTEMS[a]

YEARS	SOIL SERIES	UNRESTRICTED SOIL EROSION Total	UNRESTRICTED SOIL EROSION Avg Tons Per Acre	RESTRICTED SOIL EROSION[b] Total	RESTRICTED SOIL EROSION[b] Avg Tons Per Acre
1-7	Dennis silt loam (DSL)	1,217	8.11	750	5.00
	Parsons silt loam (PSL)	2,210	6.00	600	4.00
	Taloka silt loam (TSL)	1,169	7.64	750	5.00
	Osage silt clay loam (OSCL)	4,590	10.20	2250	5.00
	Verdigris silty clay loam (VSCL)	714	1.19	1800	3.00
8-12	Dennis silt loam (DSL)	1,127	8.11	No change from above	
	Parsons silt loam (PSL)	1,523	10.36		
	Taloka silt loam (TSL)	1,169	7.64		
	Osage silt clay loam (OSCL)	4,507	10.02		
	Verdigris silty clay loam (VSCL)	714	1.19		
13-19	Dennis silt loam (DSL)	1,217	8.11	No change from above	
	Parsons silt loam (PSL)	1,198	8.15		
	Taloka silt loam (TSL)	653	4.27		
	Osage silt clay loam (OSCL)	4,345	9.66		
	Verdigris silty clay loam (VSCL)	714	1.19		
20-40	Dennis silt clay loam (DSL)	1,206	8.04	No change from above	
	Parsons silt loam (PSL)	1,198	8.15		
	Taloka silt loam (TSL)	624	4.08		
	Osage silt clay loam (OSCL)	4,317	9.59		
	Verdigris silty clay loam (VSCL)	714	1.19		

[a]It is assumed that yields of minimum and no-tillage systems were three bushels/acre/year less than those of conventional tillage system.

[b]Soil erosion is restricted to SCS recommended levels.

year eight, conventional tillage dominates in the unrestricted soil erosion case because of yield advantages.

In the restricted soil erosion case, the optimum farm plan includes 57 cow-calf units, 14 acres of conventional wheat, 416 acres of wheat using minimum tillage, 49 acres of soybeans using no-tillage, 35 acres of conventional wheat-soybeans double-cropped, 239 acres of wheat-soybeans double-cropped using minimum tillage, and 147 acres of wheat-soybeans double-cropped using no-tillage. Despite the yield advantage of conventional tillage, it is more profitable to adopt reduced tillage technology when soil erosion is restricted. The net present value of Representative Farm 1 increased five percent because of the soil loss restriction over the 40-year period. However, there was an adverse impact on farm income in the short run when soil erosion is restricted.

The annual soil losses are presented in Table XLI. With the exception of Verdigris silty clay loam which is in pasture land, all types of soil have high soil erosion. After eight years, soil erosion for those types of soil decreased as the adoption of reduced tillage technology increased. However, soil loss for Parsons silt loam (PSL) increased from six in year seven to 10.36 tons per acre per year in year eight because of the shift to soybeans which are more soil erosive than the other crops. The annual soil losses for the restricted soil erosion case are presented in Table XLI.

Representative Farm 2

The results of the programming model for Representative Farm 2 are presented in Tables XLII-XLIV. In year one, farm income for the

TABLE XLII

RETURNS TO LAND, LABOR, RISK AND MANAGEMENT FOR THE REPRESENTATIVE FARM 2 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING LOWER YIELDS FOR REDUCED TILLAGE SYSTEMS[a]

YEARS	ANNUAL INCOME	
	UNRESTRICTED SOIL EROSION	RESTRICTED SOIL EROSION[b]
1	$ 48,272	$ 43,632
2-5	47,259	43,632
6-10	46,106	43,632
11-15	44,953	43,632
16-20	43,800	43,632
21-25	42,647	43,632
26-30	41,586	43,632
31-35	40,644	43,632
36-40	39,714	43,632
Total Income (Not Discounted)[c]	$1,751,038	$1,745,280
Present Value of Income Stream Discounted @ 4 Percent	888,603	863,597
Salvage Value of Farm in Year 40	992,850	1,090,800
Present Value of the Farm's Salvage Value	206,801	227,203
Net Present Value of Representative Farm 1	$1,095,404	$1,090,800

[a]It is assumed that yields of minimum and no-tillage systems were three bushels/acre/year less than those of conventional tillage.

[b]Soil erosion restricted to SCS recommended levels.

[c]To obtain the total income, the income figures for the years 1 through 40 have been added together.

TABLE XLIII

THE OPTIMUM FARM ORGANIZATION OF THE REPRESENTATIVE FARM 2 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING LOWER YIELDS FOR REDUCED TILLAGE SYSTEMS[a]

YEARS	UNRESTRICTED SOIL EROSION	RESTRICTED SOIL EROSION[b]
1-4	103 Acres improved pasture 290 Acres wheat (C)[c] 131 Acres grain sorghum (MT)[d] 134 Acres wheat-soybeans double-cropped (C)	74 Acres improved pasture 229 Acres wheat (C) 5 Acres wheat (NT) 56 Acres grain sorghum (NT) 98 Acres wheat-soybeans double-cropped (C) 167 Acres wheat-soybeans double-cropped (NT)
5-27	103 Acres improved pasture 104 Acres wheat (C) 266 Acres grain sorghum (MT) 149 Acres wheat-soybeans double-cropped (C)	No change from above
28-29	103 Acres improved pasture 140 Acres wheat (C) 175 Acres grain sorghum (MT) 130 Acres wheat-soybeans double-cropped (C) 110 Acres wheat-soybeans double-cropped (NT)[e]	No change from above
30-35	103 Acres improved pasture 140 Acres wheat (C) 150 Acres grain sorghum (MT) 23 Acres grain sorghum (NT) 132 Acres wheat-soybeans double-cropped (C) 110 Acres wheat-soybeans double-cropped (NT)	No change from above
36-40	103 Acres improved pasture 140 Acres wheat (C) 150 Acres grain sorghum (MT) 124 Acres wheat-soybeans double-cropped (C) 141 Acres wheat-soybeans double-cropped (NT)	No change from above

[a]It is assumed that yields of minimum and no-tillage systems were three bushels/acre/year less than those of conventional tillage system.

[b]Soil erosion is restricted to SCS recommended levels.

[c]CT = Conventional Tillage.

[d]MT = Minimum Tillage.

[e]NT = No-Tillage.

TABLE XLIV

ANNUAL SOIL LOSS FROM THE REPRESENTATIVE FARM 2 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING LOWER YIELDS FOR ALL TILLAGE SYSTEMS[a]

YEARS	SOIL SERIES	UNRESTRICTED SOIL EROSION Total	UNRESTRICTED SOIL EROSION Avg Tons Per Acre	RESTRICTED SOIL EROSION[b] Total	RESTRICTED SOIL EROSION[b] Avg Tons Per Acre
1-4	Oklared fine sandy loam (OF)	1,242	11.29	550	5.00
	Miller clay (MC)	1,063	6.86	775	5.00
	Lonoke silty clay loam (LS)	717	5.12	700	5.00
	Pope very fine sandy loam (PV)	975	6.50	750	5.00
	Atkins silt loam (AS)	113	1.10	309	5.00
5-27	Oklared fine sandy loam (OF)	1,242	11.29	No change from above	
	Miller clay (MC)	1,088	7.02		
	Lonoke silty clay loam (LS)	717	5.12		
	Pope very fine sandy loam (PV)	807	5.38		
	Atkins silt loam (AS)	113	1.10		
28-29	Oklared fine sandy loam (OF)	331	3.01	No change from above	
	Miller clay (MC)	1,238	7.99		
	Lonoke silty clay loam (LS)	717	5.12		
	Pope very fine sandy loam (PV)	807	5.38		
	Atkins silt loam (AS)	113	1.10		
30-35	Oklared fine sandy loam (OF)	331	3.01	No change from above	
	Miller clay (MC)	1,162	7.50		
	Lonoke silty clay loam (LS)	717	5.12		
	Pope very fine sandy loam (PV)	807	5.38		
	Atkins silt loam (AS)	113	1.10		
36-40	Oklared fine sandy loam (OF)	331	3.01	No change from above	
	Miller clay (MC)	1,094	7.06		
	Lonoke silty clay loam (LS)	717	5.12		
	Pope very fine sandy loam (PV)	807	5.38		
	Atkins silt loam (AS)	113	1.10		

[a]It is assumed that yields of minimum and no-tillage systems were three bushels/acre/year less than those of conventional tillage systems.

[a]Soil erosion is restricted to SCS recommended levels.

unrestricted soil erosion case is $48,272 (Table XLII). Annual income falls from $48,272 in year one to $39,714 in year 40, a decrease of 18 percent. The net present value of Representative Farm 2 is $1,095,404 for the case of unrestricted soil erosion.

In the case of restricted soil erosion to SCS recommended levels, annual income is $43,632 (Table XLII). The net present value of Representative Farm 2 is $1,090,300 when soil erosion is restricted, a decrease of 0.4 percent.

With unrestricted soil erosion, the optimum farm plan in year one includes 103 acres of improved pasture, 290 acres of conventional wheat, 131 acres of grain sorghum using minimum tillage, and 134 acres of wheat-soybeans double-cropped using conventional tillage (Table XLIII). Because of yield advantages of conventional tillage as it was assumed in Scenario 2, there was a slight shift to adoption of reduced tillage technology in the case of unrestricted soil erosion.

In the restricted soil erosion case, the farm plan includes 74 acres of improved pasture, 229 acres of conventional wheat, five acres of wheat using no-tillage, 56 acres of grain sorghum using no-tillage, 98 acres of wheat-soybeans double-cropped using conventional tillage, and 167 acres of wheat-soybeans double-cropped using no-tillage, and 167 acres of wheat-soybeans double-cropped using no-tillage. There is a larger shift to reduced tillage technology in the case of restricted soil erosion.

For Representative Farm 2 the net present value in the unrestricted soil erosion case is $1,095,404 which is higher than $1,090,300 in the restricted soil erosion case. Therefore, it may not pay for Representative Farm 2 to adopt reduced tillage technology under the assumption that yields of minimum and no-tillage systems were three bushels/acre/year less than that of conventional tillage systems.

The annual soil losses are presented in Table XLIV. Soil erosion is highest for Oklared fine sandy loam (OF) and Miller clay (MC). More adoption of reduced tillage technology results in less erosion as the farm organization changes.

Representative Farm 3

The results of the programming model for Representative Farm 3 are presented in Tables XLV-XLVII. In year one, farm income for the unrestricted soil erosion case is $72,012 (Table XLV). Annual farm income falls from $72,012 in year one to $36,343 in year 40, a decrease of 50 percent. The net present value of Representative Farm 3 is $1,294,290 for the case of unrestricted soil erosion.

In the case of restricted soil erosion, annual income is $47,727 (Table XLV). The net present value of Representative Farm 3 is $1,193,175 when soil erosion is restricted, a decrease of eight percent.

With unrestricted soil erosion, the optimum farm plan in year one includes 910 acres of soybeans using conventional tillage and 290 acres of conventional wheat-soybeans double-cropped. In year 15, the farm plan includes 325 acres of wheat using minimum tillage, 289 acres of conventional wheat, 296 acres of conventional soybeans, and 290 acres of conventional tillage wheat-soybeans double-cropped. Conventional tillage predominates the farm land because of its yield advantage over minimum and no-tillage systems. After 18 years, wheat using minimum tillage and soybeans using no-tillage came in the final plan (Table XLVI).

TABLE XLV

RETURNS TO LAND, LABOR, RISK AND MANAGEMENT FOR THE REPRESENTATIVE FARM 3 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING LOWER YIELDS FOR REDUCED TILLAGE SYSTEMS[a]

YEARS	ANNUAL INCOME	
	UNRESTRICTED SOIL EROSION	RESTRICTED SOIL EROSION[b]
1	$ 72,012	$ 47,727
2-5	66,453	47,727
6-10	59,667	47,727
11-15	54,558	47,727
16-20	50,247	47,727
21-25	46,190	47,727
26-30	42,190	47,727
31-35	39,471	47,727
36-40	36,343	47,727
Total Income (Not Discounted)[c]	$2,050,381	$1,909,080
Present Value of Income Stream Discounted @ 4 Percent	1,105,043	944,649
Salvage Value of Farm in Year 40	908,575	1,193,175
Present Value of the Farm's Salvage Value	189,247	248,526
Net Present Value of Representative Farm 1	$1,294,290	$1,193,175

[a]It is assumed that yields of minimum and no-tillage systems were three bushels/acre/year less than those of conventional tillage.

[b]Soil erosion restricted to SCS recommended levels.

[c]To obtain the total income, the income figures for the years 1 through 40 have been added together.

TABLE XLVI

THE OPTIMUM FARM ORGANIZATION OF THE REPRESENTATIVE FARM 3 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING LOWER YIELDS FOR REDUCED TILLAGE SYSTEMS[a]

YEARS		UNRESTRICTED SOIL EROSION		RESTRICTED SOIL EROSION[b]
1	910	Acres soybeans (C)[c]	84	Acres wheat (C)
	290	Acres wheat-soybeans double-cropped (MT)[d]	188	Acres wheat (MT)
			540	Acres wheat (NT)[e]
			97	Acres soybeans (NT)
			1	Acres grain sorghum (NT)
			97	Acres wheat-soybeans double-cropped (C)
			193	Acres wheat-soybeans double-cropped (NT)
2-10	370	Acres wheat (C)		No change from above
	540	Acres soybeans (C)		
	290	Acres wheat-soybeans double-cropped (C)		
11-15	289	Acres wheat (C)		No change from above
	325	Acres wheat (MT)		
	296	Acres soybeans (C)		
	290	Acres wheat-soybeans double-cropped (C)		
16-18	390	Acres wheat (C)		No change from above
	224	Acres wheat (MT)		
	181	Acres soybeans (C)		
	115	Acres soybeans (NT)		
	290	Acres wheat-soybeans double-cropped (C)		
19-27	327	Acres wheat (C)		No change from above
	287	Acres wheat (MT)		
	181	Acres soybeans (C)		
	115	Acres grain sorghum (NT)		
	290	Acres wheat-soybeans double-cropped (C)		
28-40	267	Acres wheat (C)		No change from above
	528	Acres wheat (MT)		
	115	Acres grain sorghum (NT)		
	290	Acres wheat-soybeans double-cropped (C)		

[a]It is assumed that yields of minimum and no-tillage systems were three bushels/acre/year less than those of conventional tillage system.

[b]Soil erosion is restricted to SCS recommended levels.

[c]CT = Conventional Tillage.

[d]MT = Minimum Tillage.

[e]NT = No-Tillage.

TABLE XLVII

ANNUAL SOIL LOSS FROM THE REPRESENTATIVE FARM 3 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING LOWER YIELDS FOR REDUCED TILLAGE SYSTEMS[a]

YEARS	SOIL SERIES	UNRESTRICTED SOIL EROSION Total	UNRESTRICTED SOIL EROSION Avg Tons Per Acre	RESTRICTED SOIL EROSION[b] Total	RESTRICTED SOIL EROSION[b] Avg Tons Per Acre
1	Okemah silt loam (OKA)	2,040	11.27	800	4.00
	Okemah silt loam (OKB)	2,828	9.75	1450	5.00
	Taloka silt loam (TKA)	13,582	22.12	3070	5.00
	Bates loam (BAB)	2,354	20.47	408	4.00
	Bates loam (BAC)	776	0.97	2400	3.00
2-10	Okemah silt loam (OKA)	2,040	11.27	No change from above	
	Okemah silt loam (OKB)	2,828	9.75		
	Taloka silt loam (TKA)	9,956	16.22		
	Bates loam (BAB)	2,354	20.47		
	Bates loam (BAC)	776	0.97		
11-15	Okemah silt loam (OKA)	2,040	11.27	No change from above	
	Okemah silt loam (OKB)	2,828	9.75		
	Taloka silt loam (TKA)	6,053	9.86		
	Bates loam (BAB)	2,354	20.47		
	Bates loam (BAC)	776	0.97		
16-18	Okemah silt loam (OKA)	2,040	11.27	No change from above	
	Okemah silt loam (OKB)	2,828	9.75		
	Taloka silt loam (TKA)	6,523	10.62		
	Bates loam (BAB)	589	5.12		
	Bates loam (BAC)	776	0.97		
19-27	Okemah silt loam (OKA)	2,040	11.27		
	Okemah silt loam (OKB)	2,828	9.75		
	Taloka silt loam (TKA)	6,232	10.15		
	Bates loam (BAB)	498	4.33		
	Bates loam (BAC)	776	0.97		
28-39	Okemah silt loam (OKA)	1,137	6.28	No change from above	
	Okemah silt loam (OKB)	2,828	9.75		
	Taloka silt loam (TKA)	5,105	8.31		
	Bates loam (BAB)	498	4.33		
	Bates loam (BAC)	776	0.97		
40	Okemah silt loam (OKA)	1,137	6.28	No change from above	
	Okemah silt loam (OKB)	2,828	9.75		
	Taloka silt loam (TKA)	4,703	7.66		
	Bates loam (BAB)	498	4.33		
	Bates loam (BAC)	776	0.97		

[a]It is assumed that yields of minimum and no-tillage systems were three bushels/acre/year less than those of conventional tillage system.

[b]Soil erosion is restricted to SCS recommended levels.

In the restricted soil erosion case, the farm plan includes 84 acres of conventional wheat, 188 acres of wheat using minimum tillage, 540 acres of wheat using no-tillage, 97 acres of soybeans using no-tillage, one acre of grain sorghum using no-tillage, 97 acres of conventional tillage wheat-soybeans double-cropped, and 193 acres of wheat-soybeans double-cropped using no-tillage (Table XLVI).

The annual soil losses on Representative Farm 3 are presented in Table XLVII). Soil erosion is highest for Taloka silt loam (TKA) and Bates loam (BAB) which are in soybeans. Soil erosion decreases over time as a result of the change in the farm plan towards adoption of reduced tillage technology. Based on the net present values of Representative Farm 3 in the unrestricted and restricted soil erosion cases, it would not pay for Representative Farm 3 to adopt reduced tillage technology.

Scenario 2 Summary

Based on the assumption that yields of minimum and no-tillage systems were three bushels/acre/year less than those of conventional tillage system, programming results suggest that restricting soil erosion results in an increase in the net present value of Representative Farm 1. However, restricting soil erosion results in a decrease in the net present values of Representative Farms 2 and 3.

In the case of the Representative Farm 1, the net present value of the farm for the restricted soil erosion case is $1,097,876 which compares with $1,046,102 for the unrestricted soil erosion case, an increase of five percent. Therefore, it would pay for Representative Farm 1 to adopt reduced tillage technology.

Restricting soil erosion on Representative Farm 2 decreased the net present value of the farm 0.42 percent from $1,095,404 to $1,090,800. Restricting soil erosion on Representative Farm 3 decreased the net present value of the farm eight percent from $1,294,290 to $1,193,175. Consequently, there is no incentive for Representative Farms 2 and 3 to adopt reduced tillage technology.

Scenario 3 Programming Results

Scenario 3 assumed that the yields of the minimum and no-tillage systems were three bushels/acre/year more than the yields of the conventional tillage system.

Representative Farm 1

The programming results for Representative Farm 1 are presented in Tables XLVIII-L. Annual income falls from $81,718 in year one to $69,376 in year 40, a decrease of 15 percent. The net present value of Representative Farm 1 is $1,851,288 for the case of unrestricted soil erosion.

In the case of restricted soil erosion, annual income is $80,973, a for all 40 years. The net present value of Representative Farm 1 is $2,024,324 in the restricted soil erosion case, an increase of nine percent over the unrestricted soil erosion case (Table XLVIII).

With unrestricted soil erosion in year one through five, the optimum farm plan includes 286 acres of wheat, 76 acres of soybeans, and 538 acres of wheat-soybeans double-cropped using minimum tillage (Table XLIX). In year six through 40, the farm plan changed and included 250 acres of minimum tillage wheat, 538 acres of wheat-soybeans

TABLE XLVIII

RETURNS TO LAND, LABOR, RISK AND MANAGEMENT FOR THE REPRESENTATIVE FARM 1 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING HIGHER YIELDS FOR REDUCED TILLAGE SYSTEMS[a]

YEARS	ANNUAL INCOME	
	UNRESTRICTED SOIL EROSION	RESTRICTED SOIL EROSION[b]
1	$ 81,718	$ 80,873
2-5	80,345	80,973
6-10	78,777	80,973
11-15	77,211	80,973
16-20	75,644	80,973
21-25	74,077	80,973
26-30	72,510	80,973
31-35	70,943	80,973
36-40	69,376	80,973
Total Income (Not Discounted)[c]	$3,019,039	$3,238,920
Present Value of Income Stream Discounted @ 4 Percent	1,490,030	1,602,677
Salvage Value of Farm in Year 40	1,734,400	2,024,325
Present Value of the Farm's Salvage Value	361,258	421,647
Net Present Value of Representative Farm 1	$1,851,288	$2,024,324

[a]It is assumed that yields of minimum and no-tillge systems were three bushels/acre/year more than those of conventional tillage.

[b]Soil erosion restricted to SCS recommended levels.

[c]To obtain the total income, the income figures for the years 1 through 40 have been added together.

TABLE XLIX

THE OPTIMUM FARM ORGANIZATION OF THE REPRESENTATIVE FARM 1 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING HIGHER YIELDS FOR REDUCED TILLAGE SYSTEMS[a]

YEARS	UNRESTRICTED SOIL EROSION		RESTRICTED SOIL EROSION[b]	
1-5	286	Acres wheat (MT)[c]	202	Acres wheat (MT)
	76	Acres soybeans (MT)	2	Acres soybeans (MT)
	538	Acres wheat-soybeans double-cropped (MT)	146	Acres soybeans (NT)
			403	Acres wheat-soybeans double-cropped (MT)
			147	Acres wheat-soybeans double-cropped (NT)
6-40	250	Acres wheat (MT)		No change from above
	112	Acres soybeans (NT)[d]		
	538	Acres wheat-soybeans double-cropped (MT)		

[a]It is assumed that yields of minimum and no-tillage systems were three bushels/acre/year more than those of conventional tillage.

[b]Soil erosion is restricted to SCS recommended levels.

[c]MT = Minimum Tillage.

[d]NT = No-Tillage.

TABLE L

ANNUAL SOIL LOSS FROM THE REPRESENTATIVE FARM 1 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING HIGHER YIELDS FOR REDUCED TILLAGE SYSTEMS[a]

YEARS	SOIL SERIES	UNRESTRICTED SOIL EROSION		RESTRICTED SOIL EROSION[b]	
		Total	Avg Tons Per Acre	Total	Avg Tons Per Acre
1-5	Dennis silt loam (DSL)	671	4.47	670	4.00
	Parsons silt loam (PSL)	1,198	8.15	600	4.00
	Taloka silt loam (YSL)	624	4.08	624	4.00
	Osage silt clay loam (OSCL)	2,763	6.14	2250	5.00
	Verdigris silty clay loam (VSCL)	714	1.19	120	3.00
6-40	Dennis silt loam (DSL)	671	4.47	No change from above	
	Parsons silt loam (PSL)	1,198	8.15		
	Taloka silt loam (TSL)	624	4.08		
	Osage silt clay loam (OSCL)	2,304	5.12		
	Verdigris silty clay loam (VSCL)	714	1.19		

[a]It is assumed that yields of minimum and no-tillage systems were three bushels/acre/year more than those of conventional tillage.

[b]Soil erosion is restricted to SCS recommended levels.

double-cropped using minimum tillage, and 112 acres of soybeans using no-tillage. Because of yield advantage, reduced tillage technology dominates the farm plan.

In the restricted soil erosion case, reduced tillage technology also dominates the farm plan. The optimum plan for the restricted soil erosion case includes 202 acres of wheat and 2 acres of soybeans using minimum tillage, 146 acres of soybeans and 147 acres of wheat-soybeans double-cropped using no-tillage, and 403 acres of wheat-soybeans double-cropped using minimum tillage (Table XLIX). The annual soil losses for Representative Farm 1 are presented in Table L. For the unrestricted soil erosion case, soil erosion is highest for Parsons silt loam (PSL) which is in soybeans and wheat-soybeans double-cropped.

Representative Farm 2

The programming results of Representative Farm 2 are presented in Tables LI-LIII. In the case of unrestricted soil erosion, annual income falls from $65,402 in year one to $57,294 in year 40, a decrease of 12 percent. The net present value of Representative Farm 2 is $1,524,990. In the case of restricted soil erosion, annual income is $61,911. The net present value of Representative Farm 2 is $1,547,772 when soil erosion is restricted, an increase of 1.5 percent (Table LI). In both the unrestricted and restricted soil erosion case, reduced tillage technology dominates in the farm plan shown in Table LII. The annual soil losses for Representative Farm 2 are presented in Table LIII. Since reduced tillage technology dominates in the final plan in the unrestricted and restricted soil erosion cases, soil erosion is not a problem and is even lower than the SCS recommended levels in year 34 through 40.

TABLE LI

RETURNS TO LAND, LABOR, RISK AND MANAGEMENT FOR THE REPRESENTATIVE FARM 2 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING HIGHER YIELDS FOR REDUCED TILLAGE SYSTEMS[a]

YEARS	ANNUAL INCOME	
	UNRESTRICTED SOIL EROSION	RESTRICTED SOIL EROSION[b]
1	$ 65,402	$ 61,911
2-5	64,351	61,911
6-10	63,036	61,911
11-15	61,862	61,911
16-20	60,832	61,911
21-25	59,803	61,911
26-30	58,809	61,911
31-35	57,984	61,911
36-40	57,294	61,911
Total Income (Not Discounted)[c]	$3,641,258	$2,476,440
Present Value of Income Stream Discounted @ 4 Percent	1,226,646	1,225,386
Salvage Value of Farm in Year 40	1,432,350	1,547,775
Present Value of the Farm's Salvage Value	298,344	322,386
Net Present Value of Representative Farm 1	$1,524,990	$1,547,772

[a]It is assumed that yields of minimum and no-tillage systems were three bushels/acre/year more than those of conventional tillage system.

[b]Soil erosion restricted to SCS recommended levels.

[c]To obtain the total income, the income figures for the years 1 through 40 have been added together.

TABLE LII

THE OPTIMUM FARM ORGANIZATION OF THE REPRESENTATIVE FARM 2 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING HIGHER YIELDS FOR REDUCED TILLAGE SYSTEMS[a]

YEARS		UNRESTRICTED SOIL EROSION		RESTRICTED SOIL EROSION[b]
1-12	103	Acres improved pasture	74	Acres improved pasture
	290	Acres soybeans (MT)[c]	229	Acres soybeans (MT)
	265	Acres wheat-soybeans double-cropped (MT)	82	Acres soybeans (NT)
			228	Acres wheat-soybeans double-cropped (MT)
			37	Acres wheat-soybeans double-cropped (NT)
13-28	103	Acres improved pasture		No change from above
	140	Acres soybeans (MT)		
	150	Acres grain sorghum (MT)		
	265	Acres wheat-soybeans double-cropped (MT)		
29-33	103	Acres improved pasture		No change from above
	140	Acres soybeans (MT)		
	150	Acres grain sorghum (MT)		
	155	Acres wheat-soybeans double-cropped (MT)		
	110	Acres wheat-soybeans double-cropped (NT)[d]		
34-40	103	Acres improved pasture		No change from above
	140	Acres soybeans (NT)		
	150	Acres grain sorghum (MT)		
	155	Acres wheat-soybeans double-cropped (MT)		
	110	Acres wheat-soybeans double-cropped (NT)		

[a]It is assumed that yields of minimum and no-tillage systems were three bushels/acre/year more than those of conventional tillage system.

[b]Soil erosion is restricted to SCS recommended levels.

[c]MT = Minimum Tillage.

[d]NT = No-Tillage.

TABLE LIII

ANNUAL SOIL LOSS FROM THE REPRESENTATIVE FARM 2 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING HIGHER YIELDS FOR REDUCED TILLAGE SYSTEMS[a]

YEARS	SOIL SERIES	UNRESTRICTED SOIL EROSION Total	UNRESTRICTED SOIL EROSION Avg Tons Per Acre	RESTRICTED SOIL EROSION[b] Total	RESTRICTED SOIL EROSION[b] Avg Tons Per Acre
1-12	Oklared fine sandy loam (OF)	662	6.02	550	5.00
	Miller clay (MC)	682	5.93	682	4.40
	Lonoke silty clay loam (LS)	742	5.30	700	5.00
	Pope very fine sandy loam (PV)	1,008	6.72	750	5.00
	Atkins silt loam (AS)	113	1.10	309	3.00
13-28	Oklared fine sandy loam (OF)	662	6.02	No change from above	
	Miller clay (MC)	682	5.93		
	Lonoke silty clay loam (LS)	742	5.30		
	Pope very fine sandy loam (PV)	807	5.38		
	Atkins silt loam (AS)	113	1.10		
29-33	Oklared fine sandy loam (OF)	331	3.01	No change from above	
	Miller clay (MC)	682	5.93		
	Lonoke silty clay loam (LS)	742	5.30		
	Pope very fine sandy loam (PV)	807	5.38		
	Atkins silt loam (AS)	113	1.10		
34-40	Oklared fine sandy loam (OF)	331	3.01	No change from above	
	Miller clay (MC)	683	5.93		
	Lonoke silty clay loam (LS)	322	2.30		
	Pope very fine sandy loam (PV)	807	5.38		
	Atkins silt loam (AS)	113	1.10		

[a]It is assumed that yields of minimum and no-tillage systems were three bushels/acre/year more than those of conventional tillage system.

[b]Soil erosion is restricted to SCS recommended levels.

Representative Farm 3

The programming results for Representative Farm 3 are presented in Tables LIV-LVI. In the case of unrestricted soil erosion, annual income falls from $94,719 in year one to $73,010 in year 40, a decrease of 23 percent. The net present value of Representative Farm 3 is $2,059,295. In the case of restricted soil erosion, annual income is $87,735. The net present value of Representative Farm 3 is $2,193,374 compared with $2,059,295 when soil erosion is unrestricted, an increase of seven percent when soil erosion is restricted. Because of yield advantages, the optimum farm plan includes only crops using reduced tillage technology (Table LV). Since reduced tillage technology dominates in the final plan, soil erosion decreases and is no longer a problem. The annual soil losses for Representative Farm 3 are presented in Table LVI. Soil losses stayed at 6.5 tons/acre/year for Okemah silt loam through year 16 because there was no change in the farm organization for that period of time.

Scenario 3 Summary

Based on the assumption that yields of minimum and no-tillage systems were three bushels/acre/year more than for the conventional tillage system, programming results suggest that restricting soil erosion results in an increase in the net present values of Representative Farms 1, 2 and 3. In the case of Representative Farm 1, the net present value of the farm for the restricted soil erosion case is $2,024,324 which compares with $1,851,288 for the unrestricted soil erosion case, an increase of nine percent.

TABLE LIV

RETURNS TO LAND, LABOR, RISK AND MANAGEMENT FOR THE REPRESENTATIVE FARM 3 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING HIGHER YIELDS FOR REDUCED TILLAGE SYSTEMS[a]

YEARS	ANNUAL INCOME	
	UNRESTRICTED SOIL EROSION	RESTRICTED SOIL EROSION[b]
1	$ 94,719	$ 87,735
2-5	91,140	87,735
6-10	88,140	87,735
11-15	85,248	87,735
16-20	82,694	87,735
21-25	80,206	87,735
26-30	77,719	87,735
31-35	75,231	87,735
36-40	73,010	87,735
Total Income (Not Discounted)[c]	$3,310,141	$2,509,400
Present Value of Income Stream Discounted @ 4 Percent	1,679,114	1,736,516
Salvage Value of Farm in Year 40	1,825,250	2,193,375
Present Value of the Farm's Salvage Value	380,181	456,858
Net Present Value of Representative Farm 1	$2,059,295	$2,193,374

[a]It is assumed that yields of minimum and no-tillge systems were 3 bushels/acre/year more than those of conventional tillage system.

[b]Soil erosion restricted to SCS recommended levels.

[c]To obtain the total income, the income figures for the years 1 through 40 have been added together.

TABLE LV

THE OPTIMUM FARM ORGANIZATION OF THE REPRESENTATIVE FARM 3 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING HIGHER YIELDS FOR REDUCED TILLAGE SYSTEMS[a]

YEARS		UNRESTRICTED SOIL EROSION		RESTRICTED SOIL EROSION[b]
1-3	910	Acres soybeans (MT)[c]	305	Acres wheat (MT)
	290	Acres wheat-soybeans double-cropped (MT)	79	Acres soybeans (MT)
			526	Acres soybeans (NT)
			268	Acres wheat-soybeans double-cropped (MT)
			22	Acres wheat-soybeans double-cropped (NT)
4-9	614	Acres wheat (MT)		No change from above
	296	Acres soybeans (MT)		
	290	Acres wheat-soybeans double-cropped (MT)		
10-16	614	Acres wheat (MT)		No change from above
	181	Acres soybeans (MT)		
	115	Acres soybeans (NT)[d]		
	290	Acres wheat-soybeans double-cropped (MT)		
17-35	614	Acres wheat (MT)		No change from above
	296	Acres soybeans (NT)		
	290	Acres wheat-soybeans double-cropped (MT)		
36-40	614	Acres wheat (MT)		No change from above
	296	Acres soybeans (NT)		
	290	Acres wheat-soybeans double-cropped (NT)		

[a]It is assumed that yields of minimum and no-tillage systems were three bushels/acre/year more than those of conventional tillage system.

[b]Soil erosion is restricted to SCS recommended levels.

[c]MT = Minimum Tillage.

[d]NT = No-Tillage.

TABLE LVI

ANNUAL SOIL LOSS FROM THE REPRESENTATIVE FARM 3 WITH UNRESTRICTED AND RESTRICTED SOIL EROSION, ASSUMING HIGHER YIELDS FOR REDUCED TILLAGE SYSTEMS[a]

YEARS	SOIL SERIES	UNRESTRICTED SOIL EROSION Total	UNRESTRICTED SOIL EROSION Avg Tons Per Acre	RESTRICTED SOIL EROSION[b] Total	RESTRICTED SOIL EROSION[b] Avg Tons Per Acre
1-3	Okemah silt loam (OKA)	1,177	6.50	800	4.42
	Okemah silt loam (OKB)	1,508	5.20	1450	5.00
	Taloka silt loam (TKA)	7,835	12.76	3070	5.00
	Bates loam (BAB)	1,358	11.81	408	3.55
	Bates loam (BAC)	776	0.97	2400	3.00
4-9	Okemah silt loam (OKA)	1,177	6.50	No change from above	
	Okemah silt loam (OKB)	1,508	5.20		
	Taloka silt loam (TKA)	4,703	7.66		
	Bates loam (BAB)	1,358	11.81		
	Bates loam (BAC)	776	0.97		
10-16	Okemah silt loam (OKA)	1,177	6.50	No change from above	
	Okemah silt loam (OKB)	1,508	5.20		
	Taloka silt loam (TKA)	4,703	7.66		
	Bates loam (BAB)	589	5.12		
	Bates loam (BAC)	776	0.97		
17-35	Okemah silt loam (OKA)	510	2.82	No change from above	
	Okemah silt loam (OKB)	1,508	5.20		
	Taloka silt loam (TKA)	4,703	7.66		
	Bates loam (BAB)	589	5.12		
	Bates loam (BAC)	776	0.97		
36-40	Okemah silt loam (OKA)	510	2.82		
	Okemah silt loam (OKB)	754	2.60		
	Taloka silt loam (TKA)	4,702	7.66		
	Bates loam (BAB)	589	5.12		
	Bates loam (BAC)	776	0.97		

[a]It is assumed that yields of minimum and no-tillage systems were three bushels/acre/year more than those of conventional tillage system.

[b]Soil erosion is restricted to SCS recommended levels.

Restricting soil erosion for Representative Farm 2 increased the net present value of the farm 1.5 percent from $1,524,990 to $1,547,772. In the case of Representative Farm 3, the net present value of the farm for the restricted soil erosion case is $2,193,374 which compares with $2,059,295 for the unrestricted soil erosion case, an increase of seven percent. Consequently, it pays for all three Representative Farms to adopt reduced tillage technology.

Regression Results

Some personal characteristics of the farmer were thought to be important factors in adopting reduced tillage technology. Age, education, experience in farm management and in reduced tillage technology and health status were expected to influence adoption rates. Also, the number of acres cropped were thought to be an important factor. These relationships were tested statistically using a multiple regression model. The regression results are presented in equation 23.

$$\begin{aligned} y = & -430.403\,X_0 + 0.453\,X_1 - 2.541\,X_2 + 18.790\,X_3 \\ & \;\;(-1.50)^{*} \quad\;\; (11.70) \quad\;\; (-0.39) \quad\;\; (2.59) \\ & + 6.743\,X_4 + 5.60\,X_5 - 0.021\,X_6 + 130.50\,X_7 \\ & \;\;(0.42) \quad\;\; (2.23) \quad\;\; (-0.13) \quad\;\; (1.24) \\ & - 41.720\,X_8 - 17.277\,X_9 - 0.099\,X_{10} \\ & \;\;(-0.33) \quad\;\; (-0.17) \quad\;\; (0.76) \end{aligned} \qquad (23)$$

$$R^2 = 0.76, \qquad F = 36.49$$

where y is the farmer's cropped acreage on which reduced tillage technology was used in 1982 and the X's are the personal characteristics of the farmer and the number of acres cropped as explanatory variables. Only three of the explanatory variables were statistically significant in explaining reduced tillage technology adoption. The number of

*Numbers in parantheses are T-values.

cropped acres (X_1), the farmer's years of experience in reduced tillage technology (X_3), and the farmer's age (X_5) were significant and positively related to reduced tillage technology adoption. The larger the cropped acreages and the more years of farmer experience in reduced tillage technology, the greater was the adoption of reduced tillage technology.

The signs of the regression coefficients for the explanatory variables X_2, X_5, X_6, X_8 and X_9 were not as expected. Of the significant independent variables, only the sign of the regression coefficient of the independent variable X_5 was not as expected. The regression coefficients of the independent variables X_2, X_4, X_6, X_7, X_8, X_9 and X_{10} were not significantly different from zero.

It was hypothesized that the number of soil conservation practices other than redcued tillage technology is a function of the number of tillable acres on the farm, the type of soils on the farm, age, education and the farmer's experience in farm management. This relationship was tested statistically using a second multiple regression model.

The regression results for the soil conservation practices other than reduced tillage technology are presented in equation 24.

$$C = \underset{(0.04)^*}{0.071\ D_0} + \underset{(0.34)}{0.00063\ D_1} - \underset{(-0.25)}{0.009\ D_2} + \underset{(0.55)}{0.018\ D_3} + \underset{(1.28)}{0.102\ D_4} - \underset{(-0.13)}{0.00084\ D_5} \quad (24)$$

$R^2 = 0.053$, $F = 0.55$

* = Numbers in parenthese are T-values

Results in equation 24 show that no variation in adoption rates as expressed by the R^2 could be explained by the explanatory variables. The coefficients of all explanatory variables, D_1, D_2, D_3, D_4 and D_5, were statistically not significant from zero. With the exception of the explanatory variable D_4 (education), the signs of all explanatory variables also were not as expected.

MOTAD Results

Three tillage systems were analyzed using negative deviations from an expected return as a measure of risk. Expected returns were calculated using an unequally weighted three-year moving average with weights of 0.5 for the most recent year and 0.3 and 0.2 for the two previous years, net of total variable costs. Six different income levels were specified for each tillage system to determine risk-efficient farm plans. The results are presented in Tables LVII-LXI. One of these income levels for each tillage system is its LP maximum solution, denoted with asterisks. The other five income levels for each tillage system were arbitrarily selected. Furthermore, income levels were selected to facilitate comparisons between the tillage systems, namely conventional tillage (System I), minimum tillage (System II) and no-tillage (System III).

Scenario 1

Scenario 1 assumed that the yields of the minimum and no-tillage systems were three bushels/acre/year less than the yields of the conventional tillage system. Results show the maximum expected income of tillage system III (no-tillage) is smaller than the maximum expected income of the tillage Systems I and II (conventional and minimum

TABLE LVII

RESULTS OF THE CONVENTIONAL TILLAGE SYSTEM USING MOTAD MODEL
(SYSTEM I)

FARM PLANS	UNIT	UNEQUALLY WEIGHTED THREE-YEAR MOVING AVERAGE					
Expected Income	$	35,650*	30,000	20,000	10,000	5,000	1,000
Standard Deviation	$	4,090	3,442	2,295	1,147	574	150
Coefficient of Variation	%	11.47	11.47	11.47	11.47	11.47	11.47
Wheat	Acres	392.0	330.0	220.0	110.0	55.0	11.0
Soybeans	Acres	-	-	-	-	-	-
Grain Sorghum	Acres	131.0	110.0	73.0	37.0	18.0	4.0
Wheat-Soybeans double-cropped	Acres	-	-	-	-	-	-
Land	Acres	522.0	440.0	293.0	147.0	73.0	15.0
JMLAB**	Hrs	372.0	313.0	209.0	104.0	52.0	10.0
AJLAB**	Hrs	236.0	199.0	133.0	66.0	33.0	7.0
JSLAB**	Hrs	391.0	330.0	220.0	110.0	55.0	11.0
ODLAB**	Hrs	-	-	-	-	-	-
Annual Capital	$	14,993	12,616	8,411	4,205	2,103	421
Intermediate Capital	$	64,923	54,634	36,423	18,211	9,106	1,821

*LP income maximization.

**Defined in Appendix C.

TABLE LVIII

RESULTS OF THE MINIMUM TILLAGE SYSTEM USING MOTAD MODEL AND LOWER YIELDS THAN FOR CONVENTIONAL TILLAGE (SYSTEM II)[a]

FARM PLANS	UNIT	UNEQUALLY WEIGHTED THREE-YEAR MOVING AVERAGE					
Expected Income	$	28,847*	17,000	12,000	8,000	5,000	1,000
Standard Deviation	$	2,267	1,336	943	629	393	79
Coefficient of Variation	%	7.86	7.86	7.86	7.86	7.86	7.86
Wheat	Acres	421.0	248.0	175.0	118.0	73.0	15.0
Soybeans	Acres	-	-	-	-	-	-
Grain Sorghum	Acres	8.0	5.0	3.0	2.0	1.0	1.0
Wheat-Soybeans double-cropped	Acres	-	-	-	-	-	-
Land	Acres	429.0	253.0	178.0	119.0	74.0	15.0
JMLAB**	Hrs	214.0	126.0	89.0	59.0	37.0	7.0
AJLAB**	Hrs	105.0	62.0	44.0	29.0	18.0	4.0
JSLAB**	Hrs	215.0	127.0	89.0	60.0	37.0	7.0
ODLAB**	Hrs	-	-	-	-	-	-
Annual Capital	$	16,320	9,618	6,789	4,526	2,829	566
Intermediate Capital	$	42,980	25,329	17,879	11,919	7,450	1,490

[a]Assuming that the yields for minimum tillage were 3 bushels/acre/year less than those of conventional tillage.

*LP income maximization.

**Defined in Appendix C.

TABLE LIX

RESULTS OF THE NO-TILLAGE SYSTEM USING MOTAL MODEL AND LOWER YIELDS THAN FOR CONVENTIONAL TILLAGE (SYSTEM III)[a]

FARM PLANS	UNIT	UNEQUALLY WEIGHTED THREE-YEAR MOVING AVERAGE					
Expected Income	$	23,397*	20,000	15,000	10,000	5,000	1,000
Standard Deviation	$	2,118	1,729	1,297	864	432	86
Coefficient of Variation	%	9.05	8.65	8.65	8.65	8.65	8.65
Wheat	Acres	383.0	340.0	255.0	170.0	85.0	17.0
Soybeans	Acres	-	-	-	-	-	-
Grain Sorghum	Acres	-	15.0	11.0	8.0	4.0	1.0
Wheat-Soybeans double-cropped	Acres	12.0	-	-	-	-	-
Land	Acres	396.0	355.0	266.0	177.0	89.0	18.0
JMLAB**	Hrs	112.0	104.0	78.0	52.0	26.0	5.0
AJLAB**	Hrs	63.0	54.0	40.0	27.0	13.0	3.0
JSLAB**	Hrs	115.0	105.0	79.0	53.0	26.0	5.0
ODLAB**	Hrs	8.0	-	-	-	-	-
Annual Capital	$	19,685	17,011	12,759	8,506	4,253	851
Intermediate Capital	$	38,788	33,565	25,173	16,782	8,391	1,678

[a]Assuming that the yields of no-tillage were 3 bushels/acre/year less than those of conventional tillage.

*LP income maximization.

**Defined in Appendix C.

TABLE LX

RESULTS OF THE MINIMUM TILLAGE SYSTEM USING MOTAD MODEL AND HIGHER YIELDS THAN FOR CONVENTIONAL TILLAGE (SYSTEM II)[a]

FARM PLANS	UNIT	UNEQUALLY WEIGHTED THREE-YEAR MOVING AVERAGE					
Expected Income	$	54,414*	40,000	30,000	20,000	10,000	5,000
Standard Deviation	$	6,078	2,167	1,625	1,083	542	271
Coefficient of Variation	%	11.17	5.42	5.42	5.42	5.42	5.42
Wheat	Acres	329.0	421.0	316.0	210.0	105.0	53.0
Soybeans	Acres	-	-	-	-	-	-
Grain Sorghum	Acres	-	35.0	26.0	17.0	9.0	4.0
Wheat-Soybeans double-cropped	Acres	-	-	-	-	-	-
Land	Acres	594.0	456.0	342.0	228.0	114.0	57.0
JMLAB**	Hrs	244.0	226.0	170.0	113.0	57.0	28.0
AJLAB**	Hrs	256.0	120.0	90.0	60.0	30.0	15.0
JSLAB**	Hrs	255.0	231.0	173.0	115.0	58.0	29.0
ODLAB**	Hrs	106.0	-	-	-	-	-
Annual Capital	$	19,685	16,832	12,624	8,416	4,208	2,104
Intermediate Capital	$	61,459	46,302	34,727	23,151	11,576	5,788

[a]Assuming that the yields of minimum tillage were 3 bushels/acre/year more than those of conventional tillage.

*LP income maximization.

**Defined in Appendix C.

TABLE LXI

RESULTS OF THE NO-TILLAGE SYSTEM USING MOTAD MODEL AND HIGHER YIELDS THAN FOR CONVENTIONAL TILLAGE (SYSTEM III)[a]

FARM PLANS	UNIT	UNEQUALLY WEIGHTED THREE-YEAR MOVING AVERAGE					
Expected Income	$	43,862*	30,000	20,000	10,000	5,000	1,000
Standard Deviation	$	5,702	1,946	1,297	649	324	85
Coefficient of Variation	%	13.0	6.49	6.49	6.49	6.49	8.50
Wheat	Acres	62.0	360.0	240.0	120.0	60.0	12.0
Soybeans	Acres	-	-	-	-	-	-
Grain Sorghum	Acres	-	18.0	12.0	6.0	3.0	1.0
Wheat-Soybeans double-cropped	Acres	240.0	-	-	-	-	-
Land	Acres	302.0	378.0	252.0	126.0	63.0	13.0
JMLAB**	Hrs	40.0	111.0	74.0	37.0	18.0	4.0
AJLAB**	Hrs	184.0	58.0	38.0	19.0	10.0	2.0
JSLAB**	Hrs	90.0	112.0	75.0	37.0	19.0	4.0
ODLAB**	Hrs	149.0	-	-	-	-	-
Annual Capital	$	19,685	18.079	12,053	6,026	3,013	603
Intermediate Capital	$	61,515	35,810	23,874	11,937	5,968	1,194

[a]Assuming that the yields of no-tillage were 3 bushels/acre/year more than those of conventional tillage.

*LP income maximization.

**Defined in Appendix C.

tillage). The maximum expected income of the optimal farm organization derived by LP for tillage system III is $23,397, compared to $35,650 and $28,847 for tillage systems I and II, respectively (Tables LVII-LIX). The farm plans differ considerably. In all three tillage systems, wheat and grain sorghum were profitable and thus appeared in the final plan. However, the wheat-soybeans double-cropped activity was only profitable in tillage system II. The plans also differ in regards to labor and capital. However, in all three tillage systems, labor and capital activities were profitable and thus appeared in the final plan. Standard deviation and relative variation in net returns, as measured by the coefficient of variation are highest for tillage system I (conventional tillage).

As the expected income level is reduced and variation in net returns becomes important, the resulting farm plans become more diversified. Different measures of variation result in the selection of quite different risk-efficient farm plans. When the expected income level is set at $20,000, it is seen that tillage system II (minimum tillage) results in a less risky plan than the tillage systems I and III. The standard deviation is $1,576 compared to $2,295 and $1,729. At this income level wheat-soybeans double-cropped is not included in the plans of minimum and conventional tillage systems (systems II and I), soybeans is not included in tillage systems I, II and III (conventional, minimum and no-tillage) and grain sorghum is included in all three tillage systems.

Similarly, when income is set at $5,000 the resulting farm plan of tillage system II (minimum tillage) is less risky and much more diversified than the tillage systems I and III. Standard deviation and relative variability of tillage system II (minimum tillage) are smaller than for tillage systems I and III at $5,000 income level.

For all three tillage systems, starting at the maximum expected income and moving to the left on the risk-efficiency frontier (Figure 2), results in a reduction in risk as measured by either total negative deviation or the standard deviation. Moving to the right along the risk-efficiency frontier, greater amounts of risk have to be assumed by the farmer or the decision-maker to obtain a given increase in expected income.

Scenario 2

Scenario 2 assumed that the yields of minimum and no-tillage systems were three bushels/acre/year more than the yields of the conventional tillage system.

Results show that the maximum expected income of tillage system II (minimum tillage) is higher than the maximum expected income of the tillage system I and III (conventional and no-tillage). The maximum expected income of the optimal farm organization derived by LP for tillage system II is $54,414 as compared to $35,650 and $43,862 for tillage systems I and III, respectively (Tables LX-LXI). In all three tillage systems, wheat and grain sorghum activities were profitable and thus appeared in the final plan. However, the wheat-soybeans double-cropped activity was only profitable in tillage system III. Soybeans activity was not profitable in all three tillage systems. Capital and labor activities were profitable in all three tillage systems. Standard deviation and relative variation in net returns are highest for tillage system I (conventional tillage).

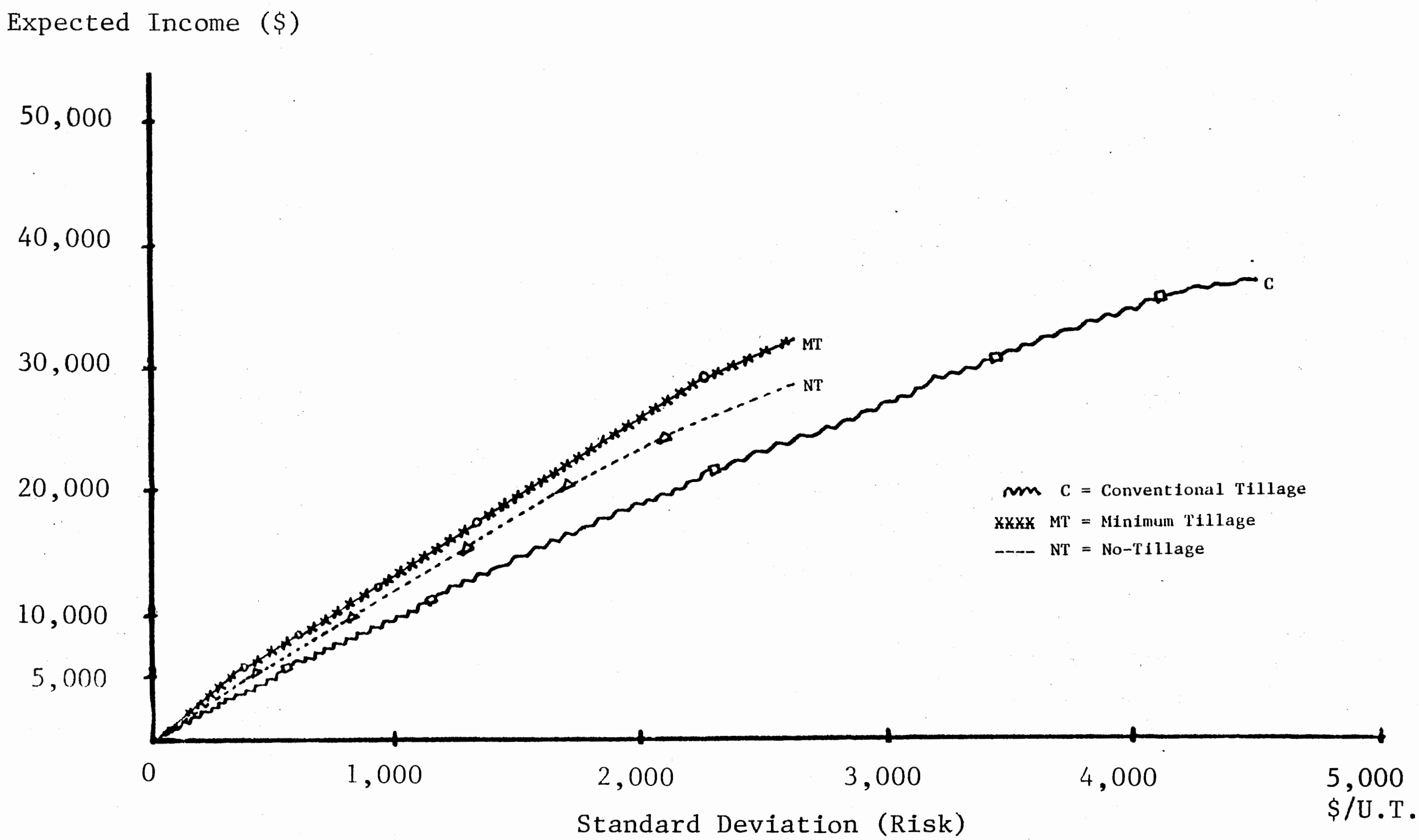

Figure 2. Risk-Efficiency Frontier for Conventional, Minimum and No-Tillage Systems, Assuming Lower Yields for Reduced Tillage Systems (Scenario 1)

When the expected income level is set at $30,000, it can be seen that tillage system II (minimum tillage) results in a less risky plan than the tillage systems I and III. The standard deviation is $1,625 compared to $3,442 and $1,946. At this income level, only wheat and soybeans are included in all three tillage systems. Similarly, when income is set at $10,000, the resulting farm plan of tillage system II (minimum tillage) is less risky than the tillage systems I and III. Standard deviation and relative variability of tillage system II (minimum tillage) are smaller than for tillage systems I and III at $10,000 income level. The trade-off between expected income and risk is shown in Figure 3.

In the case of Scenarios 1 and 2 using the MOTAD model, the resulting efficient frontiers are illustrated in Figures 2 and 3. Net return above variable costs was varied in $5,000 to $10,000 intervals. There is a specific farm plan associated with each point on the frontier. Diversification has a major impact on risk and net return. The more diversified farm plans have lower levels of net return and risk. The trade-off between returns and risk is expressed by the coefficient of variation. As net return decreases, the coefficient of variation is reduced which shows that risk per unit of expected return in reduced.

An efficient frontier provides information with regard to the trade-off between risk and return in farm enterprise choice decisions. The frontier is efficient because it represents a series of farm enterprise combinations, each of which having minimum risk for a specified level of return. In addition, moving to the left on the

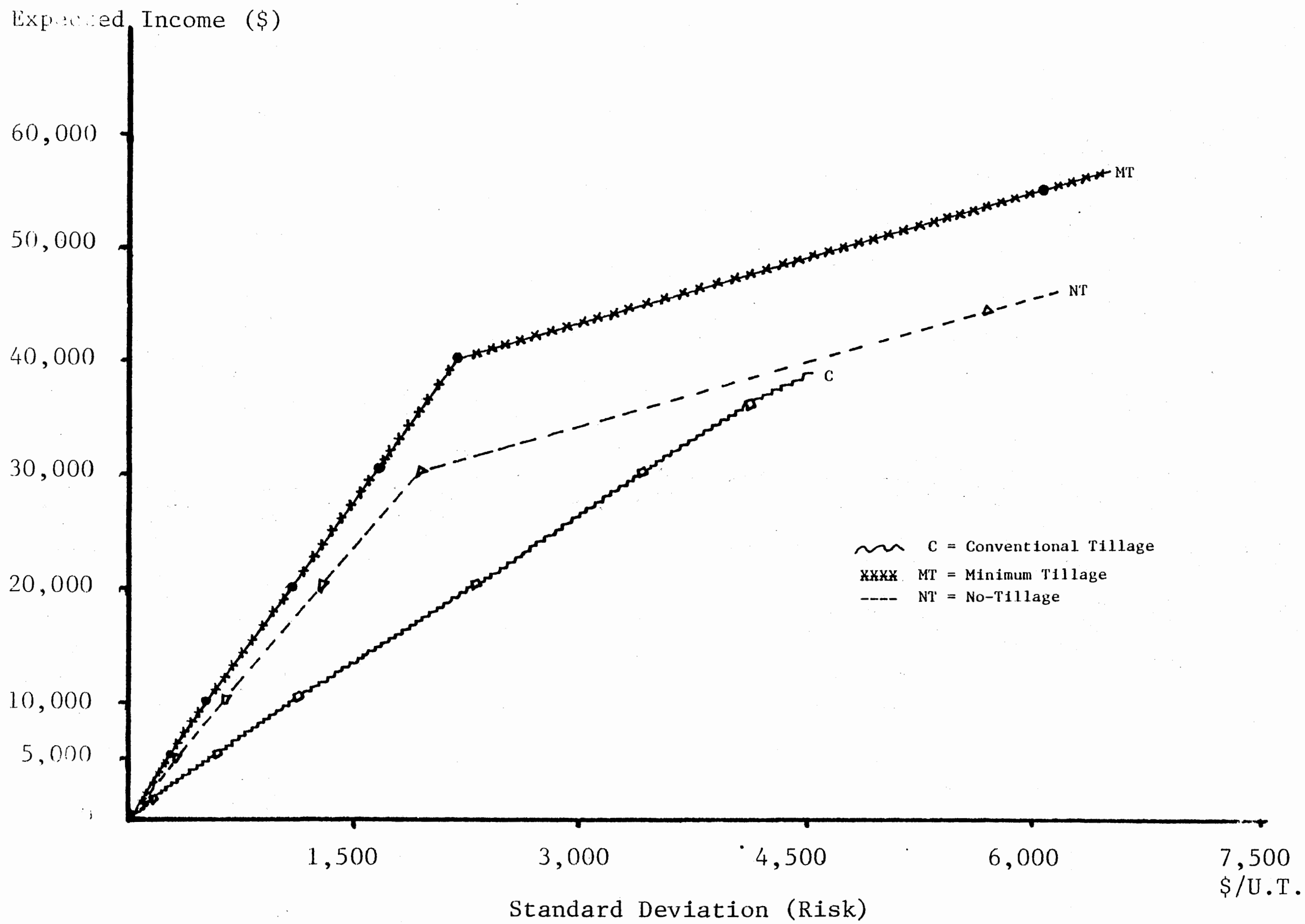

Figure 3. Risk-Efficiency Frontier for Conventional, Minimum and No-Tillage Systems, Assuming Higher Yields for Reduced Tillage Systems (Scenario 2)

risk-efficiency frontier is associated with less risk. Moving to the right along the risk-efficiency frontier is associated with more risk if a higher income is to be expected.

CHAPTER VII

SUMMARY AND CONCLUSIONS

Summary

This study analyzed the short term and long term impact of restricting soil erosion on income at the farm level. Reduced tillage technology (minimum tillage and no-tillage) as a best management practice (BMP) to control soil erosion was selected for this study.

Farmers in eastern Oklahoma were interviewed concerning their attitudes on adoption of reduced tillage technology and costs for minimum tillage and no-tillage. A list of names of farmers who used or were planning to use reduced tillage technology was obtained with the help of Soil Conservation District Conservationists and OSU County Extension Directors. The eastern Oklahoma counties included in the survey were Craig, LeFlore, Okmulgee, Ottawa and Wagoner.

Selected Representative Farms were developed for Craig, LeFlore and Okmulgee counties. The Craig County Representative Farm is also applicable to Wagoner and Ottawa counties. The three Representative Farms were used to examine the impact of restricting soil erosion on current and future farm income.

Production cost estimates for various crop enterprises using reduced tillage technology were calculated using the information obtained from the survey. Production costs estimates for various crop enterprises using conventional tillage were based on information obtained from the Oklahoma State University Enterprise Budget Generator. The crop enterprises included pasture, wheat, soybeans and grain sorghum. The BMP's used were pasture management, minimum tillage, no-tillage and conventional tillage. Double-cropping soybeans after wheat was also considered in the analysis.

On the average, farmers in the survey were about 44 years of age, have competed high school, have been farming most of their lives, and have been using reduced tillage technology in the last three years. They farm an average size of nearly 1,405 tillage acres of which about one third is owned and the remaining two thirds are rented in from others. The average acres cropped were about 853. Eighteen percent of the total acres cropped was double-cropped. About 95 percent of the farmers in the survey were part-owner operators. Reduced tillage is being employed on 42 percent of the acres cropped, with minimum tillage being the predominant form of reduced tillage system. Reasons for adopting reduced tillage technology agree with the notions that reduced tillage technology is labor and fuel cost reducing and soil conserving.

Farmer's rankings of reasons for adopting reduced tillage technology were: (1) reduced labor cost; (2) reduces fuel cost; (3) reduces soil erosion; (4 and 5) timeliness and conserves moisture with the same ranking; (6) conserves future soil productivity;(7) reduces equipment cost; and, (8) increases yield.

A linear programming (LP) model was developed and applied using the costs and returns estimated from the enterprise budgets. The LP model maximized net returns to farm land, labor, risk and management subject to the resource constraints. The resource constraints included land, labor, capital and AUM's (Animal Unit Months of grazing). In the case of restricted soil erosion, another constraint was added, namely the restricted soil erosion recommended by SCS according to soil types. Two cases were used for each of the three representative farms: (1) an unrestricted soil erosion case; and (2) a restricted soil erosion case based on SCS recommended T-values or soil loss limits. A planning horizon of 40 years and a discount rate of four percent were assumed in this analysis. Three Scenarios were used for each of the three Representative Farms: (1) Scenario 1 assumed that the yields were the same for all three tillage systems; (2) Scenario 2 assumed that the yields of minimum and no-tillage systems were three bushels/acre/year less than those of the conventional tillage system; and (3) Scenario 3 assumed that the yields of minimum and no-tillage systems were three bushels/acre/year more than those of the conventional tillage system.

Soil loss coefficients were estimated for different types of soils on all three Representative Farms using the Universal Soil Loss Equation (USLE). These soil loss coefficients were converted into inches of soil per year to calculate the yield reducitons associated with the loss of topsoil for the different types of soils using conventional, minimum and no-tillage systems. For this purpose, it was assumed that a loss of five percent of the topsoil reduced the yield of wheat by one bushel. Adjustments have been made for yields of other crops to be comparable with wheat yield reduction. This soil erosion and crop yields relationship was incorporated into the objective function of the LP model to examine the impact of soil erosion on farm income for the 40 year period.

LP Results

Based on the assumption that the farmer's objective was to maximize the net present value of the farm for a planning horizon of 40 years, and yields were the same for conventional, minimum, and no-tillage systems, restricting soil erosion had no adverse impact on all three representative farms. However, there was an adverse impact on the farm' incomes in the short run from restricting soil erosion. In the long run, for all three representative farms, it was profitable to adopt reduced tillage technology to control soil erosion. The net present value for Representative Farm 1 increased 9 percent, from $1,108,318 in the unrestricted soil erosion case to $1,211,623 in the restricted soil erosion case. The net present value of Representative Farm 2, increased 5 percent from $1,228,741 in the unrestricted soil erosion case to $1,287,398 in the restricted soil erosion case. The net present value of Representative Farm 3 has increased 8 percent from $1,528,885 in the unrestricted soil erosion case to $1,654,547 in the restricted soil erosion case.

Based on the assumption that yields of minimum and no-tillage systems were three bushels/acre/year less than those of conventional tillage (Scenario 2), restricting soil erosion results in an increase in the net present value of Representative Farm 1 and a decrease in the net present values of Representative Farms 2 and 3.

In the case of the Representative Farm 1, the net present value of the farm for the restricted soil erosion case is $1,097,876 which compares with $1,046,102 for the unrestricted soil erosion case, an increase of five percent. Restricting soil erosion on Representative

Farm 2 decreased the net present value of the farm 0.42 percent from $1,095,404 to $1,090,800. Restricting soil erosion on Representative Farm 3 decreased the net present value of the farm eight percent from $1,294,290 to $1,193,175.

In the case of Scenario 3, which assumed that the yields of the minimum and no-tillage systems were three bushels/acre/year more than the yields of the conventional tillage system, restricting soil erosion results in an increase in the net present values of Representative Farms 1, 2 and 3. In the case of Representative Farm 1, the net present value of the farm for the restricted soil erosion case is $2,024,324 which compares with $1,851,288 for the unrestricted soil erosion case, an increase of nine percent. Restricting soil erosion for Representative Farm 2 increased the net present value of the farm 1.5 percent from $1,524,990 to $1,547,772. In the case of the Representative Farm 3, the net present value of the farm for the restricted soil erosion case is $2,193,374 which compares with $2,059,295 for the unrestricted soil erosion case, an increase of seven percent.

Since the net present value of all three representative farms has increased by restricting soil erosion to SCS recommended levels in scenario 1 and 3, an educational program would be an appropriate policy to control soil erosion. For the short term adverse impact on the farm income, a subsidy payment program would be an appropriate policy alternative. In the case of Scenario 2, only the net present value of Representative Farm 1 has increased by restricting soil erosion to SCS recommended levels. However, the net present value of Representative Farms 2 and 3 has decreased when soil erosion is restricted.

Regression Results

Attitudes on adoption of reduced tillage technology have been analyzed in identifying farmers' characteristics and adoption rates of reduced tillage technology and examining some socio-economic factors which explain the adoption of this new technology. A multiple regression was developed and applied for the analysis on farmers' attitudes using the information obtained from the survey.

Only three of the explanatory variables were statistically significant in explaining reduced tillage technology adoption. The number of cropped acres (X_1), the farmer's years of experience in reduced tillage technology (X_3) and the farmer's age (X_5), were significant and positively related to reduced tillage technology adoption. The larger the cropped acreage and the more years of farmer experience in reduced tillage technology, the greater was the adoption of reduced tillage technology.

A second multiple regression was developed and used to test the hypothesis that the number of soil conservation practices other than reduced tillage technology is a function of the number of tillable acres on the farm, the type of soils on the farm, age, education,and the farmer's experience in farm management.

As far as soil conservation practices other than reduced tillage technology is concerned, no variation in adoption rates as expressed by the R^2 could be explained by the explanatory variables. The coefficients of all explanatory variables D_1, D_2, D_3, D_4 and D_5 were statistically not significant.

MOTAD Results

Risk and uncertainty in farm planning analysis have been analyzed in this study. For this purpose, information obtained from the survey for Representative Farm 3 and additional secondary data on yields and prices were used. A MOTAD model was developed and used to analyze conventional, minimum and no-tillage systems using negative deviations from an expected return as a measure of risk. Expected returns were calculated using an unequally weighted three-year moving average with weights of 0.5 for the most recent year and 0.3 and 0.2 for the two previous years, net of total variable costs.

Six different income levels were specified for each tillage system to determine risk-efficient farm plans. The highest of these income levels for each tillage system is its LP maximum solution. The other five income levels for each tillage system were arbitrarily selected. Furthermore, income levels were selected to facilitate comparisons between the tillage systems, namely conventional tillage (system I), minimum tillage (system II), and no-tillage (system III).

Two scenarios were used in the MOTAD analysis: (1) Scenario 1 assumed that the yields of minimum and no-tillage systems were three bushels/acre/year less than those of the conventional tillage system; and (2) Scenario 2 assumed that the yields of minimum and no-tillage systems were three bushels/acre/year more than those of the conventional tillage system.

In the case of Scenario 1, MOTAD results show that the maximum expected income of tillage system III (no-tillage) was smaller than the maximum expected income of the tillage systems I and II (conventional and minimum tillage). The maximum expected income of the optimal farm organization derived by LP for tillage system III was $23,397 as compared to $35,650 and $28,847 for tillage systems I and II, respectively. In all three tillage systems, wheat and grain sorghum were profitable and this appreared in the final plan. However, the wheat-soybeans double-cropped activity was only profitable in tillage system II. Also, labor and capital activities were profitable and thus appeared in the final plan in all three tillage systems.

Standard deviation and the coefficient of variation are highest for tillage system I (conventional tillage). When the expected income level is set at $20,000, it can be seen that tillage system II (minimum tillage) results in a less risky plan than tillage systems I and III. The standard deviation is $1,576 compared to $2,295 and $1,729. Similarly, when income is set at $5,000, the resulting farm plan of tillage system II (minimum tillage) is less risky than the tillage systems I and III. Standard deviation and the coefficient of variation of tillage system II (minimum tillage) are smaller than for tillage systems I and III at the $5,000 income level.

In the case of Scenario 2, MOTAD results show that the maximum expected income of tillage system II (minimum tillage) is higher than the maximum expected income of tillage systems I and III (conventional and no-tillage). The maximum expected income of the optimal farm organization derived by LP for tillage system II is $54,414 as compared to $35,650 and $43,862 for tillage systems I and III, respectively. In all three tillage systems, wheat and grain sorghum activities were profitable and thus appeared in the final plan. However, the wheat-soybeans double-cropped activity was only profitable in tillage system III. Soybeans activity was not profitable in all three tillage systems. Capital and labor activities were profitable in all three tillage systems. Standard deviation and coefficient of variation in net returns are highest for tillage system I (conventional tillage).

When the expected income level is set at $30,000, it can be seen that tillage system II (minimum tillage) results in a less risky plan than tillage systems I and III. The standard deviation is $1,625 compared to $3,442 and $1,946. At this income level, only wheat and soybeans are included in all three tillage system. Similarly, when income is set at $10,000, the resulting farm plan of tillage system II (minimum tillage) is less risky than tillage systems I and III. Standard deviation and coefficient of variation of tillage system II (minimum tillage) are smaller than for tillage systems I and III at $10,000 income level. The trade-off between expected income and risk associated with all three tillage systems is shown in Figures 2 and 3 for Scenarios 1 and 2, respectively.

Moving to the left on the risk-efficiency frontier resulted in a reduction in risk as measured by either total negative deviation or the standard deviation. Moving to the right along the risk-efficiency frontier resulted in greater amounts of risk being assumed by the farmer or the decision-maker to obtain a given increase in expected income.

Limitations and Recommendations for Future Research

This study has shortcomings which could be traced to the establishment of soil loss and soil productivity relationship. Research is needed to determine the soil loss and soil productivity relationship at the national, regional and farm level. Soil experiments related to soil loss and crop yields would help solve the soil loss and soil productivity problem. Non-availability of yield data for minimum and no-tillage systems is also a limitation. Therefore, there is a need for more research on yields for those tillage systems.

Another limitation of this study is the arbitrariness of the decision critera to be used in the analysis to measure risk. In addition, how expectations are formed to be used in the MOTAD model raises questions. The chosen weights of 0.5 for the most recent year and 0.3 and 0.2 for the two previous years for the three-year moving average are arbitrary. With this regard more research and more farmers' interviews are needed. Also, the resulting efficiency frontier is not uniform for all farmers or decision-makers; each decision-maker can choose a farm enterprise plan and return-risk situation which is consistent with his preference and goals. More research is needed for different situations and different farms to provide a wide range of farm enterprise plans and return-risk situations.

More field (test) data on relationships between yields and minimum tillage and no-tillage are needed. Also there is a need for more data on inches of top soil remaining and yield reductions as top soil is lost by soil type (depends on class B horizon). Moreover, there is future research potential and need for a better way to measure farmers' ability to take risks and when to take risks.

Policy Implementations

Public policies that can reduce or control soil erosion include direct regulations, provision of economic incentives, taxation, education and public investment. The economic incentive option include alternatives such as federal or state cost-sharing for adoption of reduced tillage technology, and desincentives such as taxes on soil erosion. For all three representative farms, education is the most viable and appropriate policy option because adoption of reduced tillage technology is profitable and can increase farmers' incomes.

However, there are policy options that can be implemented to compensate for the decrease in farm income in the short run. One policy option would be a subsidy payment to the farm for adoption of reduced tillage technology as a soil conservation practice. The amount of the subsidy payment would be the decrease in income as a result of restricting soil erosion or the difference between the income in the unrestricted soil erosion case and the income in the restricted soil erosion case.

Another policy option would be to restrict soil loss, but to a higher level than the SCS tolerance limits (T-values). Findings of this study suggest that the income level is the same for both the unrestricted and restricted soil erosion case when soil loss was restricted to about 10 tons per acre per year instead of the SCS recommended tolerance level. This was the case for all three representative farms. Another option would be a soil loss tax policy, which may not be practical or easy to implement. A combination of the above policy options may provide a good solution to the problem.

To summarize the soil erosion control options, the following policies may be considered: (1) restricting soil loss to SCS recommended levels; (2) restricting soil loss to 10 tons per acre per year; (3) subsidy payments or cost-sharing arrangements of 50 percent or more on chemicals and equipment for the adoption of reduced tillage technology; (4) taxes on soil loss; (5) education programs to inform farmers about reduced tillage technology and to provide them with complete information on the economics of this technology and on reduced tillage equipment and chemicals; (6) restricting soil loss to SCS tolerance limit with a 50 percent cost-sharing program on chemicals and equipment; (7) restricting soil loss to be greater than the SCS tolerance or T-value for those soil types, with a 50 percent cost-sharing policy on chemicals and equipment; (8) subsidy payment with education program; and (9) restricting soil loss to SCS tolerance level with a 50 percent cost-sharing on chemicals and equipment and with an educational program.

Of the above policy alternatives, a combination of restricting soil loss to SCS recommended tolerance level with a 50 percent cost-sharing on chemicals and equipment of reduced tillage technology may provide the best solution to the problem. Another good solution would be a combination of restricting soil loss to 10 tons per acre per year with an educational program.

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APPENDICES

APPENDIX A

A COPY OF THE SURVEY FORM

CONFIDENTIAL

SURVEY ON ATTITUDES ON ADOPTION OF REDUCED TILLAGE TECHNOLOGY BY FARMERS IN EASTERN OKLAHOMA

Oklahoma State University
Department of Agricultural Economics
Stillwater, Oklahoma 74074
Summer, 1982

I. GENERAL

NAME ______________________________

ADDRESS ______________________________

COUNTY ____________________ TELEPHONE ____________

1. Age of operator: (circle appropriate letter)
   - A. under 25 — C. 35-44 — E. 55-64
   - B. 25-34 — D. 45-54 — F. 65 and over

2. Education of operator: (circle the highest number of years of school completed)

   Less than 6, 7, 8, Elementary — 9, 10, 11, 12 High School — 13, 14, 15, 16. 17, 18, or more College

3. Experience of operator in:
   - A. Farm management ____________ years
   - B. Reduced tillage farming ____________ years

4. For how long have you operated or owned this farm? __________ years

5a) How often do you use OSU extension and SCS information (fact sheets, bulletins, frequency of attending group programs organized and sponsored by the extension service on new information, e.g., new products and procedures)
   - A. Frequently — C. Seldom
   - B. Sometimes — D. Never

b) How often do you use the district SCS services?
   - A. Frequently — C. Seldom
   - B. Sometimes — D. Never

6. Do you intend to retire, sell, or cease operating the farm in the next five (5) years? YES ______ NO ______

7. If you do plan to discontinue operating the farm, will one or more of your children operate the farm? YES ______ NO ______

   Please explain: ______________________________

   ____

   ____

   ____

   ____

I. GENERAL (con't.)

8. Total acres operated ____________; acres cropped ____________
   A. Acres owned and operated by you ____________
   B. Acres rented in and operated by you ____________
      a. Cash lease ____________
      b. Share lease ____________
      c. Other (specify) ____________
   C. Acres rented out to others to operate ____________
      a. Cash lease ____________
      b. Share lease ____________
      c. Other (specify) ____________

9. Type of farm organization: (circle appropriate letter)
   A. Sole proprietor (individually operated) ____________
   B. Family ownership (exclude partnership & corporations) ____________
   C. Partnership with family members ____________
   D. Partnership with non-family members ____________
   E. Family corporation ____________
   F. Non-farm corporation ____________
   G. Other (specify) ____________

10. Types of soils and acres of each ____________
____
____
____
____

11. Tenancy
   A. Full-owner operator ____________ Cash rent operator only ____________
      Part-owner operator ____________ Crop-share rent operator only ____________
   B. Do you consider yourself to be:
      a. Part-time farmer ____________
      b. full-time farmer ____________
      c. If you work off the farm, how many hours per week, weeks, and/or days per year do you work off the farm? ____________

12. Percent of family income from the farm?
   A. 100% ____________ D. 40-59% ____________
   B. 80-99% ____________ E. 20-39% ____________
   C. 60-79% ____________ F. 0-19% ____________

I. GENERAL (con't.)

13. Type of operation (number of acres or head for each, if appropriate)

A. Beef cattle ________
B. Dairy ________
C. Alfalfa ________
D. Wheat ________
E. Other small grains ________ (barley or oats) ________
F. Soybeans ________
G. Corn ________
H. Grain sorghum ________
I. Cotton ________
J. Melons ________
K. Peanuts ________
L. Other (specify) ________

14. What type of crop rotation practices are you following? (Ex. grain sorgnum after soybeans one year and wheat after soybeans next year). Please explain and indicate acres involved. ________________

____

____

____

15. Did you have CAPITAL EXPENDITURES during the last three years for

A. Terraces YES ________ NO ________ WHEN ________
B. Grass waterways YES ________ NO ________ WHEN ________
C. Cover establishment YES ________ NO ________ WHEN ________

16. Have you participated in ACP cost-sharing program on the following:

A. Terraces; YES_____ NO_____ If yes, how many linear feet on how many acres? ________________ Cost-sharing rate ____________ (% paid by government)

B. Grass waterways; YES_____ NO_____ If yes, how many acres on how many fields? ________________ Cost-sharing rate ____________ (% paid by government)

C. Cover establishment; YES_____ NO_____ If yes, how many acres?________ Cost-sharing rate ________________ (% paid by government)

17. Value per acre of cropland (without mineral rights):

A. No response
B. $ 1 - 99
C. $100 - 299
D. $300 - 499
E. $500 - 699
F. $700 - 899
G. $ 900 - 1,099
H. $1,100 - 1,299
I. $1,300 - 1,499
J. $1,500 - 1,699
K. $1,700 - 1,899
L. $1,900 and more

II. REDUCED (minimum and zero-till) TILLAGE

1a) What should OSU be doing in the area of reduced tillage technology?

____

____

____

b) What should SCS be doing in the area of reduced tillage technology?

____

____

____

2. Did you have CAPITAL EXPENDITURES during the last three years for reduced tillage equipment?

YES ________ NO ________ WHEN ________

3. Do you own reduced-till (minimum or zero-till)

planter? YES ________ NO ________

drill? YES ________ NO ________

4. Which of the other following equipment do you have?

	SIZE	QUANTITY	YEAR OF PURCHASE
A. Chisel plow			
B. Moldboard plow			
C. Field cultivator			
D. Disk (tandem)			
E. Offset disk			
F. Other equipment:			

5. If you do not own a (no-till, slot-till, zero-till, sidewinder, buffalo or stubble) planter, or a drill, have you rented or leased one, or have you hired (custom hired) someone to use one on your farm?

YES________ NO________ Explain which: ______________

6. If you do not own reduced tillage planting equipment, do you plan to purchase such equipment (no-till, slot-till, zero-till, sidewinder, buffalo, or stubble planter or drill) within the next 2-3 years?

YES________ NO________

7. Would you lease reduced tillage planting equipment if it were available for leasing at reasonable prices?

YES________ NO________ How much would you pay to lease this equipment?

____

II. REDUCED (minimum and zero-till) TILLAGE (con't.)

8. In the blanks below, indicate the number of acres of the following crops planted in 1981 and 1982 under each of the tillage systems listed.

A. LAND OWNED AND OPERATED BY YOU

	Reduced Tillage		Conventional Tillage		
	No Till	Minimum Till	Moldboard Plow	Chisel Plow	Other
Wheat (1981)	____	____	____	____	____
Wheat in sod pasture	____	____	____	____	____
Soybeans	____	____	____	____	____
Corn	____	____	____	____	____
Grain sorghum	____	____	____	____	____
Grain sorghum (1981)	____	____	____	____	____
Others specify ________	____	____	____	____	____
________	____	____	____	____	____
________	____	____	____	____	____

B. LAND RENTED IN AND OPERATED BY YOU

	Reduced Tillage		Conventional Tillage		
	No Till	Minimum Till	Moldboard Plow	Chisel Plow	Other
Wheat (1981)	____	____	____	____	____
Wheat in sod pasture	____	____	____	____	____
Soybeans	____	____	____	____	____
Corn	____	____	____	____	____
Grain sorghum	____	____	____	____	____
Grain sorghum (1981)	____	____	____	____	____
Others specify ________	____	____	____	____	____
________	____	____	____	____	____
________	____	____	____	____	____

II. REDUCED (minimum and zero-till) TILLAGE (con't.)

8 C. LAND OWNED BUT RENTED OUT TO OTHERS

	Reduced Tillage		Conventional Tillage		
	No Till	Minimum Till	Moldboard Plow	Chisel Plow	Other
Wheat (1981)	______	______	______	______	______
Wheat in sod pasture	______	______	______	______	______
Soybeans	______	______	______	______	______
Corn	______	______	______	______	______
Grain sorghum	______	______	______	______	______
Grain sorghum (1981)	______	______	______	______	______
Others specify ______	______	______	______	______	______
______	______	______	______	______	______
______	______	______	______	______	______

9. Do you have a field boom sprayer? YES________ NO________

10. If you do not have one, have you rented or leased one, or have you hired (custom hired) someone to spray (ground or airplane) on your farm?

YES________ NO________

11. Is spraying of herbicides a separate operation for:

Wheat YES ________ NO ________

Soybeans YES ________ NO ________

Other (specify) ____________ YES ________ NO ________

12. If you doublecrop, say soybeans after wheat, does a delayed wheat harvest affect negatively your decision on planting soybeans? YES________ NO________

If YES, when is it a good time to harvest wheat if you plan to follow with soybeans?

June 1 - June 14 ____________ July 1 - 15 ______________

June 15 - June 30 ____________ When was it this year ________

13. Would you participate in an ACP cost-share program for application of herbicides for reduced tillage (minimum or no-till) operations on your farm?

YES________ NO________

If YES, what percentage of the cost of the herbicides would you be willing to pay? ____________%

On how many acres of cropland would you be willing to practice reduced tillage (minimum or no-tillage) with this cost-sharing rate? ______________acres.

14. Do you feel that farming with conventional tillage has caused sufficient loss of soil so that your crop yields per acre have been reduced and consequently caused a reduction in your income? YES________ NO________

II. REDUCED (minimum and zero-till) TILLAGE (con't.)

15. Does farming with conventional tillage have a negative impact on the sale value of your farm? YES________ NO________

16. If reduced tillage has been used or it is planned for the future, indicate why. (Abbreviations: SA = strongly agree; A = agree; I = indifferent; D = disagree; SD = strongly disagree)

a.	Reduces labor cost	SA	A	I	D	SD
b.	Reduces fuel cost	SA	A	I	D	SD
c.	Reduces equipment cost	SA	A	I	D	SD
d.	Increases yield	SA	A	I	D	SD
e.	Reduces soil erosion	SA	A	I	D	SD
f.	Conserves future soil productivity	SA	A	I	D	SD
g.	Farming operations done faster (timeliness)	SA	A	I	D	SD
h.	Other (specify) ______________	SA	A	I	D	SD

17. If reduced tillage has not been used and is not planned to be used in the future, indicate why. NOTE: Use the same abbreviations as in #16 above.

a.	Type of soil is not conducive to reduced tillage planting	SA	A	I	D	SD
b.	Weed control problems	SA	A	I	D	SD
c.	Poor stands	SA	A	I	D	SD
d.	Increases labor costs	SA	A	I	D	SD
e.	Pest control problems	SA	A	I	D	SD
f.	Increases fuel costs	SA	A	I	D	SD
g.	Increases equipment costs	SA	A	I	D	SD
h.	Other (specify) ______________	SA	A	I	D	SD

18. If reduced tillage has been used, but will not be used in the future, briefly explain why. ____

____

____

In which year did you discontinue its use? ___________

III. SUMMARY

1. Any comments on relationship between minimum tillage and reduction in loss of soil due to:

   A. Wind erosion: ______________________________

   ____

   ____

   B. Water (run-off) erosion: ______________________________

   ____

   ____

2. Any comments on other advantages or benefits of minimum tillage? ________

   ____

   ____

   ____

   ____

3. Any comments on other problems, disadvantages or costs of minimum tillage?

   ____

   ____

   ____

   ____

DDB/MAS/mds
Summer, 1982

IV. INFORMATION ON INPUTS (seeds, fertilizer, herbicides and labor) FOR DIFFERENT CROPS

Crop: ____________

	Rate of Application #/acre/year	$/acre/year
1. SEED		
________	________	________
2. FERTILIZER		
________	________	________
________	________	________
________	________	________
________	________	________
________	________	________
3. HERBICIDES OR PESTICIDES		
________	________	________
________	________	________
________	________	________
________	________	________
________	________	________
4. LABOR		
________	________	________
________	________	________
________	________	________
________	________	________
________	________	________

APPENDIX B

INITIAL LINEAR PROGRAMMING TABLEAUS

FOR THE REPRESENTATIVE FARMS

TABLE LXII

INITIAL LINEAR PROGRAMMING TABLEAU FOR REPRESENTATIVE FARM 1

		LABHIRE1	LABHIRE2	LABHIRE3	LABHIRE4	BANNCAP	BINTMCAP	IMPPVSCL	CCIMPP	WDSLC	WPSLC	WTSLC	WOSCLC	WDSLMT	WPSLMT	WTSLMT	WOSCLMT	WDSLNT	WPSLNT	WTSLNT	WOSCLNT	SBDSLC	SBPSLC	SBTSLC	SBOSCLC	SBDSLMT	SBPSLMT	SBTSLMT	SBOSCLMT
OBJ	N	-A	-A	-A	-A	-T	-T	-B	C	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
DSL	L									1				1				1				1				1			
PSL	L										1				1				1				1				1		
TSL	L											1				1				1				1				1	
OSCL	L												1				1				1				1				1
VSCL	L							1																					
JSIMPP	L							-A	A																				
OFIMPP	L							-T	A																				
MMIMPP	L							-T	A																				
JMLAB	L	-1							A	T	T	T	T	T	T	T	T	U	U	U	U								
AJLAB	L		-1						A	U	U	U	U	U	U	U	U	U	U	U	U	A	A	A	A	T	T	T	T
JSLAB	L			-1				T	A	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
ODLAB	L				-1				A	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
BANNCAP	L					-1		B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
BINTMCAP	L						-1	A	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
LABOR	L							T	B	A	A	A	A	A	A	A	A	T	T	T	T	A	A	A	A	A	A	A	A
LABHIRE	L	1	1	1	1																								
SOILOSS1	G							A		A				A				A				B				A			
SOILOSS2	G										B				A				A				B				B		
SOILOSS3	G											A				A				A				B				A	
SOILOSS4	G												A				A				A				B				A
SOILOSS5	G																												

		SBDSLNT	SBPSLNT	SBTSLNT	SBOSCLNT	QSDSLC	QSPSLC	QSTSLC	QSOSCLC	QSDSLMT	QSPSLMT	QSTSLMT	GSOSCLMT	QSDSLNT	QSPSLNT	QSTSLNT	GSOSCLNT	WSBDSLC	WSBPSLC	WSBTSLC	WSBOSCLC	WSBDSLMT	WSBPSLMT	WSBTSLMT	WSBOSCLM	WSBDSLNT	WSBPSLNT	WSBTSLNT
OBJ	N	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
DSL	L	1				1				1				1				1				1				1		
PSL	L		1				1				1				1				1				1				1	
TSL	L			1				1				1				1				1				1				1
OSCL	L				1				1				1				1				1				1			
VSCL	L																											
JSIMPP	L																											
OFIMPP	L																											
MMIMPP	L																											
JMLAB	L					T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	U	U	U
AJLAB	L	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	1	T	T	T	T	T	T	T	T	T	T
JSLAB	L	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
ODLAB	L	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	1	1	1	1	T	T	T	T	U	U	U
BANNCAP	L	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B		B	B	B	B	B	B	B
BINTMCAP	L	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
LABOR	L	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
LABHIRE	L																											
SOILOSS1	G	A				B				A				A				A				A				A		
SOILOSS2	G		A				B				B				A				B				A				A	
SOILOSS3	G			A				B				A				A				A				A				A
SOILOSS4	G				A				B				A				A				A							
SOILOSS5	G																											

TABLE LXII (Continued)

ACTIVITY	LABHIRE1	LABHIRE2	LABHIRE3	LABHIRE4	BANNCAP	BINTMCAP	IMPPVSCL	CCIMPP	1....1 ACTIVITY
OBJ	4.25000-	4.25000-	4.25000-	4.25000-	.17000-	.17000-	68.64000-	126.11000	OBJ
VSCL	.	.	.	.	.	.	1.00000	.	VSCL
JSIMPP	.	.	.	.	.	.	4.70000-	5.00000	JSIMPP
OFIMPP	.	.	.	.	.	.	.40000-	1.75000	OFIMPP
MMIMPP	.	.	.	.	.	.	.90000-	1.50000	MMIMPP
JMLAB	1.00000-	.	.	.	.	.	.	2.88000	JMLAB
AJLAB	.	1.00000-	.	.	.	.	.	2.62000	AJLAB
JSLAB	.	.	1.00000-	.	.	.	.69000	2.72000	JSLAB
ODLAB	.	.	.	1.00000-	.	.	.	2.62000	ODLAB
BANNCAP	.	.	.	.	1.00000-	.	23.05000	51.96000	BANNCAP
BINTMCAP	.	.	.	.	.	1.00000-	8.74000	587.56000	BINTMCAP
LABOR	.	.	.	.	.	.	.69000	10 89000	LABOR
LABHIRE	1.00000	1.00000	1.00000	1.00000	.	.	.	.	LABHIRE

ACTIVITY	WDSLC	WPSLC	WTSLC	WOSCLC	WDSLMT	WPSLMT	WTSLMT	WOSCLMT	2....1 ACTIVITY
OBJ	47.46000	59.46000	63.46000	27.46000	42.50000	54.50000	58.50000	22.05000	OBJ
DSL	1.00000	.	.	.	1.00000	.	.	.	DSL
PSL	.	1.00000	.	.	.	1.00000	.	.	PSL
TSL	.	.	1.00000	.	.	.	1.00000	.	TSL
OSCL	.	.	.	1.00000	.	.	.	1.00000	OSCL
JMLAB	.14000	.14000	.14000	.14000	.11000	.11000	.11000	.11000	JMLAB
AJLAB	.10000	.10000	.10000	.10000	.08000	.08000	.08000	.08000	AJLAB
JSLAB	.84000	.84000	.84000	.84000	.67000	.67000	.67000	.67000	JSLAB
ODLAB	.30000	.30000	.30000	.30000	.24000	.24000	.24000	.24000	ODLAB
BANNCAP	34.25000	34.25000	34.25000	34.25000	39.35000	39.35000	39.35000	39.35000	BANNCAP
BINTMCAP	128.12000	128.12000	128.12000	128.12000	111.47000	111.47000	111.47000	111.47000	BINTMCAP
LABOR	1.38000	1.38000	1.38000	1.38000	1.10000	1.10000	1.10000	1.10000	LABOR

TABLE LXII (Continued)

ACTIVITY	WDSLNT	WPSLNT	WTSLNT	WOSCLNT	SBDSLC	SBPSLC	SBTSLC	SBOSCLC	3....1 ACTIVITY
	.	.	.	.	.	.	.	.	
OBJ	31.85000	43.85000	47.85000	11.85000	53.61000	59.36000	65.11000	47.86000	OBJ
DSL	1.00000	.	.	.	1.00000	.	.	.	DSL
PSL	.	1.00000	.	.	.	1.00000	.	.	PSL
TSL	.	.	1.00000	.	.	.	1.00000	.	TSL
OSCL	.	.	.	1.00000	.	.	.	1.00000	OSCL
JMLAB	.08000	.08000	.08000	.08000	.	.	.	.	JMLAB
AJLAB	.05000	.05000	.05000	.05000	1.10000	1.10000	1.10000	1.10000	AJLAB
JSLAB	.46000	.46000	.46000	.46000	.22000	.22000	.22000	.22000	JSLAB
ODLAB	.17000	.17000	.17000	.17000	.78000	.78000	.78000	.78000	ODLAB
BANNCAP	50.35000	50.35000	50.35000	50.35000	27.30000	27.30000	27.30000	27.30000	BANNCAP
BINTMCAP	105.06000	105.06000	105.06000	105.06000	154.88000	154.88000	154.88000	154.88000	BINTMCAP
LABOR	.76000	.76000	.76000	.76000	2.10000	2.10000	2.10000	2.10000	LABOR

ACTIVITY	SBDSLMT	SBPSLMT	SBTSLMT	SBOSCLMT	SBDSLNT	SBPSLNT	SBTSLNT	SBOSCLNT	4....1 ACTIVITY
	.	.	.	.	.	.	.	.	
OBJ	52.11000	57.86000	62.86000	46.36000	44.16000	49.91000	55.66000	38.41000	OBJ
DSL	1.00000	.	.	.	1.00000	.	.	.	DSL
PSL	.	1.00000	.	.	.	1.00000	.	.	PSL
TSL	.	.	1.00000	.	.	.	1.00000	.	TSL
OSCL	.	.	.	1.00000	.	.	.	1.00000	OSCL
AJLAB	.81000	.81000	.81000	.81000	.57000	.57000	.57000	.57000	AJLAB
JSLAB	.17000	.17000	.17000	.17000	.12000	.12000	.12000	.12000	JSLAB
ODLAB	.57000	.57000	.57000	.57000	.40000	.40000	.40000	.40000	ODLAB
BANNCAP	32.76000	32.76000	32.76000	32.76000	41.88000	41.88000	41.88000	41.88000	BANNCAP
BINTMCAP	131.65000	131.65000	131.65000	131.65000	123.88000	123.88000	123.88000	123.88000	BINTMCAP
LABOR	1.55000	1.55000	1.55000	1.55000	1.09000	1.09000	1.09000	1.09000	LABOR

TABLE LXII (Continued)

ACTIVITY	QSDSLC	QSPSLC	QSTSLC	QSOSCLC	QSDSLMT	QSPSLMT	QSTSLMT	QSOSCLMT	5....1 ACTIVITY
	.	.	.	.	.	.	.	.	
OBJ	47.75000	37.89000	57.51000	30.67000	45.64000	35.88000	55.40000	28.56000	OBJ
DSL	1.00000	.	.	.	1.00000	.	.	.	DSL
PSL	.	1.00000	.	.	.	1.00000	.	.	PSL
TSL	.	.	1.00000	.	.	.	1.00000	.	TSL
OSCL	.	.	.	1.00000	.	.	.	1.00000	OSCL
JMLAB	.41000	.41000	.41000	.41000	.28000	.28000	.28000	.28000	JMLAB
AJLAB	.71000	.71000	.71000	.71000	.50000	.50000	.50000	.50000	AJLAB
JSLAB	.20000	.20000	.20000	.20000	.14000	.14000	.14000	.14000	JSLAB
ODLAB	.72000	.72000	.72000	.72000	.51000	.51000	.51000	.51000	ODLAB
BANNCAP	38.92000	38.92000	38.92000	38.92000	50.65000	50.65000	50.65000	50.65000	BANNCAP
BINTMCAP	144.10000	144.10000	144.10000	144.10000	122.47000	122.47000	122.47000	122.47000	BINTMCAP
LABOR	2.04000	2.04000	2.04000	2.04000	1.43000	1.43000	1.43000	1.13000	LABOR

ACTIVITY	QSDSLNT	QSPSLNT	QSTSLNT	QSOSCLNT	WSBDSLC	WSBPSLC	WSBTSLC	WSBOSCLC	6....1 ACTIVITY
	.	.	.	.	.	.	.	.	
OBJ	35.43000	25.67000	45.19000	18.35000	59.63000	77.38000	87.13000	33.88000	OBJ
DSL	1.00000	.	.	.	1.00000	.	.	.	DSL
PSL	.	1.00000	.	.	.	1.00000	.	.	PSL
TSL	.	.	1.00000	.	.	.	1.00000	.	TSL
OSCL	.	.	.	1.00000	.	.	.	1.00000	OSCL
JMLAB	.22000	.22000	.22000	.22000	.11000	.11000	.11000	.11000	JMLAB
AJLAB	.39000	.39000	.39000	.39000	.72000	.72000	.72000	.72000	AJLAB
JSLAB	.11000	.11000	.11000	.11000	.70000	.70000	.70000	.70000	JSLAB
ODLAB	.39000	.39000	.39000	.39000	1.00000	1.00000	1.00000	1.00000	ODLAB
BANNCAP	56.47000	56.47000	56.47000	56.47000	45.04000	45.04000	45.04000	.	BANNCAP
BINTMCAP	115.29000	115.29000	115.29000	115.29000	345.77000	345.77000	345.77000	345.77000	BINTMCAP
LABOR	1.12000	1.12000	1.12000	1.12000	2.53000	2.53000	2.53000	2.53000	LABOR

TABLE LXII (Continued)

ACTIVITY	WSBDSLMT	WSBPSLMT	WSBTSLMT	WSBOSCLM	WSBDSLNT	WSBPSLNT	WSBTSLNT	WSBOSCLN	7....1 ACTIVITY
	.	.	.	.	.	.	.	.	
OBJ	59.06000	76.81000	86.56000	33.31000	46.12000	63.87000	73.62000	20.37000	OBJ
DSL	1.00000	.	.	.	1.00000	.	.	.	DSL
PSL	.	1.00000	.	.	.	1.00000	.	.	PSL
TSL	.	.	1.00000	.	.	.	1.00000	.	TSL
OSCL	.	.	.	1.00000	.	.	.	1.00000	OSCL
JMLAB	.11000	.11000	.11000	.11000	.08000	.08000	.08000	.08000	JMLAB
AJLAB	.68000	.68000	.68000	.68000	.51000	.51000	.51000	.51000	AJLAB
JSLAB	.66000	.66000	.66000	.66000	.50000	.50000	.50000	.50000	JSLAB
ODLAB	.24000	.24000	.24000	.24000	.05000	.05000	.05000	.05000	ODLAB
BANNCAP	54.06000	54.06000	54.06000	54.06000	63.06000	63.06000	63.06000	63.06000	BANNCAP
BINTMCAP	293.89000	293.89000	293.89000	293.89000	276.61000	276.61000	276.61000	276.61000	BINTMCAP
LABOR	1.69000	1.69000	1.69000	1.69000	1.14000	1.14000	1.14000	1.14000	LABOR

ACTIVITY	RHS1	ACTIVITY
	.	
DSL	150.00000	DSL
PSL	147.00000	PSL
TSL	153.00000	TSL
OSCL	450.00000	OSCL
VSCL	40.00000	VSCL
JSIMPP	330.00000	JSIMPP
OFIMPP	100.00000	OFIMPP
MMIMPP	101.00000	MMIMPP
JMLAB	300.00000	JMLAB
AJLAB	450.00000	AJLAB
JSLAB	950.00000	JSLAB
ODLAB	700.00000	ODLAB
BANNCAP	50000.000	BANNCAP
BINTMCAP	200000.00	BINTMCAP
LABOR	2400.0000	LABOR

TABLE LXIII

INITIAL LINEAR PROGRAMMING TABLEAU FOR REPRESENTATIVE FARM 2

		LABHIRE1	LABHIRE2	LABHIRE3	LABHIRE4	BANNCAP	BINTMCAP	IMPPASC	WOFC	WMCC	WLSC	WPVC	WOFMT	WMCMT	WLSMT	WPVMT	WOFNT	WMCNT	WLSNT	WPVNT	SBOFC	SBMCC	SBLSC	SBPVC	SBOFMT	SBMCMT
OBJ	N	-A	-A	-A	-A	-T	-T	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
OF	L								1				1				1				1				1	
MC	L									1				1				1				1				1
LS	L										1				1				1				1			
PV	L											1				1				1				1		
AS	L							1																		
JMLAB	L	-1						T	T	T	T	T	U	U		U	U	U	U	U						
AJLAB	L		-1					1	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
JSLAB	L			-1					T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
ODLAB	L				-1			T													T	T	T	T	T	T
BANNCAP	L					-1		B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
BINTMCAP	L						-1	B	C	C	C	C	C	C	C	C	B	B	B	B	C	C	C	C	C	C
LABOR	L							A	A	A	A	A	A	A	A	A	T	T	T	T	A	A	A	A	A	A
LABHIRE	L	1	1	1	1																					
SOILOSS1	G							A	B				A				A				B				B	
SOILOSS2	G									A				A				A				B				A
SOILOSS3	G										A				A				A				A			
SOILOSS4	G											A				A				A				B		

		SBLSMT	SBPVMT	SBOFNT	SBMCNT	SBLSNT	SBPVNT	QSOFC	QSMCC	QSLSC	QSPVC	GSOFMT	GSMCMT	GSLSMT	GSPVMT	GSOFNT	GSMCNT	GSLSNT	GSPVNT	WSBOFC	WSBMCC	WSBOFMT	WSBMCMT	WSBOFNT	WSBMCNT	RHS1
OBJ	N	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	C	B	C	B	C	B	
OF	L			1				1				1				1				1		1		1		
MC	L				1				1				1				1				1		1		1	C
LS	L	1				1				1				1				1								C
PV	L		1				1				1				1				1							C
AS	L																									C
JMLAB	L							T	T	T	T	T	T	T	T	T	T	T	T	T	T	U	U	U	U	C
AJLAB	L	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	A	A	A	A	T	T	C
JSLAB	L	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T							C
ODLAB	L	T	T	T	T	T	T													A	A	T	T	T	T	C
BANNCAP	L	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	E
BINTMCAP	L	C	C	C	C	C	C	C	C	C	C	B	B	B	B	B	B	B	B	C	C	C	C	C	C	F
LABOR	L	A	A	T	T	T	T	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	D
LABHIRE	L																									
SOILOSS1	G			A				B				A				A				B		A		A		
SOILOSS2	G				A				B				A				A				A		A		A	
SOILOSS3	G	A				A				A				A				A								
SOILOSS4	G		A				A				A				A				A							

TABLE LXIII (Continued)

ACTIVITY	LABHIRE1	LABHIRE2	LABHIRE3	LABHIRE4	BANNCAP	BINTMCAP	IMPPASC	WOFC	1....1 ACTIVITY
OBJ	3.65000-	3.65000-	3.65000-	3.65000-	.15000-	.15000-	92.28000	69.58000	OBJ
OF	.	.	.	.	.	.	.	1.00000	OF
AS	.	.	.	.	.	.	1.00000	.	AS
JMLAB	1.00000-	.	.	.	.	.	.12000	.11000	JMLAB
AJLAB	.	1.00000-	.	.	.	.	1.00000	.69000	AJLAB
JSLAB	.	.	1.00000-	.	.	.	.	.60000	JSLAB
ODLAB	.	.	.	1,00000-	.	.	.42000	.	ODLAB
BANNCAP	.	.	.	.	1.00000-	.	59.79000	24.24000	BANNCAP
BINTMCAP	.	.	.	.	.	1.00000-	47.50000	121.57000	BINTMCAP
LABOR	.	.	.	.	.	.	1.55000	1.40000	LABOR
LABHIRE	1.00000	1.00000	1.00000	1.00000	.	.	.	.	LABHIRE
SOILOSS1	.	.	.	.	.	.	.	10.91000	SOILOSS1
SOILOSS5	.	.	.	.	.	.	1.10000	.	SOILOSS5

ACTIVITY	WMCC	WLSC	WPVC	WOFMT	WMCMT	WLSMT	WPVMT	WOFNT	2....1 ACTIVITY
OBJ	45.58000	65.58000	61.58000	63.53000	39.53000	69.53000	55.53000	57.67000	OBJ
OF	.	.	.	1.00000	.	.	.	1.00000	OF
MC	1.00000	.	.	.	1.00000	.	.	.	MC
LS	.	1.00000	.	.	.	1.00000	.	.	LS
PV	.	.	1.00000	.	.	.	1.00000	.	PV
JMLAB	.11000	.11000	.11000	.09000	.09000	.	.09000	.06000	JMLAB
AJLAB	.69000	.69000	.69000	.50000	.50000	.50000	.50000	.35000	AJLAB
JSLAB	.60000	.60000	.60000	.44000	.44000	.44000	.44000	.31000	JSLAB
BANNCAP	24.24000	24.24000	24.24000	31.55000	31:55000	31.55000	31.55000	36.40000	BANNCAP
BINTMCAP	121.57000	121.57000	121.57000	103.33000	103.33000	103.33000	103.33000	97.27000	BINTMCAP
LABOR	1.40000	1.40000	1.40000	1.03000	1.03000	1.03000	1.03000	.72000	LABOR
SOILOSS1	.	.	.	6.77000	.	.	.	3.39000	SOILOSS1
SOILOSS2	7.98000	.	.	.	4.95000	.	.	.	SOILOSS2
SOILOSS3	.	5.12000	.	.	.	3.18000	.	.	SOILOSS3
SOILOSS4	.	.	6.60000	.	.	.	4.03000	.	SOILOSS4

TABLE LXIII (Continued)

ACTIVITY	WMCNT	WLSNT	WPVNT	SBOFC	SBMCC	SBLSC	SBPVC	SBOFMT	3....1 ACTIVITY
	.	.	.	.	.	.	.	.	
OBJ	33.67000	53.67000	49.87000	69.21000	46.21000	63.46000	57.71000	70.79000	OBJ
OF	.	.	.	1.00000	.	.	.	1.00000	OF
MC	1.00000	.	.	.	1.00000	.	.	.	MC
LS	.	1.00000	.	.	.	1.00000	.	.	LS
PV	.	.	1.00000	.	.	.	1.00000	.	PV
JMLAB	.06000	.06000	.06000	.	.	.	.	.	JMLAB
AJLAB	.35000	.35000	.35000	.95000	.95000	.95000	.95000	.67000	AJLAB
JSLAB	.31000	.31000	.31000	.25000	.25000	.25000	.25000	.17000	JSLAB
ODLAB	.	.	.	.67000	.67000	.67000	.67000	.47000	ODLAB
BANNCAP	36.40000	36.40000	36.40000	22.06000	22.06000	22.06000	22.06000	30.89000	BANNCAP
BINTMCAP	97.27000	97.27000	97.27000	126.35000	126.35000	126.35000	126.35000	107.38000	BINTMCAP
LABOR	.72000	.72000	.72000	1.87000	1.87000	1.87000	1.87000	1.31000	LABOR
SOILOSS1	.	.	.	19.57000	.	.	.	11.29000	SOILOSS1
SOILOSS2	2.48000	.	.	.	14.31000	.	.	.	SOILOSS2
SOILOSS3	.	1.59000	.	.	.	9.19000	.	.	SOILOSS3
SOILOSS4	.	.	2.02000	.	.	.	11.65000	.	SOILOSS4

ACTIVITY	SBMCMT	SBLSMT	SBPVMT	SBOFNT	SBMCNT	SBLSNT	SBPVNT	GSOFC	4....1 ACTIVITY
	.	.	.	.	.	.	.	.	
OBJ	47.79000	65.04000	59.29000	61.43000	38.43000	55.68000	49.93000	69.72000	OBJ
OF	.	.	.	1.00000	.	.	.	1.00000	OF
MC	1.00000	.	.	.	1.00000	.	.	.	MC
LS	.	1.00000	.	.	.	1.00000	.	.	LS
PV	.	.	1.00000	.	.	.	1.00000	.	PV
JMLAB	.	.	.	.	.	.	.	.42000	JMLAB
AJLAB	.67000	.67000	.67000	.48000	.48000	.48000	.48000	.83000	AJLAB
JSLAB	.17000	.17000	.17000	.13000	.13000	.13000	.13000	.79000	JSLAB
ODLAB	.47000	.47000	.47000	.34000	.34000	.34000	.34000	.	ODLAB
BANNCAP	30.89000	30.89000	30.89000	35.30000	35.30000	35.30000	35.30000	23.22000	BANNCAP
BINTMCAP	107.38000	107.38000	107.38000	101.06000	101.06000	101.06000	101.06000	114.98000	BINTMCAP
LABOR	1.31000	1.31000	1.31000	.95000	.95000	.95000	.95000	2.04000	LABOR
SOILOSS1	.	.	.	4.89000	.	.	.	15.81000	SOILOSS1
SOILOSS2	8.26000	.	.	.	3.58000	.	.	.	SOILOSS2
SOILOSS3	.	5.30000	.	.	.	2.30000	.	.	SOILOSS3
SOILOSS4	.		6.72000	.	.	.	2.91000	.	SOILOSS4

TABLE LXIII (Continued)

ACTIVITY	QSMCC	QSLSC	QSPVC	QSOFMT	QSMCMT	QSLSMT	GSPVMT	GSOFNT	6....1 ACTIVITY
OBJ	50.20000	55.08000	64.84000	69.33000	49.81000	54.68000	64.45000	62.53000	OBJ
OF	.	.	.	1.00000	.	.	.	1.00000	OF
MC	1.00000	.	.	.	1.00000	.	.	.	MC
LS	.	1.00000	.	.	.	1.00000	.	.	LS
PV	.	.	1.00000	.	.	.	1.00000	.	PV
JMLAB	.42000	.42000	.42000	.30000	.30000	.30000	.30000	.24000	JMLAB
AJLAB	.83000	.83000	.83000	.58000	.58000	.58000	.58000	.45000	AJLAB
JSLAB	.79000	.79000	.79000	.55000	.55000	.55000	.55000	.44000	JSLAB
BANNCAP	23.22000	23.22000	23.22000	32.56000	32.56000	32.56000	32.56000	37.19000	BANNCAP
BINTMCAP	114.98000	114.98000	114.98000	97.75000	87.75000	87.75000	97.75000	92.00000	BINTMCAP
LABOR	2.04000	2.04000	2.04000	1.43000	1.43000	1.43000	1.43000	1.13000	LABOR
SOILOSS1	.	.	.	9.03000	.	.	.	4.14000	SOILOSS1
SOILOSS2	11.56000	.	.	.	6.60000	.	.	.	SOILOSS2
SOILOSS3	.	7.42000	.	.	.	4.24000	.	.	SOILOSS3
SOILOSS4	.	.	9.41000	.	.	.	5.38000	.	SOILOSS4

ACTIVITY	QSMCNT	GSLSNT	QSPVNT	WSBOFC	WSBMCC	WSBOFMT	WSBMCMT	WSBOFNT	6....1 ACTIVITY
OBJ	43.01000	47.89000	57.65000	119.65000	78.40000	116.64000	75.39000	107.16000	OBJ
OF	.	.	.	1.00000	.	1.00000	.	1.00000	OF
MC	1.00000	.	.	.	1.00000	.	1.00000	.	MC
LS	.	1.00000	.	.	.	.	.	.	LS
PV	.	.	1.00000	.	.	.	.	.	PV
JMLAB	.24000	.24000	.24000	.11000	.11000	.08000	.08000	.07000	JMLAB
AJLAB	.45000	.45000	.45000	1.65000	1.65000	1.02000	1.02000	.77000	AJLAB
JSLAB	.44000	.44000	.44000	.	.	.	.	.	JSLAB
ODLAB	.	.	.	1.26000	1.26000	.79000	.79000	.60000	ODLAB
BANNCAP	37.19000	37.19000	37.19000	38.55000	38.55000	77.80000	77.80000	83.00000	BANNCAP
BINTMCAP	92.00000	92.00000	92.00000	250.65000	250.65000	213.07000	213.07000	200.53000	BINTMCAP
LABOR	1.13000	1.13000	1.13000	3.02000	3.02000	1.89000	1.89000	1.44000	LABOR
SOILOSS1	.	.	.	11.29000	.	6.02000	.	3.01000	SOILOSS1
SOILOSS2	3.03000	.	.	.	8.26000	.	4.40000	.	SOILOSS2
SOILOSS3	.	1.94000	.	.	.	.	.	.	SOILOSS3
SOILOSS4	.	.	2.46000	.	.	.	.	.	SOILOSS4

TABLE LXIII (Continued)

ACTIVITY	WSBMCNT .	RHS1 .	ACTIVITY
OBJ	65.81000	.	OBJ
OF	.	110.00000	OF
MC	1.00000	155.00000	MC
LS	.	140.00000	LS
PV	.	150.00000	PV
AS	.	103.00000	AS
JMLAB	.07000	400.00000	JMLAB
AJLAB	.77000	600.00000	AJLAB
JSLAB	.	400.00000	JSLAB
ODLAB	.60000	400.00000	ODLAB
BANNCAP	83.00000	40000.000	BANNCAP
BINTMCAP	200.53000	200000.00	BINTMCAP
LABOR	1.44000	1800.0000	LABOR
SOILOSS1	.	550.00000	SOILOSS1
SOILOSS2	2.20000	775.00000	SOILOSS2
SOILOSS3	.	700.00000	SOILOSS3
SOILOSS4	.	750.00000	SOILOSS4
SOILOSS5	.	81.00000	SOILOSS5

TABLE LXIV

INITIAL LINEAR PROGRAMMING TABLEAU FOR REPRESENTATIVE FARM 3

		LABHIRE1	LABHIRE2	LABHIRE3	LABHIRE4	BANNCAP	BINTMCAP	IMPPBACC	CCIMPP	WOKAC	WOKBC	WTKAC	WBABC	WOKAMT	WOKBMT	WTKAMT	WBABMT	WOKANT	WOKBNT	WTKANT	WBABNT	SBOKAC	SBOKBC	SBTKAC	SBBABC	SBOKAMT	SBOKBMT	SBTKAMT	SBBABMT	SBOKANT	SBOKBNT	SBTKANT	SBBABNT	GSOKAC	GSOKBC	GSTKAC	GSBABC	GSOKAMT	GSOKBMT	GSTKAMT	GSBABMT	GSOKANT	GSOKBNT	GSTKANT	GSBABNT	WSBOKBC	WSBOKBMT	WSBOKBNT	RHS1
OBJ	N	-A	-A	-A	-A	-T	-T	-B	C	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	
OKA	L									1				1				1				1				1				1				1				1				1							C
OKB	L										1				1				1				1				1				1				1				1				1			1	1	1	C
TKA	L											1				1				1				1				1				1				1				1				1					C
BAB	L												1				1				1				1				1				1				1				1				1				C
BAC	L							1																																									C
JSIMPP	L							T	A																																								
OFIMPP	L							T	A																																								
MMIMPP	L							U	A																																								
JMLAB	L	-1						T	A	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	U	C
AJLAB	L		-1					T	A	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	A	A	T	D
JSLAB	L			-1					A	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	D
ODLAB	L				-1				A													T	T	T	T	T	T	T	T	T	T	T	T													A	T	T	D
BANNCAP	L					-1		B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	F
BINTMCAP	L						-1	B	C	C	C	C	C	B	B	B	B	B	B	B	B	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	F
LABOR	L							T	A	A	A	A	A	A	A	A	A	T	T	T	T	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	D
LABHIRE	L	1	1	1	1																																												
SOILOSS1	G							T		A				A				A				B				A				A				A				A				A							
SOILOSS2	G										A				A				A				B				A				A				B				A				A			A	A	A	
SOILOSS3	G											B				A				A				B				B				A				B				B				A					
SOILOSS4	G												B				A				A				B				B				A				B				A				A				

TABLE LXIV (Continued)

ACTIVITY	LABHIRE1	LABHIRE2	LABHIRE3	LABHIRE4	BANNCAP	BINTMCAP	IMPPBACC	CCIMPP	1....1 ACTIVITY
	.	.	.	.	.	.	.	.	
OBJ	4.00000-	4.00000-	4.00000-	4.00000-	.16000-	.16000-	88.57000-	147.83000	OBJ
BAC	.	.	.	.	.	.	1.00000	.	BAC
JSIMPP	.	.	.	.	.	.	.86000	4.00000	JSIMPP
OFIMPP	.	.	.	.	.	.	.50000	3.00000	OFIMPP
MMIMPP	.	.	.	.	.	.	.03000	3.40000	MMIMPP
JMLAB	1.00000-	.	.	.	.	.	.25000	2.34000	JMLAB
AJLAB	.	1.00000-	.	.	.	.	.39000	2.15000	AJLAB
JSLAB	.	.	1.00000-	.	.	.	.	2.24000	JSLAB
ODLAB	.	.	.	1.00000-	.	.	.	2.15000	ODLAB
BANNCAP	.	.	.	.	1.00000-	.	14.13000	41.34000	BANNCAP
BINTMCAP	.	.	.	.	.	1.00000-	17.27000	600.12000	BINTMCAP
LABOR	.	.	.	.	.	.	.64000	8.88000	LABOR
LABHIRE	1.00000	1.00000	1.00000	1.00000	.	.	.	.	LABHIRE
SOILOSS5	.	.	.	.	.	.	.97000	.	SOILOSS5

ACTIVITY	WOKAC	WOKBC	WTKAC	WBABC	WOKAMT	WOKBMT	WTKAMT	WBABMT	2....1 ACTIVITY
	.	.	.	.	.	.	.	.	
OBJ	58.10000	42.10000	58.10000	38.10000	59.04000	43.04000	59.04000	39.04000	OBJ
OKA	1.00000	.	.	.	1.00000	.	.	.	OKA
OKB	.	1.00000	.	.	.	1.00000	.	.	OKB
TKA	.	.	1.00000	.	.	.	1.00000	.	TKA
BAB	.	.	.	1.00000	.	.	.	1.00000	BAB
JMLAB	.74000	.74000	.74000	.74000	.50000	.50000	.50000	.50000	JMLAB
AJLAB	.34000	.34000	.34000	.34000	.24000	.24000	.24000	.24000	AJLAB
JSLAB	.72000	.72000	.72000	.72000	.50000	.50000	.50000	.50000	JSLAB
BANNCAP	33.45000	33.45000	33.45000	33.45000	38.44000	38.44000	38.44000	38.44000	BANNCAP
BINTMCAP	117.50000	117.50000	117.50000	117.50000	99.88000	99.88000	99.88000	99.88000	BINTMCAP
LABOR	1.80000	1.80000	1.80000	1.80000	1.24000	1.24000	1.24000	1.24000	LABOR
SOILOSS1	6.28000	.	.	.	3.90000	.	.	.	SOILOSS1
SOILOSS2	.	9.43000	.	.	.	5.85000	.	.	SOILOSS2
SOILOSS3	.	.	12.33000	.	.	.	7.66000	.	SOILOSS3
SOILOSS4	.	.	.	11.42000	.	.	.	7.09000	SOILOSS4

TABLE LXIV (Continued)

ACTIVITY	WOKANT	WOKBNT	WTKANT	WBABNT	SBOKAC	SBOKBC	SBTKAC	SBBABC	3....1 ACTIVITY
	.	.	.	.	.	.	.	.	
OBJ	48.41000	32.41000	48.41000	28.41000	71.12000	59.62000	59.62000	48.12000	OBJ
OKA	1.00000	.	.	.	1.00000	.	.	.	OKA
OKB	.	1.00000	.	.	.	1.00000	.	.	OKB
TKA	.	.	1.00000	.	.	.	1.00000	.	TKA
BAB	.	.	.	1.00000	.	.	.	1.00000	BAB
JMLAB	.29000	.29000	.29000	.29000	.42000	.42000	.42000	.42000	JMLAB
AJLAB	.14000	.14000	.14000	.14000	.91000	.91000	.91000	.91000	AJLAB
JSLAB	.29000	.29000	.29000	.29000	.29000	.29000	.29000	.29000	JSLAB
ODLAB	.	.	.	.	.55000	.55000	.55000	.55000	ODLAB
BANNCAP	49.13000	49.13000	49.13000	49.13000	19.64000	19.64000	19.64000	19.64000	BANNCAP
BINTMCAP	83.69000	83.69000	83.69000	83.69000	127.00000	127.00000	127.00000	127.00000	BINTMCAP
LABOR	.72000	.72000	.72000	.72000	2.17000	2.17000	2.17000	2.17000	LABOR
SOILOSS1	1.95000	.	.	.	11.27000	.	.	.	SOILOSS1
SOILOSS2	.	2.93000	.	.	.	16.90000	.	.	SOILOSS2
SOILOSS3	.	.	3.83000	.	.	.	22.12000	.	SOILOSS3
SOILOSS4	.	.	.	3.64000	.	.	.	20.47000	SOILOSS4

ACTIVITY	SBOKAMT	SBOKBMT	SBTKAMT	SBBABMT	SBOKANT	SBOKBNT	SBTKANT	SBBABNT	4....1 ACTIVITY
	.	.	.	.	.	.	.	.	
OBJ	67.68000	56.18000	56.18000	44.68000	62.21000	50.71000	50.71000	39.21000	OBJ
OKA	1.00000	.	.	.	1.00000	.	.	.	OKA
OKB	.	1.00000	.	.	.	1.00000	.	.	OKB
TKA	.	.	1.00000	.	.	.	1.00000	.	TKA
BAB	.	.	.	1.00000	.	.	.	1.00000	BAB
JMLAB	.30000	.30000	.30000	.30000	.21000	.21000	.21000	.21000	JMLAB
AJLAB	.67000	.67000	.67000	.67000	.47000	.47000	.47000	.47000	AJLAB
JSLAB	.23000	.23000	.23000	.23000	.16000	.16000	.16000	.16000	JSLAB
ODLAB	.40000	.40000	.40000	.40000	.27000	.27000	.27000	.27000	ODLAB
BANNCAP	26.56000	26.56000	26.56000	26.56000	30.50000	30.50000	30.50000	30.50000	BANNCAP
BINTMCAP	107.94000	107.94000	107.94000	107.94000	105.00000	105.00000	105.00000	105.00000	BINTMCAP
LABOR	1.60000	1.60000	1.60000	1.60000	1.11000	1.11000	1.11000	1.11000	LABOR
SOILOSS1	6.50000	.	.	.	2.82000	.	.	.	SOILOSS1
SOILOSS2	.	9.75000	.	.	.	4.23000	.	.	SOILOSS2
SOILOSS3	.	.	12.76000	.	.	.	5.53000	.	SOILOSS3
SOILOSS4	.	.	.	11.81000	.	.	.	5.12000	SOILOSS4

TABLE LXIV (Continued)

ACTIVITY	GSOKAC	GSOKBC	GSTKAC	GSBABC	GSOKAMT	GSOKBMT	GSTKAMT	GSBABMT	6....1 ACTIVITY
	.	.	.	.	.	.	.	.	
OBJ	51.03000	41.27000	43.71000	31.51000	48.13000	38.37000	40.81000	28.61000	OBJ
OKA	1.00000	.	.	.	1.00000	.	.	.	OKA
OKB	.	1.00000	.	.	.	1.00000	.	.	OKB
TKA	.	.	1.00000	.	.	.	1.00000	.	TKA
BAB	.	.	.	1.00000	.	.	.	1.00000	BAB
JMLAB	.63000	.63000	.63000	.63000	.45000	.45000	.45000	.45000	JMLAB
AJLAB	.79000	.79000	.79000	.79000	.55000	.55000	.55000	.55000	AJLAB
JSLAP	.84000	.84000	.84000	.84000	.58000	.58000	.58000	.58000	JSLAB
BANNCAP	14.46000	14.46000	14.46000	14.46000	18.78000	18.78000	18.78000	18.78000	BANNCAP
BINTMCAP	144.67000	144.67000	144.67000	144.67000	122.94000	122.94000	122.94000	122.94000	BINTMCAP
LABOR	2.26000	2.26000	2.26000	2.26000	1.58000	1.58000	1.58000	1.58000	LABOR
SOILOSS1	9.10000	.	.	.	5.20000	.	.	.	SOILOSS1
SOILOSS2	.	13.65000	.	.	.	7.80000	.	.	SOILOSS2
SOILOSS3	.	.	17.86000	.	.	.	10.21000	.	SOILOSS3
SOILOSS4	.	.	.	16.53000	.	.	.	9.45000	SOILOSS4

ACTIVITY	GSOKANT	GSOKBNT	GSTKANT	GSBABNT	WSBOKBC	WSBOKBMT	WSBOKBNT	RHS1	6....1 ACTIVITY
	.	.	.	.	.	.	.	.	
OBJ	46.91000	37.15000	39.59000	27.39000	64.79000	67.82000	60.34000	.	OBJ
OKA	1.00000	.	.	.	.	.	.	181.00000	OKA
OKB	.	1.00000	.	.	1.00000	1.00000	1.00000	290.00000	OKB
TKA	.	.	1.00000	.	.	.	.	614.00000	TKA
BAB	.	.	.	1.00000	.	.	.	115.00000	BAB
BAC	.	.	.	.	.	.	.	800.00000	BAC
JMLAB	.34000	.34000	.34000	.34000	.17000	.13000	.09000	550.00000	JMLAB
AJLAB	.42000	.42000	.42000	.42000	1.69000	1.10000	.73000	1925.0000	AJLAB
JSLAB	.45000	.45000	.45000	.45000	.69000	.45000	.30000	1925.0000	JSLAB
ODLAB	.	.	.	.	1.43000	.95000	.62000	1100.0000	ODLAB
BANNCAP	21.67000	21.67000	21.67000	21.67000	43.40000	60.75000	69.38000	125000.00	BANNCAP
BINTMCAP	115.72000	115.72000	115.72000	115.72000	280.00000	246.38000	232.38000	350000.00	BINTMCAP
LABOR	1.21000	1.21000	1.21000	1.21000	3.98000	2.63000	1.74000	5500.0000	LABOR
SOILOSS1	2.38000	.	.	.	.	.	.	800.00000	SOILOSS1
SOILOSS2	.	3.58000	.	.	9.75000	5.20000	2.60000	1450.0000	SOILOSS2
SOILOSS3	.	.	4.68000	.	.	.	.	3070.0000	SOILOSS3
SOILOSS4	.	.	.	4.33000	.	.	.	408.00000	SOILOSS4
SOILOSS5	.	.	.	.	.	.	.	2400.0000	SOILOSS5

APPENDIX C

ABBREVIATIONS USED IN THE LINEAR

PROGRAMMING TABLEAUS

ABBREVIATIONS USED IN THE LINEAR PROGRAMMING TABLEAUS

DSL	Dennis silt loam
PSL	Parsons silt loam
TSL	Taloka silt loam
OSCL	Osage silt clay loam
VSCL	Verdigris silty clay loam
OF	Oklared fine sandy loam
MC	Miller clay
LS	Lonoke silty clay loam
PV	Pope very fine sandy loam
AS	Atkins silt loam
OKA	Okemah silt loam
OKB	Okemah silt loam
TKA	Taloka silt loam
BAB	Bates loam
BAC	Bates loam
JMLAB	Labor for the first quarter, January through March
AJLAB	Labor for the second quarter, April through June
JSLAB	Labor for the third quarter, July through September
ODLAB	Labor for the fourth quarter, October through December
LABOR	Total labor used

$LABHIRE_i$	Hired labor for the i^{th} quarter of the year
LABHIRE	Total hired labor
ANNCAP	Annual capital required
INTMCAP	Intermediate capital required
BANNCAP	Borrowed annual capital
BINTMCAP	Borrowed intermediate capital
JSIMPP	Improved pasture for June through September
OFIMPP	Improved pasture for October through February
MMIMPP	Improved pasture for March through May
$SOILOSS_j$	Soil loss coefficient for the j^{th} soil series
C	Conventional tillage
MT	Minimum tillage
NT	No-tillage
W	Wheat
SB	Soybeans
GS	Grain sorghum
WSB	Wheat-soybeans double-cropped
CC	Cow-calf
IMPP	Improved pasture

APPENDIX D

INITIAL MOTAD MODEL TABLEAUS FOR CONVENTIONAL, MINIMUM, AND NO-TILLAGE SYSTEMS

TABLE LXV

INITIAL MOTAD MODEL TABLEAU FOR CONVENTIONAL TILLAGE SYSTEM

		WC	SBC	GSC	WSBC	YBAR1	YBAR2	YBAR3	YBAR4	YBAR5	YBAR6	YBAR7	YBAR8	YBAR9	YBAR10	YBAR11	YBAR12	YBAR13	YBAR14	YBAR15	YBAR16	YBAR17	YBAR18	YBAR19	YBAR20	YBAR21	YBAR22	YBAR23	YBAR24	YBAR25	YBAR26	YBAR27	YBAR28	YBAR29	YBAR30	RHS1
OBJ	N					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
LAND	L	1	1	1	1																															C
JMLAB	L	T	T	T	T																															C
AJLAB	L	T	T	T	A																															C
JSLAB	L	T	T	T	T																															C
ODLAB	L		T		A																															C
BANNCAP	L	B	B	B	B																															E
BINTMCAP	L	C	C	C	C																															E
LABOR	L																																			D
T1	G	-A	-B	-B	-B	1																														
T2	G	-A	-B	-B	-B		1																													
T3	G	-B	-B	-B	-B			1																												
T4	G	-B	-B	-B	-B				1																											
T5	G	-B	-B	-B	-B					1																										
T6	G	-B	-B	-B	-B						1																									
T7	G	-B	-B	-A	-B							1																								
T8	G	-B	-B	-A	-B								1																							
T9	G	-A	-B	-A	-B									1																						
T10	G	-1	-A	-A	-A										1																					
T11	G	-1	-B	-B	-B											1																				
T12	G	-A	-B	-A	-B												1																			
T13	G	-B	-B	-B	-B													1																		
T14	G	-B	-B	-A	-B														1																	
T15	G	-B	-A	-A	-B															1																
T16	G	-B	1	A	-B																1															
T17	G	-B	-A	-A	-B																	1														
T18	G	-B	-B	-B	-B																		1													
T19	G	-B	-A	1	-B																			1												
T20	G	-A	B	-A	B																				1											
T21	G	B	B	B	B																					1										
T22	G	A	B	B	B																						1									
T23	G	-A	B	B	B																							1								
T24	G	B	B	B	B																								1							
T25	G	B	B	1	B																									1						
T26	G	B	1	B	A																										1					
T27	G	B	B	B	C																											1				
T28	G	B	-B	-B	B																												1			
T29	G	B	B	B	B																													1		
T30	G	B	B	B	C																														1	
INCOME	E	B	B	B	B																															E

TABLE LXV (Continued)

ACTIVITY	WC	SBC	GSC	WSBC	YBAR1	YBAR2	YBAR3	YBAR4	1....1 ACTIVITY
	.	.	.	.	.	.	.	.	
OBJ	.	.	.	.	1.00000	1.00000	1.00000	1.00000	OBJ
LAND	.00000	1.00000	1.00000	1.00000	.	.	.	.	LAND
JMLAB	.74000	.42000	.63000	.17000	.	.	.	.	JMLAB
AJLAB	.34000	.91000	.79000	1.69000	.	.	.	.	AJLAB
JSLAB	.72000	.29000	.84000	.69000	.	.	.	.	JSLAB
ODLAB	.	,55000	.	1.43000	.	.	.	.	ODLAB
BANNCAP	33.45000	19.64000	14.46000	43.40000	.	.	.	.	BANNCAP
BINTMCAP	117.50000	127.00000	144.67000	280.00000	.	.	.	.	BINTMCAP
T1	18.00000-	19.00000	1.00000	1.00000	1.00000	.	.	.	T1
T2	5.00000	13.00000	11.00000	27.00000	.	1.00000	.	.	T2
T3	14.00000	1.00000	10.00000	6.00000	.	.	1.00000	.	T3
T4	15.00000	1.00000	1.00000-	13.00000	.	.	.	1.00000	T4
T5	15.00000	8.00000	1.00000-	14.00000	.	.	.	.	T5
T6	6.00000	5.00000-	8.00000-	2.00000-	.	.	.	.	T6
T7	1.00000-	18.00000-	1.00000	20.00000-	.	.	.	.	T7
T8	10.00000-	4.00000	1.00000	6.00000-	.	.	.	.	T8
T9	12.00000-	1.00000	11.00000	8.00000-	.	.	.	.	T9
T10	7.00000-	17.00000	3.00000	14.00000	.	.	.	.	T10
T11	3.00000-	13.00000	9.00000	13.00000	.	.	.	.	T11
T12	7.00000-	3.00000-	2.00000-	8.00000-	.	.	.	.	T12
T13	5.00000-	18.00000-	11.00000-	21.00000-	.	.	.	.	T13
T14	1.00000-	12.00000	7.00000	11.00000	.	.	.	.	T14
T15	12.00000	18.00000	5.00000-	38.00000	.	.	.	.	T15
T16	44.00000	57.00000	42.00000	99.00000	.	.	.	.	T16
T17	16.00000	35.00000	6.00000	28.00000	.	.	.	.	T17
T18	13.00000-	33.00000-	37.00000	47.00000-	.	.	.	.	T18
T19	20.00000	12.00000	5.00000-	31.00000	.	.	.	.	T19
T20	3.00000	23.00000-	39.00000-	20.00000-	.	.	.	.	T20
T21	2.00000-	36.00000-	6.00000-	40.00000-	.	.	.	.	T21
T22	48.00000	24.00000	32.00000	70.00000	.	.	.	.	T22
T23	2.00000	47.00000-	50.00000-	47.00000-	.	.	.	.	T23
T24	12.00000	42.00000	20.00000	53.00000	.	.	.	.	T24
T25	7.00000	43.00000	22.00000	48.00000	.	.	.	.	T25
INCOME	79.00000	77.00000	36.00000	142.00000	.	.	.	.	INCOME

TABLE LXV (Continued)

ACTIVITY	YBAR5	YBAR6	YBAR7	YBAR8	YBAR9	YBAR10	YBAR11	YBAR12	2....1 ACTIVITY
	.	.	.	.	.	.	.	.	
OBJ	1.00000	1.00000	1.00000	1.00000	1 00000	1.00000	1.00000	1.00000	OBJ
T5	1.00000	.	.	.	.	.	.	.	T5
T6	.	1.00000	.	.	.	.	.	.	T6
T7	.	.	1.00000	.	.	.	.	.	T7
T8	.	.	.	1.00000	.	.	.	.	T8
T9	.	.	.	.	1.00000	.	.	.	T9
T10	.	.	.	.	.	1.00000	.	.	T10
T11	.	.	.	.	.	.	1.00000	.	T11
T12	.	.	.	.	.	.	.	1.00000	T12

ACTIVITY	YBAR13	YBAR14	YBAR15	YBAR16	YBAR17	YBAR18	YBAR19	YBAR20	3....1 ACTIVITY
	.	.	.	.	.	.	.	.	
OBJ	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	OBJ
T13	1.00000	.	.	.	.	.	.	.	T13
T14	.	1.00000	.	.	.	.	.	.	T14
T15	.	.	1.00000	.	.	.	.	.	T15
T16	.	.	.	1.00000	.	.	.	.	T16
T17	.	.	.	.	1.00000	.	.	.	T17
T18	.	.	.	.	.	1.00000	.	.	T18
T19	.	.	.	.	.	.	1.00000	.	T19
T20	.	.	.	.	.	.	.	1.00000	T20

TABLE LXV (Continued)

ACTIVITY	YBAR21	YBAR22	YBAR23	YBAR24	YBAR25	RHS1	ACTIVITY
	.	.	.	.	.		
OBJ	1.00000	1.00000	1.00000	1.00000	1.00000		OBJ
LAND	.	.	.	.	.	594.00000	LAND
JMLAB	.	.	.	.	.	372.00000	JMLAB
AJLAB	.	.	.	.	.	256.00000	AJLAB
JSLAB	.	.	.	.	.	391.00000	JSLAB
ODLAB	.	.	.	.	.	149.00000	ODLAB
BANNCAP	.	.	.	.	.	19685.000	BANNCAP
BINTMCAP	.	.	.	.	.	62000.000	BINTMCAP
T21	1.00000	.	.	.	.	.	T21
T22	.	1.00000	.	.	.	.	T22
T23	.	.	1.00000	.	.	.	T23
T24	.	.	.	1.00000	.	.	T24
T25	.	.	.	.	1.00000	.	T25
INCOME	.	.	.	.	.	35650.000	INCOME

TABLE LXVI

INITIAL MOTAD MODEL TABLEAU FOR MINIMUM TILLAGE SYSTEM

		WMT	SBMT	QSMT	WSBMT	YBAR1	YBAR2	YBAR3	YBAR4	YBAR5	YBAR6	YBAR7	YBAR8	YBAR9	YBAR10	YBAR11	YBAR12	YBAR13	YBAR14	YBAR15	YBAR16	YBAR17	YBAR18	YBAR19	YBAR20	YBAR21	YBAR22	YBAR23	YBAR24	YBAR25	YBAR26	YBAR27	YBAR28	YBAR29	YBAR30	RHS1
OBJ	N					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
LAND	L	1	1	1	1																															C
JMLAB	L	T	T	T	T																															C
AJLAB	L	T	T	T	A																															C
JSLAB	L	T	T	T	T																															C
ODLAB	L		T		T																															C
BANNCAP	L	B	B	B	B																															E
BINTMCAP	L	B	C	C	C																															E
LABOR	L																																			D
T1	G	B	-B	A	A	1																														
T2	G	B	-A	A	A		1																													
T3	G	-A	-B	-A	-B			1																												
T4	G	-B	A	-A	-A				1																											
T5	G	1	-A	1	-A					1																										
T6	G	-B	B	1	-1						1																									
T7	G	B	B	B	B							1																								
T8	G	A	1	A	A								1																							
T9	G	B	1	1	B									1																						
T10	G	A	A	-1	B										1																					
T11	G	A	-A	-A	-A											1																				
T12	G	-A	-B	1	-B												1																			
T13	G	-A	A	-A	-A													1																		
T14	G	-A	1	A	-A														1																	
T15	G	-A	B	A	B															1																
T16	G	-1	B	A	B																1															
T17	G	-A	-A	-A	-A																	1														
T18	G	-1	-B	-B	-B																		1													
T19	G	1	B	A	-A																			1												
T20	G	B	B	-A	B																				1											
T21	G	B	B	B	C																					1										
T22	G	A	B	A	B																						1									
T23	G	-B	-B	B	-B																							1								
T24	G	B	B	-A	B																								1							
T25	G	1	-B	-B	-B																									1						
T26	G	-A	-B	-A	-B																										1					
T27	G	B	B	B	B																											1				
T28	G	A	-B	-B	-B																												1			
T29	G	B	B	B	B																													1		
T30	G	A	B	B	B																														1	
INCOME	E	B	B	B	C																															E

TABLE LXVI (Continued)

ACTIVITY	WMT	SBMT	GSMT	WSBMT	YBAR1	YBAR2	YBAR3	YBAR4	1....1 ACTIVITY
	.	.	.	.	.	.	.	.	
OBJ	.	.	.	.	1.00000	1.00000	1.00000	1.00000	OBJ
LAND	1.00000	1.00000	1.00000	1.00000	.	.	.	.	LAND
JMLAB	.50000	.30000	.45000	.13000	.	.	.	.	JMLAB
AJLAB	.24000	.67000	.55000	1.10000	.	.	.	.	AJLAB
JSLAB	.50000	.23000	.58000	.45000	.	.	.	.	JSLAB
ODLAB	.	.40000	.	.95000	.	.	.	.	ODLAB
BANNCAP	38.44000	26.56000	18.78000	60.75000	.	.	.	.	BANNCAP
BINTMCAP	99.88000	107.94000	122.94000	246.38000	.	.	.	.	BINTMCAP
T1	14.60000	13.00000	12.26000-	28.20000	1.00000	.	.	.	T1
T2	6.25000	.38000	10.77000	6.95000	.	1.00000	.	.	T2
T3	13.64000	.13000-	.68000	13.72000	.	.	1.00000	.	T3
T4	6.50000	6.43000	.80000-	12.58000	.	.	.	1.00000	T4
T5	2.21000	4.49000-	6.58000-	3.04000-	.	.	.	.	T5
T6	2.92000-	18.51000-	1.16000	21.64000-	.	.	.	.	T6
T7	7.02000-	3.61000	4.84000-	3.30000-	.	.	.	.	T7
T8	6.77000-	.23000	10.35000	6.54000-	.	.	.	.	T8
T9	3.32000-	15.26000	3.42000	11.48000	.	.	.	.	T9
T10	.10000	13.80000	9.33000	13.94000	.	.	.	.	T10
T11	5.29000-	2.22000-	2.67000-	7.22000-	.	.	.	.	T11
T12	1.89000-	17.52000-	11.24000-	19.30000	.	.	.	.	T12
T13	.14000-	10.97000	7.59000	10.42000	.	.	.	.	T13
T14	3.38000	23.60000	5.50000-	25.72000	.	.	.	.	T14
T15	8.69000	10.59000	3.48000-	17.18000	.	.	.	.	T15
T16	36.50000	41.98000	38.91000	76.11000	.	.	.	.	T16
T17	9.84000-	25.26000	3.93000	12.67000	.	.	.	.	T17
T18	13.04000-	28.94000-	36.88000	41.44000-	.	.	.	.	T18
T19	22.21000	8.04000	3.43000-	28.16000	.	.	.	.	T19
T20	5.75000	20.53000-	37.25000-	15.08000-	.	.	.	.	T20
T21	3.05000-	40.21000-	5.94000-	44.66000-	.	.	.	.	T21
T22	44.25000	23.92000	30.48000	67.29000	.	.	.	.	T22
T23	.92000	50.54000-	53.40000-	52.34000-	.	.	.	.	T23
T24	11.83000	44.17000	20.49000	46.68000	.	.	.	.	T24
T25	6.02000	43.73000	22.56000	49.21000	.	.	.	.	T25
INCOME	68.08000	54.57000	25.97000	108.36000	.	.	.	.	INCOME

TABLE LXVI (Continued)

ACTIVITY	YBAR5	YBAR6	YBAR7	YBAR8	YBAR9	YBAR10	YBAR11	YBAR12	2....1 ACTIVITY
	.	.	.	.	.	.	.	.	
OBJ	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	OBJ
T5	1.00000	.	.	.	.	.	.	.	T5
T6	.	1.00000	.	.	.	.	.	.	T6
T7	.	.	1.00000	.	.	.	.	.	T7
T8	.	.	.	1.00000	.	.	.	.	T8
T9	.	.	.	.	1.00000	.	.	.	T9
T10	.	.	.	.	.	1.00000	.	.	T10
T11	.	.	.	.	.	.	1.00000	.	T11
T12	.	.	.	.	.	.	.	1.00000	T12

ACTIVITY	YBAR13	YBAR14	YBAR15	YBAR16	YBAR17	YBAR18	YBAR19	YBAR20	3....1 ACTIVITY
	.	.	.	.	.	.	.	.	
OBJ	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	OBJ
T13	1.00000	.	.	.	.	.	.	.	T13
T14	.	1.00000	.	.	.	.	.	.	T14
T15	.	.	1.00000	.	.	.	.	.	T15
T16	.	.	.	1.00000	.	.	.	.	T16
T17	.	.	.	.	1.00000	.	.	.	T17
T18	.	.	.	.	.	1.00000	.	.	T18
T19	.	.	.	.	.	.	1.00000	.	T19
T20	.	.	.	.	.	.	.	1.00000	T20

TABLE LXVI (Continued)

ACTIVITY	YBAR21	YBAR22	YBAR23	YBAR24	YBAR25	RHS1	ACTIVITY
	.	.	.	.	.		
OBJ	1.00000	1.00000	1.00000	1.00000	1.00000		OBJ
LAND	.	.	.	.	.	594.00000	LAND
JMLAB	.	.	.	.	.	372.00000	JMLAB
AJLAB	.	.	.	.	.	256.00000	AJLAB
JSLAB	.	.	.	.	.	391.00000	JSLAB
ODLAB	.	.	.	.	.	149.00000	ODLAB
BANNCAP	.	.	.	.	.	19685.000	BANNCAP
BINTMCAP	.	.	.	.	.	62000.000	BINTMCAP
T21	1.00000	.	.	.	.		T21
T22	.	1.00000	.	.	.	.	T22
T23	.	.	1.00000	.	.	.	T23
T24	.	.	.	1.00000	.	.	T24
T25	.	.	.	.	1.00000	.	T25
INCOME	.	.	.	.	.	28847.000	INCOME

TABLE LXVII

INITIAL MOTAD MODEL TABLEAU FOR NO-TILLAGE SYSTEM

		WNT	SBNT	GSNT	WSBNT	YBAR1	YBAR2	YBAR3	YBAR4	YBAR5	YBAR6	YBAR7	YBAR8	YBAR9	YBAR10	YBAR11	YBAR12	YBAR13	YBAR14	YBAR15	YBAR16	YBAR17	YBAR18	YBAR19	YBAR20	YBAR21	YBAR22	YBAR23	YBAR24	YBAR25	YBAR26	YBAR27	YBAR28	YBAR29	YBAR30	RHS1
OBJ	N					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
LAND	L	1	1	1	1																															C
JMLAB	L	T	T	T	U																															C
AJLAB	L	T	T	T	T																															C
JSLAB	L	T	T	T	T																															C
ODLAB	L		T		T																															C
BANNCAP	L	B	B	B	B																															E
BINTMCAP	L	B	C	C	C																															E
LABOR	L																																			D
T1	G	-A	-B	-B	-B	1																														
T2	G	-1	-B	-B	-B		1																													
T3	G	-B	-B	-B	-B			1																												
T4	G	-B	-B	-B	-B				1																											
T5	G	-B	-B	-B	-B					1																										
T6	G	-B	-B	-B	-B						1																									
T7	G	-A	-A	-A	-B							1																								
T8	G	-B	-B	-A	-B								1																							
T9	G	-A	-B	-A	-B									1																						
T10	G	1	-A	-A	-A										1																					
T11	G	1	-B	-B	-B											1																				
T12	G	-A	-B	-A	-B												1																			
T13	G	-A	-B	-B	-B													1																		
T14	G	-B	-B	-A	-B														1																	
T15	G	-B	-1	-A	-B															1																
T16	G	-B	A	A	-A																1															
T17	G	-B	-A	-A	-B																	1														
T18	G	-B	-B	-B	-B																		1													
T19	G	-B	A	A	-B																			1												
T20	G	-A	B	-A	B																				1											
T21	G	B	B	B	B																					1										
T22	G	A	B	B	B																						1									
T23	G	-A	B	B	B																							1								
T24	G	B	B	B	B																								1							
T25	G	B	B	1	B																									1						
T26	G	A	1	B	A																										1					
T27	G	B	B	B	C																											1				
T28	G	B	-B	-B	B																												1			
T29	G	B	B	B	B																													1		
T30	G	B	B	B	C																														1	
INCOME	E	B	B	B	B																															E

TABLE LXVII (Continued)

	WNT	SBNT	GSNT	WSBNT	YBAR1	YBAR2	YBAR3	YBAR4	1....1
ACTIVITY	.	.	.	.	.	.	.	.	ACTIVITY
OBJ	.	.	.	.	1.00000	1.00000	1.00000	1.00000	OBJ
LAND	1.00000	1.00000	1.00000	1.00000	.	.	.	.	LAND
JMLAB	.29000	.21000	.34000	.09000	.	.	.	.	JMLAB
AJLAB	.14000	.47000	.42000	.73000	.	.	.	.	AJLAB
JSLAB	.29000	.16000	.45000	.30000	.	.	.	.	JSLAB
ODLAB	.	.27000	.	.62000	.	.	.	.	ODLAB
BANNCAP	49.13000	30.50000	21.67000	69.38000	.	.	.	.	BANNCAP
BINTMCAP	93.69000	105.00000	115.72000	232.38000	.	.	.	.	BINTMCAP
T1	14.48000	12.57000	12.02000	28.20000	1.00000	.	.	.	T1
T2	6.18000	.17000	1.61000-	6.95000	.	1.00000	.	.	T2
T3	13.62000	.13000-	.88000	13.72000	.	.	1.00000	.	T3
T4	6.48000	6.43000	.80000-	12.58000	.	.	.	1.00000	T4
T5	2.14000	4.49000-	7.58000-	3.04000-	.	.	.	.	T5
T6	2.99000-	17.51000-	1.66000	21.64000-	.	.	.	.	T6
T7	7.09000-	3.11000	4.54000-	3.33000-	.	.	.	.	T7
T8	6.80000-	2.07000-	.91000	6.54000-	.	.	.	.	T8
T9	3.48000-	15.06000	3.42000	11.48000	.	.	.	.	T9
T10	.01000	13.80000	9.33000	13.94000	.	.	.	.	T10
T11	1.61000	2.22000-	2.67000-	7.22000-	.	.	.	.	T11
T12	.45000-	17.52000-	12.24000-	20.30000-	.	.	.	.	T12
T13	.35000-	10.98000	8.09000	9.92000	.	.	.	.	T13
T14	3.10000	23.57000	6.56000-	26.52000	.	.	.	.	T14
T15	8.32000	10.60000	3.60000	17.68000	.	.	.	.	T15
T16	35.46000	41.99000	38.81000	75.31000	.	.	.	.	T16
T17	9.02000-	24.27000	4.01000	11.17000	.	.	.	.	T17
T18	14.12000-	29.44000-	36.88000	42.14000-	.	.	.	.	T18
T19	21.43000	6.84000	2.43000-	26.96000	.	.	.	.	T19
T20	5.21000	21.03000-	37.75000-	14.58000-	.	.	.	.	T20
T21	3.84000-	41.17000-	6.24000-	45.36000-	.	.	.	.	T21
T22	42.79000	25.61000	30.28000	65.99000	.	.	.	.	T22
T23	.68000-	51.74000-	52.40000-	53.04000-	.	.	.	.	T23
T24	10.47000	43.67000	19.99000	55.48000	.	.	.	.	T24
T25	5.08000	43.06000	22.04000	48.23000	.	.	.	.	T25
INCOME	57.78000	49.34000	25.06000	101.32000	.	.	.	.	INCOME

TABLE LXVII (Continued)

ACTIVITY	YBAR5	YBAR6	YBAR7	YBAR8	YBAR9	YBAR10	YBAR11	YBAR12	2....1 ACTIVITY
	.	.	.	.	.	.	.	.	
OBJ	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	OBJ
T5	1.00000	.	.	.	.	.	.	.	T5
T6	.	1.00000	.	.	.	.	.	.	T6
T7	.	.	1.00000	.	.	.	.	.	T7
T8	.	.	.	1.00000	.	.	.	.	T8
T9	.	.	.	.	1.00000	.	.	.	T9
T10	.	.	.	.	.	1.00000	.	.	T10
T11	.	.	.	.	.	.	1.00000	.	T11
T12	.	.	.	.	.	.	.	1.00000	T12

ACTIVITY	YBAR13	YBAR14	YBAR15	YBAR16	YBAR17	YBAR18	YBAR19	YBAR20	3....1 ACTIVITY
	.	.	.	.	.	.	.	.	
OBJ	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	OBJ
T13	1.00000	.	.	.	.	.	.	.	T13
T14	.	1.00000	.	.	.	.	.	.	T14
T15	.	.	1.00000	.	.	.	.	.	T15
T16	.	.	.	1.00000	.	.	.	.	T16
T17	.	.	.	.	1.00000	.	.	.	T17
T18	.	.	.	.	.	1.00000	.	.	T18
T19	.	.	.	.	.	.	1.00000	.	T19
T20	.	.	.	.	.	.	.	1.00000	T20

TABLE LXVII (Continued)

ACTIVITY	YBAR21	YBAR22	YBAR23	YBAR24	YBAR25	RHS1	ACTIVITY
	.	.	.	.	.	.	
OBJ	1.00000	1.00000	1.00000	1.00000	1.00000		OBJ
LAND	.	.	.	.	.	594.00000	LAND
JMLAB	.	.	.	.	.	372.00000	JMLAB
AJLAB	.	.	.	.	.	256.00000	AJLAB
JSLAB	.	.	.	.	.	391.00000	JSLAB
ODLAB	.	.	.	.	.	149.00000	ODLAB
BANNCAP	.	.	.	.	.	19685.000	BANNCAP
BINTMCAP	.	.	.	.	.	62000.000	BINTMCAP
T21	1.00000	.	.	.	.	.	T21
T22	.	1.00000	.	.	.	.	T22
T23	.	.	1.00000	.	.	.	T23
T24	.	.	.	1.00000	.	.	T24
T25	.	.	.	.	1.00000	.	T25
INCOME	.	.	.	.	.	23397.000	INCOME

APPENDIX E

PRODUCTION COSTS OF DIFFERENT CROPS FOR CONVENTIONAL, MINIMUM AND NO-TILLAGE SYSTEMS FOR THE REPRESENTATIVE FARMS

TABLE LXVIII

PRODUCTION COSTS OF WHEAT FOR REPRESENTATIVE FARM 1

CROP: Wheat COUNTY: Northeast

Owned Equipment

Operating Inputs	Unit	Price/ Unit	CONVENTIONAL TILLAGE Quantity	CONVENTIONAL TILLAGE Cost/ Acre	MINIMUM TILLAGE Quantity	MINIMUM TILLAGE Cost/ Acre	NO-TILLAGE Quantity	NO-TILLAGE Cost/ Acre
	BU	--	--	--	--	--	--	--
WHEAT SEED	BU	5.00	1.50	7.50	1.50	7.50	1.50	9.00
NITROGEN (N)	LBS	0.250	70.00	17.50	70.00	17.50	70.00	17.50
PHOSPORUS (P_2O_5)	LBS	0.240	40.00	9.60	40.00	9.60	60.00	14.40
POTASH (K_2O)	LBS	0.100	40.00	4.00	40.00	4.00	60.00	6.00
SPRAYER	ACRE	--	--	--	--	--	--	--
FERTILIZER SPREADER	ACRE	2.25	1.00	2.25	1.00	2.25	1.00	2.25
MISCELLANEOUS EXPENSE	BU	--	--	--	--	--	--	--
ANNUAL OPERATING CAPITAL	DOL	0.17	34.255	5.82	39.35	6.69	50.35	8.00
LABOR	HOUR	4.250	1.38	5.87	1.10	4.66*	0.76	3.00
MACHINERY, FUEL, LUBE, REPAIRS	ACRE	--	--	20.00	--	15.75*	--	12.00*
HERBICIDE (Paraquat)	LBS	3.88	--	--	--	--	2.84	11.00
TOTAL OPERATING COSTS				72.54		67.95		83.15
FIXED COSTS								
Machinery Interest 17.0%	DOL	--	128.12	21.78	111.47	18.95*	105.06	17.86
Depr., Taxes, Insurance	DOL	--	--	17.42	--	14.81	--	11.76
TOTAL FIXED COSTS				39.20		33.76		29.62
TOTAL PRODUCTION				111.74		101.71		112.77

* Adjustments were made for using conventional equipment every four years.

TABLE LXIX

PRODUCTION COSTS OF SOYBEANS FOR REPRESENTATIVE FARM 1

CROP: SOYBEAN   COUNTY: NORTHEAST

Operating Inputs	Unit	Price/ Unit	CONVENTIONAL TILLAGE Quantity	CONVENTIONAL TILLAGE Cost/ Acre	MINIMUM TILLAGE Quantity	MINIMUM TILLAGE Cost/ Acre	NO-TILLAGE Quantity	NO-TILLAGE Cost/ Acre
	BU							
SOYBEAN SEED	LBS	0.170	30.00	5.10	35.00	5.95	40.00	6.80
NITROGEN (N)	LBS	0.300	10.00	3.00	10.00	3.00	10.00	3.00
PHOSPORUS (P_2O_5)	LBS	0.260	30.00	7.80	30.00	7.80	30.00	7.80
POTASH (K_2O)	LBS	0.140	15.00	2.10	15.00	2.10	15.00	2.10
SPRAYER	ACRE	4.00	1.00	4.00	1.25	5.00	2.00	8.00
FERTILIZER SPREADER	ACRE	4.00	1.00	4.00	1.00	4.00	1.00	4.00
MISCELLANEOUS EXPENSE	BU	--	--	--	--	--	--	--
ANNUAL OPERATING CAPITAL	DOL	0.170	27.302	4.64	32.76	5.57	41.88	7.12
LABOR	HOUR	4.250	2.10	8.92	1.55	6.57*	1.09	4.62*
MACHINERY, FUEL, LUBE, REPAIRS	ACRE	--	--	21.58	--	18.15	--	13.65*
HERBICIDE		9.50	1.00	9.50	1.47	14.00	2.42	23.00
LIME	TONS	20.00	0.40	8.00	0.40	8.00	0.40	8.00
TOTAL OPERATING COSTS				78.64		80.14		88.09
FIXED COSTS								
Machinery Interest 17.0%	DOL	--	154.88	26.330	131.65	22.38*	123.88	21.06*
Depr., Taxes, Insurance	DOL	--	--	21.060	--	17.90	--	16.63
TOTAL FIXED COSTS				47.39		40.28		37.69
TOTAL PRODUCTION				126.03		120.42		125.78

*Adjustments were made for using conventional equipment every four years.

TABLE LXX

PRODUCTION COSTS OF GRAIN SORGHUM FOR REPRESENTATIVE FARM 1

CROP: GRAIN SORGHUM COUNTY: NORTHEAST

Upland clay loam soils
Owned harvest equipment

			CONVENTIONAL TILLAGE		MINIMUM TILLAGE		NO-TILLAGE	
Operating Inputs	Unit	Price/ Unit	Quantity	Cost/ Acre	Quantity	Cost/ Acre	Quantity	Cost/ Acre
	BU							
GRAIN SORGHUM SEED	LBS	0.750	4.00	3.00	4.00	3.00	4.50	3.38
NITROGEN (N)	LBS	0.300	60.00	18.00	65.00	19.50	65.00	19.50
PHOSPORUS (P_2O_5)	LBS	0.260	30.00	7.80	35.00	9.10	35.00	9.10
POTASH (K_2O)	LBS	0.140	40.00	5.60	40.00	5.60	40.00	5.60
SPRAYER	ACRE	4.00	1.00	--	--	--	1.00	4.00
FERTILIZER SPREADER	ACRE	4.00	1.00	4.00	1.00	4.00	1.00	4.00
MISCELLANEOUS EXPENSE	BU	--	--	--	--	--	--	--
ANNUAL OPERATING CAPITAL	DOL	0.170	38.916	6.62	50.65	8.61	56.47	10.60
LABOR	HOUR	4.250	2.045	8.69	1.43	6.09*	1.12	4.75*
MACHINERY, FUEL, LUBE, REPAIRS	ACRE	--	--	20.82	--	14.74*	--	11.92*
HERBICIDE	ACRE	8.00	1.00	8.00	1.75	14.00	2.75	22.00
INSECTICIDE	ACRE	4.50	0.330	1.48	0.330	1.48	0.330	1.48
TOTAL OPERATING COSTS				84.01		86.12		96.33
FIXED COSTS								
Machinery Interest 17.0%	DOL	--	144.10	24.487	122.47	20.82*	115.29	19.60*
Depr., Taxes, Insurance	DOL	--	--	19.353	--	16.45	--	15.29
TOTAL FIXED COSTS				43.850		37.27		34.89
TOTAL PRODUCTION				127.860		123.39		131.22

*Adjustments were made for using conventional equipment every 4 years.

TABLE LXXI

PRODUCTION COSTS OF WHEAT-SOYBEANS DOUBLE-CROPPED FOR REPRESENTATIVE FARM 1

CROP: WHEAT & SOYBEANS COUNTY: NORTHEAST
Classes I & II double-cropped
Owned equipment

Operating Inputs	Unit	Price/Unit	CONVENTIONAL TILLAGE Quantity	CONVENTIONAL TILLAGE Cost/Acre	MINIMUM TILLAGE Quantity	MINIMUM TILLAGE Cost/Acre	NO-TILLAGE Quantity	NO-TILLAGE Cost/Acre
WHEAT SEED	BU	5.00	1.50	6.75	1.50	7.50	1.80	9.00
SOYBEAN SEED	LBS	0.170	50.00	8.50	55.00	9.35	60.00	10.20
NITROGEN (N)	LBS	0.250	80.00	20.00	80.00	20.00	80.00	20.00
PHOSPORUS (P_2O_5)	LBS	0.240	70.00	16.80	70.00	16.80	70.00	16.80
POTASH (K_2O)	LBS	0.100	50.00	5.00	55.00	5.50	55.00	5.50
SPRAYER	ACRE	4.00	1.00	4.00	1.00	4.00	2.00	8.00
FERTILIZER SPREADER	ACRE	4.00	1.00	4.00	1.00	4.00	1.00	4.00
MISCELLANEOUS EXPENSE	BU	--	--	--	--	--	--	--
ANNUAL OPERATING CAPITAL	DOL	0.180	45.042	8.11	54.06	9.73	63.06	11.35
LABOR	HOUR	4.250	2.53	10.75	1.69	7.19*	1.14	4.85*
MACHINERY, FUEL, LUBE, REPAIRS	ACRE	--	--	30.28	--	23.22*	--	18.17*
HERBICIDE	ACRE	6.00	0.83	5.00	1.00	6.00	3.00	18.00
LIME	TONS	20.00	0.330	6.60	0.330	6.60	0.330	6.60
TRUCKING	BU	0.220	44.00	9.68	44.00	9.68	44.00	9.68
TOTAL OPERATING COSTS				136.17		129.57		142.15
FIXED COSTS								
Machinery Interest 18.0%	DOL	--	345.77	62.24	293.89	52.90*	276.61	49.79*
Depr., Taxes, Insurance	DOL	--	--	51.96	--	44.16	--	41.04
TOTAL FIXED COSTS				114.19		97.06		90.83
TOTAL PRODUCTION				250.36		226.63		232.98

*Adjustments were made for using conventional equipment every 4 years.

TABLE LXXII

PRODUCTION COSTS FOR BERMUDA GRASS FOR REPRESENTATIVE FARM 1

CROP: BERMUDA PASTURE
Class I & II Land

COUNTY: NORTHEAST

			CONVENTIONAL TILLAGE[a]		MINIMUM TILLAGE		NO-TILLAGE	
Operating Inputs	Unit	Price/ Unit	Quantity	Cost/ Acre	Quantity	Cost/ Acre	Quantity	Cost/ Acre
	BU							
1/10 EST. CHARGE	ACRE	46.780	0.10	4.68				
NITROGEN (N)	LBS	0.300	100.00	30.00				
PHOSPORUS (P_2O_5)	LBS	0.260	40.00	10.40				
POTASH (K_2O)	LBS	0.140	40.00	5.60				
SPRAYER	ACRE	--	--	--				
FERTILIZER SPREADER	ACRE	4.00	2.00	8.00				
MISCELLANEOUS EXPENSE	BU	--	--	--				
ANNUAL OPERATING CAPITAL	DOL	0.170	23.054	3.92				
LABOR	HOUR	4.250	0.685	2.91				
MACHINERY, FUEL, LUBE, REPAIRS	ACRE	--	--	3.13				
HERBICIDE		--	--	--				
TOTAL OPERATING COSTS				68.64				
FIXED COSTS								
Machinery Interest 17.0%	DOL	0.170	8.74	1.485				
Depr., Taxes, Insurance	DOL			1.437				
TOTAL FIXED COSTS				2.92		—		—
TOTAL PRODUCTION				71.57		—		—

[a]OSU Enterprise Budget 83301101.

TABLE LXXIII

PRODUCTION COSTS OF WHEAT FOR REPRESENTATIVE FARM 2

CROP: WHEAT COUNTY: LEFLORE

Loam soils
Owned equipment

Operating Inputs	Unit	Price/ Unit	CONVENTIONAL TILLAGE Quantity	CONVENTIONAL TILLAGE Cost/ Acre	MINIMUM TILLAGE Quantity	MINIMUM TILLAGE Cost/ Acre	NO-TILLAGE Quantity	NO-TILLAGE Cost/ Acre
	BU							
WHEAT SEED	BU	5.00	1.50	7.50	1.75	8.75	2.00	10.00
NITROGEN (N)	LBS	0.250	51.00	12.75	60.00	15.00	65.00	16.25
PHOSPHORUS (P_2O_5)	LBS	0.240	46.00	11.04	55.00	13.20	60.00	14.40
POTASH (K_2O)	LBS	0.140	40.00	5.60	45.00	6.30	55.00	7.70
SPRAYER	ACRE	--	--	--	--	--	--	--
FERTILIZER SPREADER	ACRE	2.25	2.00	4.50	2.00	4.50	2.00	4.50
MISCELLANEOUS EXPENSE	BU	--	--	--	--	--	--	--
ANNUAL OPERATING CAPITAL	DOL	0.150	24.238	3.64	31.55	4.73	36.40	5.46
LABOR	HOUR	3.650	1.398	5.10	1.03	3.77*	0.72	2.62*
MACHINERY, FUEL, LUBE, REPAIRS	ACRE	--	--	16.29	--	12.62*	--	11.40*
HERBICIDE (PARAQUAT)		4.00	--	--	1.50	5.00	1.50	6.00
TOTAL OPERATING COSTS				66.42		72.47		79.33
FIXED COSTS								
Machinery Interest 15.0%	DOL	--	121.57	18.235	103.33	15.50*	97.27	14.59*
Depr., Taxes, Insurance	DOL	--	--	16.410	--	13.95	--	12.96
TOTAL FIXED COSTS				34.645		29.45		27.55
TOTAL PRODUCTION				101.07		101.92		105.88

*Adjustments were made for using conventional equipment every 4 years.

TABLE LXXIV

PRODUCTION COSTS OF SOYBEANS FOR REPRESENTATIVE FARM 2

CROP: SOYBEANS COUNTY: LEFLORE
Bottomland
Owned equipment

Operating Inputs	Unit	Price/ Unit	CONVENTIONAL TILLAGE Quantity	CONVENTIONAL TILLAGE Cost/ Acre	MINIMUM TILLAGE Quantity	MINIMUM TILLAGE Cost/ Acre	NO-TILLAGE Quantity	NO-TILLAGE Cost/ Acre
	BU							
SOYBEAN SEED	LBS	0.170	45.00	7.65	45.00	7.65	55.00	9.350
NITROGEN (N)	LBS	0.300	32.00	9.60	32.00	9.60	32.00	9.60
PHOSPORUS (P_2O_5)	LBS	0.260	48.00	12.48	48.00	12.48	48.00	12.48
POTASH (K_2O)	LBS	0.140	48.00	6.72	48.00	6.72	48.00	6.72
SPRAYER	ACRE	4.00	--	--	1.00	4.00	1.25	5.00
FERTILIZER SPREADER	ACRE	--	--	--	--	--	--	--
MISCELLANEOUS EXPENSE	BU	--	--	--	--	--	--	--
ANNUAL OPERATING CAPITAL	DOL	0.160	22.064	3.53	30.89	4.94	35.30	5.65
LABOR	HOUR	3.750	1.870	7.01	1.31	4.91*	0.95	3.58*
MACHINERY, FUEL, LUBE, REPAIRS	ACRE	--	--	18.30	--	13.41*	--	11.44*
HERBICIDE a. PREPLANT HERB	ACRE	6.75	1.00	6.75	1.00	6.75	3.00	13.50
b. POST-EMERG HERB	ACRE	2.50	1.00	2.50	1.00	2.50	2.00	5.00
TOTAL OPERATING COSTS				74.54		72.96		82.32
FIXED COSTS								
Machinery Interest 16.0%	DOL	--	126.35	20.216	107.38	17.18*	101.06	16.17*
Depr., Taxes, Insurance	DOL	--	--	19.033	--	16.18	--	15.01
TOTAL FIXED COSTS				39.25		33.36		31.21
TOTAL PRODUCTION				112.79		106.32		113.53

*Adjustments were made for using conventional equipment every 4 years.

TABLE LXXV

PRODUCTION COSTS OF GRAIN SORGHUM FOR REPRESENTATIVE FARM 2

CROP: GRAIN SORGHUM COUNTY: LEFLORE
Bottomland
Owned equipment

Operating Inputs	Unit	Price/ Unit	CONVENTIONAL TILLAGE Quantity	CONVENTIONAL TILLAGE Cost/ Acre	MINIMUM TILLAGE Quantity	MINIMUM TILLAGE Cost/ Acre	NO-TILLAGE Quantity	NO-TILLAGE Cost/ Acre
	BU							
GRAIN SORGHUM SEED	LBS	0.250	5.00	3.75	5.50	4.13	6.00	4.50
NITROGEN (N)	LBS	0.300	55.00	16.50	60.00	18.00	65.00	19.50
PHOSPORUS (P_2O_5)	LBS	0.260	30.00	7.80	35.00	9.10	40.00	10.40
POTASH (K_2O)	LBS	0.140	45.00	6.30	50.00	7.00	50.00	7.00
SPRAYER	ACRE	--	--	--	--	--	--	--
FERTILIZER SPREADER	ACRE	4.00	1.00	4.00	1.00	4.00	1.00	4.00
MISCELLANEOUS EXPENSE	BU	--	--	--	--	--	--	--
ANNUAL OPERATING CAPITAL	DOL	0.160	23.219	3.72	32.56	5.21	37.19	5.95
LABOR	HOUR	3.750	2.045	7.67	1.43	5.37*	1.13	4.22*
MACHINERY, FUEL, LUBE, REPAIRS	ACRE	--	--	14.06	--	11.38*	--	10.32*
HERBICIDE	ACRE	5.00	1.00	5.00	1.00	5.00	2.00	10.10
INSECTICIDE	ACRE	3.00	1.00	3.00	1.00	3.00	1.00	3.00
TOTAL OPERATING COSTS				71.80		72.19		78.99
FIXED COSTS								
Machinery Interest 16.0%	DOL	--	114.98	18.396	97.75	15.64*	92.00	14.72*
Depr., Taxes, Insurance	DOL	--	--	16.768	--	14.25	--	13.05
TOTAL FIXED COSTS				35.164		29.890		27.970
TOTAL PRODUCTION				106.960		97.200		106.960

*Adjustments were made for using conventional equipment every 4 years.

TABLE LXXVI

PRODUCTION COSTS OF WHEAT-SOYBEANS DOUBLE-CROPPED FOR REPRESENTATIVE FARM 2

CROP: WHEAT AND SOYBEANS — Double-cropped, Loam soils, Owned equipment

COUNTY: LEFLORE

Operating Inputs	Unit	Price/ Unit	CONVENTIONAL TILLAGE Quantity	CONVENTIONAL TILLAGE Cost/ Acre	MINIMUM TILLAGE Quantity	MINIMUM TILLAGE Cost/ Acre	NO-TILLAGE Quantity	NO-TILLAGE Cost/ Acre
WHEAT SEED	BU	5.00	1.50	7.50	1.65	8.25	1.80	9.00
SOYBEAN SEED		0.170	45.00	7.65	50.00	8.50	55.00	9.35
NITROGEN (N)	LBS	0.250	66.00	16.50	66.00	16.50	70.00	17.50
PHOSPORUS (P_2O_5)	LBS	0.240	61.00	14.64	61.00	14.64	61.00	14.64
POTASH (K_2O)	LBS	0.100	40.00	4.00	40.00	4.00	40.00	4.00
SPRAYER	ACRE	4.00	1.00	4.00	1.50	6.00	2.00	8.00
FERTILIZER SPREADER	ACRE	2.250	2.00	4.50	2.00	4.50	2.00	4.50
MISCELLANEOUS EXPENSE	BU	--	--	--	--	--	--	--
ANNUAL OPERATING CAPITAL	DOL	0.150	38.55	7.78	77.80	11.67	83.00	12.45
LABOR	HOUR	3.650	3.023	11.03	1.89	6.89*	1.44	5.24*
MACHINERY, FUEL, LUBE, REPAIRS	ACRE	--	--	31.15	--	26.31*	--	21.81*
HERBICIDE - SOYBEANS	ACRE	6.750	1.37	9.25	2.04	13.75	3.26	22.00
TRUCKING	BU	0.150	45.00	6.75	45.00	6.75	45.00	6.75
LIME	TONS	20.000	0.330	6.60	0.330	6.60	0.330	6.60
TOTAL OPERATING COSTS				131.35		134.36		141.84
FIXED COSTS								
Machinery Interest 15.0%	DOL	--	250.65	37.598	213.070	31.96	200.53	30.08
Depr., Taxes, Insurance	DOL	--	--	30.840	--	26.21	--	24.36
TOTAL FIXED COSTS				68.438		58.17		54.44
TOTAL PRODUCTION				199.790		192.53		196.28

*Adjustments were made for using conventional equipment every 4 years.

TABLE LXXVII

PRODUCTION COSTS OF BERMUDA GRASS FOR REPRESENTATIVE FARM 2

CROP: BERMUDA GRASS Establishment   COUNTY: LEFLORE

Operating Inputs	Unit	Price/ Unit	CONVENTIONAL TILLAGE[a] Quantity	Cost/ Acre	MINIMUM TILLAGE Quantity	Cost/ Acre	NO-TILLAGE Quantity	Cost/ Acre
	BU							
CUSTOM SPRIGGING	ACRE	20.00	1.00	20.00				
NITROGEN (N)	LBS	0.180	100.00	18.00				
PHOSPORUS (P_2O_5)	LBS	0.260	60.00	15.60				
POTASH (K_2O)	LBS	0.100	120.00	12.00				
SPRAYER	ACRE	--	--	--				
FERTILIZER SPREADER	ACRE	4.00	2.00	8.00				
MISCELLANEOUS EXPENSE	BU	--	--	--				
ANNUAL OPERATING CAPITAL	DOL	0.160	59.699	9.55				
LABOR	HOUR	3.750	1.545	5.79				
MACHINERY, FUEL, LUBE, REPAIRS	ACRE	--	--	10.97				
HERBICIDE	LBS	3.00	2.00	6.00				
LIME	TONS	20.00	2.00	40.00				
2-4-D	GAL	9.50	0.190	1.80				
TOTAL OPERATING COSTS				147.72				
FIXED COSTS								
Machinery Interest 16.0%	DOL	--	--	7.60				
Depr., Taxes, Insurance	DOL	--	--	6.685				
TOTAL FIXED COSTS				14.29		—		—
TOTAL PRODUCTION				162.01		—		—

[a]OSU Enterprise Budget #3900101

TABLE LXXVIII

PRODUCTION COSTS OF WHEAT FOR REPRESENTATIVE FARM 3

CROP: WHEAT
Bottomland loam
Owned equipment

COUNTY: OKMULGEE

Operating Inputs	Unit	Price/ Unit	CONVENTIONAL TILLAGE Quantity	CONVENTIONAL TILLAGE Cost/ Acre	MINIMUM TILLAGE Quantity	MINIMUM TILLAGE Cost/ Acre	NO-TILLAGE Quantity	NO-TILLAGE Cost/ Acre
	BU							
WHEAT SEED	BU	5.00	1.50	7.50	1.65	8.25	1.80	9.00
NITROGEN (N)	LBS	0.200	70.00	14.00	80.00	16.00	85.00	17.00
PHOSPORUS (P_2O_5)	LBS	0.220	40.00	8.80	40.00	8.80	40.00	8.80
POTASH (K_2O)	LBS	0.120	40.00	4.80	40.00	4.80	40.00	4.80
SPRAYER	ACRE	4.00	--	--	--	--	1.00	4.00
FERTILIZER SPREADER	ACRE	2.250	1.00	2.25	1.00	2.25	1.00	2.25
MISCELLANEOUS EXPENSE	BU	--	--	--	--	--	--	--
ANNUAL OPERATING CAPITAL	DOL	0.160	33.447	5.35	38.44	7.15	49.13	8.86
LABOR	HOUR	4.00	1.80	7.20	1.24	5.96*	0.72	2.98*
MACHINERY, FUEL, LUBE, REPAIRS	ACRE	--	--	20.00	--	15.75*	--	13.50*
HERBICIDE (PARAQUAT)	ACRE	6.25	--	--	0.0	--	1.41	--
TOTAL OPERATING COSTS				69.90		68.96		79.59
FIXED COSTS								
Machinery Interest 16.0%	DOL	--	117.50	18.80	99.88	15.98*	93.69	14.99*
Depr., Taxes, Insurance	DOL			14.57		12.39		11.54
TOTAL FIXED COSTS				33.37		28.37		26.53
TOTAL PRODUCTION				103.27		97.33		106.12

*Adjustments were made for using conventional equipment every 4 years.

TABLE LXXIV

PRODUCTION COSTS OF SOYBEANS FOR REPRESENTATIVE FARM 3

CROP: SOYBEANS — Bottomland (loam soil), Owned equipment — COUNTY: OKMULGEE

Operating Inputs	Unit	Price/ Unit	CONVENTIONAL TILLAGE Quantity	CONVENTIONAL TILLAGE Cost/ Acre	MINIMUM TILLAGE Quantity	MINIMUM TILLAGE Cost/ Acre	NO-TILLAGE Quantity	NO-TILLAGE Cost/ Acre
	BU							
SOYBEAN SEED	LBS	0.170	45.00	7.65	45.00	7.65	55.00	9.35
NITROGEN (N)	LBS	0.200	15.00	3.00	20.00	4.00	25.00	5.00
PHOSPORUS (P_2O_5)	LBS	0.220	30.00	6.60	35.00	7.70	40.00	8.00
POTASH (K_2O)	LBS	0.120	30.00	3.60	35.00	4.20	40.00	4.80
SPRAYER	ACRE	4.00	1.00	4.00	1.00	4.00	1.50	6.00
FERTILIZER SPREADER	ACRE	--	--	--	--	--	--	--
MISCELLANEOUS EXPENSE	BU	--	--	--	--	--	--	--
ANNUAL OPERATING CAPITAL	DOL	0.180	19.643	3.54	26.56	4.78	30.50	5.49
LABOR	HOUR	4.00	2.166	8.66	1.60	6.39*	1.11	4.44*
MACHINERY, FUEL, LUBE, REPAIRS	ACRE	--	0.83	18.83	--	15.60*	--	13.21*
HERBICIDE PRE-PLANT	ACRE	6.00	--	5.00	1.33	8.00	1.00	6.00
PRE-EMERGE	ACRE	7.80	0.76	6.00	1.15	9.00	1.00	7.80
PARAQUAT	ACRE	5.70	--	--	--	--	1.00	5.70
TOTAL OPERATING COSTS				66.88		70.32		75.79
FIXED COSTS								
Machinery Interest 18.0%	DOL	--	127.00	22.86	107.94	19.43*	105.00	18.29*
Depr., Taxes, Insurance	DOL	--	--	17.72	--	15.06	--	14.00
TOTAL FIXED COSTS				40.58		34.49		32.29
TOTAL PRODUCTION				107.46		104.81		108.08

*Adjustments were made for using conventional equipment every 4 years.

TABLE LXXXI

PRODUCTION COSTS OF WHEAT-SOYBEANS DOUBLE-CROPPED FOR REPRESENTATIVE FARM 3

CROP: WHEAT & SOYBEANS COUNTY: OKMULGEE

Doublecropped
Classes I & II
Owned equipment

Operating Inputs	Unit	Price/ Unit	CONVENTIONAL TILLAGE Quantity	CONVENTIONAL TILLAGE Cost/ Acre	MINIMUM TILLAGE Quantity	MINIMUM TILLAGE Cost/ Acre	NO-TILLAGE Quantity	NO-TILLAGE Cost/ Acre
WHEAT SEED	BU	5.00	1.50	7.50	1.65	8.25	1.80	9.00
SOYBEAN SEED	LBS	0.170	45.00	7.65	45.00	7.65	55.00	9.35
NITROGEN (N)	LBS	0.200	80.00	16.00	80.00	16.00	80.00	16.00
PHOSPORUS (P_2O_5)	LBS	0.220	60.00	13.20	60.00	13.20	60.00	13.20
POTASH (K_2O)	LBS	0.120.	60.00	7.20	60.00	7.20	60.00	7.20
SPRAYER	ACRE	4.00	1.00	4.00	1.50	6.00	2.00	8.00
FERTILIZER SPREADER	ACRE	2.250	0.550	1.24	0.550	1.24	0.550	1.24
MISCELLANEOUS EXPENSE	BU	--	--	--	--	--	--	--
ANNUAL OPERATING CAPITAL	DOL	0.160	43.401	6.94	60.75	9.72	69.38	11.10
LABOR	HOUR	4.00	3.974	15.90	2.63	11.13*	1.74	6.95*
MACHINERY, FUEL, LUBE, REPAIRS	ACRE	--	--	38.20	--	32.61*	--	29.74*
HERBICIDE PRE-PLANT	ACRE	6.00	1.00	6.00	1.33	8.00	1.33	8.00
PRE-EMERGE	ACRE	7.80	1.00	7.80	1.38	7.80	1.38	10.80
+ PARAQUAT	ACRE	5.70	--	--	--	--	1.00	5.70
LIME	TONS	20.00	0.330	6.60	0.330	6.60	0.330	6.60
TRUCKING	BU	0.260	48.00	12.48	48.00	12.48	48.00	12.48
TOTAL OPERATING COSTS				150.71		147.68		155.16
FIXED COSTS								
Machinery Interest 16.0%	DOL	--	280.00	44.80	246.38	39.42*	232.38	37.18*
Depr., Taxes, Insurance	DOL	--	--	35.84	--	31.18	--	29.03
TOTAL FIXED COSTS				80.64		70.60		66.21
TOTAL PRODUCTION				231.35		218.28		221.37

*Adjustments were made for using conventional equipment every 4 years.

TABLE LXXX

PRODUCTION COSTS OF GRAIN SORGHUM FOR REPRESENTATIVE FARM 3

CROP: GRAIN SORGHUM   COUNTY: OKMULGEE

Bottomland-loam soil
Owned equipment

Operating Inputs	Unit	Price/ Unit	CONVENTIONAL TILLAGE Quantity	CONVENTIONAL TILLAGE Cost/ Acre	MINIMUM TILLAGE Quantity	MINIMUM TILLAGE Cost/ Acre	NO-TILLAGE Quantity	NO-TILLAGE Cost/ Acre
	BU							
GRAIN SORGHUM SEED	LBS	0.750	5.00	3.75	5.00	3.75	6.00	4.50
NITROGEN (N)	LBS	0.200	50.00	10.00	55.00	11.00	60.00	12.00
PHOSPORUS (P_2O_5)	LBS	0.220	25.00	5.50	30.00	6.60	35.00	7.70
POTASH (K_2O)	LBS	0.120	20.00	2.40	2.40	3.00	30.00	3.60
SPRAYER	ACRE							
FERTILIZER SPREADER	ACRE							
MISCELLANEOUS EXPENSE	BU							
ANNUAL OPERATING CAPITAL	DOL	0.180	14.460	2.60	18.78	3.38	21.67	3.90
LABOR	HOUR	4.00	2.260	9.04	1.58	6.33*	1.21	4.84
MACHINERY, FUEL, LUBE, REPAIRS	ACRE	--	--	21.68	--	16.81*	--	13.55*
HERBICIDE	ACRE	5.00	1.60	8.00	2.00	10.00	2.00	10.00
HERBICIDE PARAQUAT	ACRE	6.00	--	--	--	--	1.17	7.00
HERBICIDE INSECTICIDE	ACRE	3.00	2.67	8.00	2.67	8.00	2.67	8.00
TOTAL OPERATING COSTS				70.97		73.87		75.09
FIXED COSTS								
Machinery Interest 18.0%	DOL	--	144.67	26.04	122.94	22.13*	115.72	20.83*
Depr., Taxes, Insurance	DOL	--	--	20.18	--	17.15	--	15.91
TOTAL FIXED COSTS				46.22		39.28		36.77
TOTAL PRODUCTION				117.19		113.15		111.86

*Adjustments were made for using conventional equipment every 4 years.

TABLE LXXXII

PRODUCTION COSTS OF BERMUDA GRASS FOR REPRESENTATIVE FARM 3

CROP: BERMUDA GRASS COUNTY: OKMULGEE
Bottomland
Custom harvest

Operating Inputs	Unit	Price/ Unit	CONVENTIONAL TILLAGE[a] Quantity	CONVENTIONAL TILLAGE[a] Cost/ Acre	MINIMUM TILLAGE Quantity	MINIMUM TILLAGE Cost/ Acre	NO-TILLAGE Quantity	NO-TILLAGE Cost/ Acre
LIME	TONS	20.00	2.00	40.00				
	LBS	0.450	2.00	0.90				
NITROGEN (N)	LBS	0.250	110.00	27.50				
PHOSPORUS (P_2O_5)	LBS	0.240	40.00	9.60				
POTASH (K_2O)	LBS	0.120	40.00	4.80				
SPRAYER	ACRE	--	--	--				
FERTILIZER SPREADER	ACRE	4.00	3.00	12.00				
MISCELLANEOUS EXPENSE	BU	--	--	--				
ANNUAL OPERATING CAPITAL	DOL	0.180	14.126	2.54				
LABOR	HOUR	4.00	0.645	2.58				
MACHINERY, FUEL, LUBE, REPAIRS	ACRE	--	--	3.13				
HERBICIDE		--	--	--				
HARVEST EXP	ACRE	20.500	0.830	17.01				
SPRIGGING	ACRE	20.00	1.00	20.00				
TOTAL OPERATING COSTS				140.060				
FIXED COSTS								
Machinery Interest 18.0%	DOL	--	17.27	3.108				
Depr., Taxes, Insurance	DOL	--	--	2.386				
TOTAL FIXED COSTS				5.49		—		—
TOTAL PRODUCTION				145.55		—		—

[a]OSU Enterprise Budget 83500405

VITA

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