To the Graduate Council:

I am submitting herewith a thesis written by Marion Lynne Holliday entitled "Conservation Practice Decision Making: A No-Tillage Adoption Model." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics.

Thomas H Klindt

Thomas H. Klindt, Major Professor

We have read this thesis and recommend its acceptance:

William M. Park

Luther H. Keller

Accepted for the Council:

C W Minkel

Vice Provost and Dean of The Graduate School

CONSERVATION PRACTICE DECISION MAKING:
A NO-TILLAGE ADOPTION MODEL

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ABSTRACT

In this research the extent of no-till use by farm operators was examined in an attempt to explain the influence of farm level variables. The proportion of cropland subjected to no-till practices increased with the age of the operator and the size of crop sales. Other variables were not found to be significant. However, it cannot be concluded that they had no influence.

In terms of policy implications, it appears that if control of erosion through no-till practices is the desired end, then additional research to explain why small units operated by younger farmers tend not to use no-till is needed. Accordingly, it is possible that policy alternatives may need to be directed toward such operators.

Consistent with the conclusions of Taylor and Young, overcoming obstacles related to decreased yields and increased pesticide costs must be dealt with through scientific research aimed at improving crop resistance to pests. This potential solution may not be imminent. But if soil conservation goals continue to be defined in erosion reducing terms, then short term solutions are needed until technology reaches a stage where incentives are no longer necessary. It is intuitive that maximum benefits for dollars spent on soil conservation, regions differing in soils and climates should be given differing incentive treatment. Soils which tend to retain moisture may not be at all conducive to no-tillage techniques, especially in rainy

climates, and may not merit programs designed to encourage its use. In areas where pests are of specific concern, more attention should be given to encouraging no-till by cost sharing for increased use of pesticides and herbicides.

Although the variable associated with ownership was not found to be significant in this study, other studies have shown ownership related variables to be factors in determining the use of conservation practices. The increase in rented cropland in the U.S. supports the need for encouraging minimum tillage and no-tillage because of its appeal over structural practices to individuals with shorter planning periods and higher discount rates. It is suggested that identifying groups distinguished by tenancy status and differences in conservation practice adoption due to soil types and climate be given special attention by researchers to refine the criteria upon which funds are distributed for incentive programs.

If expansion of no-till is desired as a public policy goal, then in establishing future conservation policy, programs should evolve from the notion that farms are economic units and farmers act rationally as managers. With the likelihood that structurally, agriculture is becoming more corporate and ownership is declining, the dependence on the so-called farm ethic (which implies conservation decisions are made separately from concern about net returns) may not be as viable in explaining why conservation practices are undertaken.

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CHAPTER I

INTRODUCTION

A. Historical Overview of Conservation Policy

In the late spring of 1934 a natural disaster occurred in the Western Plains. Winds swept topsoil eastward across the U.S. at such magnitudes that prairie towns were darkened at midday. The plight continued relentlessly through 1936 and it became evident that the consequences of unstifled exploitation of the land were harsh. The urgency of the matter is said to have provided the impetus for the creation of the Soil Conservation Service (SCS) in the U.S. Department of Agriculture with the enactment of Public Law 46. It empowered the Secretary of Agriculture to establish the SCS and to carry out the directives outlined in the bill. The legislation recognized the loss of topsoil as a "menace to the national welfare" and charged the Secretary to "coordinate and direct all activities" associated with soil erosion (Congressional Record). The broad characterization of responsibilities to be assumed by USDA was a foreshadowing of the multi-faceted policymaking considerations which would be required to achieve soil conservation goals.

In 1936, the Agricultural Conservation Program (ACP) was established under the Soil Conservation Domestic Allotment Act which was enacted after the Agricultural Adjustment Act of 1933 which was declared unconstitutional. The provisions of the ACP extended in practice the definition of soil conservation to include farm relief. Its features allowed this through a list of conservation practices deemed as suitable for inducement payments. The practices were chosen in accord with their effectiveness in erosion control and lack of employment by farmers. The problem with the practices list was that it included practices for which inducement payments were available regardless of the physical characteristics of the land. For example, "applying commercial fertilizer" accounted for 42.4 percent of the total ACP payments in 1951 (USDA, 1951). Such questionable applications of public funds is indicative of the problems encountered by soil conservation policy makers in striving to meet goals. The situation has become more complex over time with the changes in the structure of agriculture.

Carter and Johnston contend that U.S. agricultural policy parallels the industrialization process of agriculture. The so-called "Iron Triangle" or "bureaucratic influence" consisting of local farm administrators, USDA, and House and Senate subcommittees has diminished in strength due to interests from a broader perspective. Emerging issues such as the role the U.S. plays in meeting world food requirements, domestic consumer food prices, and environmentalists' concerns have contributed to the wide spectrum of new interests which now demand input in agricultural policy formulation. More recently, the matter of cost effectiveness of agricultural programs has been a matter of public concern. This coincided with the continuing controversy over waste in federal programs.

B. Soil Conservation Programs and Cost Effectiveness

Soil conservation programs in particular have been subjected to cost effectiveness criteria. Despite the early establishment of the SCS and the ACP, the erosion problem persists. The gains made in erosion reduction in the 1950's through conservation practices such as terracing and contouring were undermined in the early 1960's by increased row crop acreage. Accelerated land values also contributed to the problem as farmers needed to quickly recoup higher investments in land by stepping up production levels and consequently discontinuing many conservation practices.

As recently as 1980 SCS observed that soil erosion exceeded tolerance levels which maintain productivity. In essence, soil erosion reduction programs have not been meeting policy goals. As noted earlier, environmental concerns have surfaced as a new policy consideration for agricultural policy makers. The passage of the Federal Water Pollution Control Act Amendments of 1972 introduced the Environmental Protection Agency into the soil conservation policy process when it became apparent that attainment of water quality objectives could not be accomplished by sole measures targeted at units of "point-source pollutants" (Stoll and Griffin). "Non-point" pollution generated by agricultural runoff presented a different problem in terms of regulatory enforcement. Taxation and subsidization incentives have not been effective means to achieve water quality goals as emitting sources are difficult to identify.

Section 208 of the FWPCA deals with non-point pollution by directing the EPA to establish agencies in areas where water quality problems exist and to develop certain requirements for the control of non-point pollution through selected "best management practices" or BMPs. BMPs are both regulatory and economic-incentive based and EPA has the power to require compliance if voluntary measures are unsuccessful.

In 1977 the Clean Water Act amended the FWPCA to provide for cost sharing of BMPs and identified the responsibility of SCS through the Rural Clean Water Program (Federal Register). As in the past, cost sharing programs were implemented to encourage conservation practices but were now developed to address a new problem. Stoll and Griffin maintain that such techniques are simply old policy instruments applied to new social objectives. But in addition to the lack of progressive policy in dealing with new goals, at the heart of the matter is the conflict between society and the individual when considering the economic value of conservation benefits.

C. Economics of Conservation from Two Perspectives: Society versus the Farmer

Society appears to place a higher value on conservation than the individual because of differing time perspectives. From the viewpoint of the farmer, higher current net incomes can generally be attained without undertaking conservation practices. The value of erosion loss does not appear as a cost to the farmer except in the case of depreciation of land values. The tenant does not incur this cost.

Furthermore, measurement of costs and benefits presents the problem of separating present costs and future benefits for individuals and society when using discounted present values of future incomes to determine the cost burden for society and the individual. There is a tendency for individuals to discount future income at a higher rate than society (Baumol). Therefore, society would be willing to bear a higher present cost for future incomes than the individual.

The future productivity issue as an argument for government intervention is a weaker case than is the water quality issue. Crosson argues that conflicting time horizons between society and the individual should not influence internalization of productivity losses. He maintains that diverging interests between society and the individual occur because, from society's perspective, the net benefits from conservation are higher, and that time periods do not enter into the issue. This is based on the assumption that farmers are economically rational and aware of the consequences of erosion and the benefits of erosion reduction and even if the market does reflect the social value of conservation, farmers may not undertake conservation practices.

Crosson's argument gives credence to the notion that farmers employ conservation practices for commercial as opposed to environmental reasons. Hence, in order to achieve more effective use of public funds, incentives should be directed to those areas where farmers are inflicting high costs to society in terms of water pollution and sedimentation and there is a clear case of market failure which requires internalization of social cost by public intervention. The goal of erosion reduction policy should be for environmental reasons and not tied directly to enhancement and maintenance of productivity.

A current trend which is thought to significantly affect adoption of conservation practices in the U.S. is the change in tenure status. Approximately 40 percent of the farmland in the U.S. is now being rented and it is likely that more will be rented in the future (Allen). It has been suggested that this trend toward more rented farmland necessitates a reassessment of soil conservation policy directives for a variety of reasons related to the fact that uniformity in programming is met with diversity in the characteristics of the participants. The feasibility of incentive programs, both politically and in terms of reaching goals, is dependent upon consideration for differences between landowners' and tenants' needs. Different conservation decisions may result on land exhibiting the same physical characteristics, depending upon the planning horizon of the operator. Lower discount rates and longer planning horizons tend to encourage conservation. Such a framework is generally typical of the landowner as opposed to the tenant, who is believed to have a higher discount rate and a shorter planning period.

The implication is that permanent or structural practices such as terracing or grassed waterways may not appeal to renter-operators. Ervin found that of five practices (terraces, contouring, waterways, crop rotations, and conservation tillage), conservation tillage was the only practice found not to differ significantly in percentage application between owned and rented land. He asserted that, based on his findings, use of reduced tillage is a commercial decision because of its cost reducing features (Ervin, February, 1982). This argument was supported by Miranowski who found no significant difference in reduced tillage use between hilly and flat land. These studies imply that adoption factors for reduced tillage practices may be different than for those associated with other conservation practices. The success with which reduced tillage controls erosion merits further consideration toward achieving conservation policy goals, particularly in light of the increasing trend toward rental arrangements. Reduced tillage practices are more economically conducive to rental situations because of their immediate advantages over more permanent practices which tend to render benefits realized in the long-term.

Many studies have addressed the issue of determination of factors which explain the adoption of minimum or reduced tillage or conservation practices in general. Fewer studies have been directed exclusively at no-tillage systems. Observation of the economic characteristics of no-till as opposed to other tillage systems will help to better explain the commercial advantages of no-till and to reinforce the argument that reduced tillage systems are undertaken as a result of commercial decisions.

D. Objective

The objective of the research reported here was to document the extent to which no-tillage was utilized on farms in a representative West Tennessee county and to identify the factors which influenced the proportion of cropland which was no-tilled, among the farmers who practiced no-tillage. This objective was the second phase of a larger research project in which the first step was to evaluate the factors which influence the probability that farmers would use no-tillage practices at all.

It was hypothesized that the use of no-tillage could be largely explained by variables representing the cost savings potential of no-till. That is, the decision to undertake no-till was economic rather than arising from a desire to reduce pollution. Physical attributes such as climate and soil type were believed to be important in that the usefulness of any conservation practice is dependent upon the effect on yields.

It was concluded that the favorable physical characteristics for no-tillage use in the study area were essential in determining the proportion of no-tilled acreage. This was a precursor for further identification of influential variables with regard to the commercial nature of the decision to undertake no-till.

CHAPTER II

CHARACTERISTICS OF NO-TILL: COSTS AND YIELDS

A. No-Tillage Systems as a Solution to the Dichotomy

The labor saving feature of no-till is exemplary in the commercial versus environmental decision dichotomy. No-tillage has been 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 or 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" (Young).

It is necessary to distinguish between no-tillage systems and other conservation tillage systems since the term "minimum" or "reduced" tillage can also be construed as simply decreasing the number of passes over the field. This latter definition implies that there are no changes in tillage practices, just an attempt to save on fuel and labor costs. The <u>No-Till Farmer</u> defines minimum tillage as any system which does not involve employment of the moldboard plow, leaving sufficient crop residue to reduce erosion with some reliance on herbicides for weed control. Crosson used this definition to compare the economic aspects of conventional and conservation tillage. Since no-till is an extreme form of this definition, it can be extended to assess cost considerations for no-till.

Labor requirements for no-till are reduced because of decreased trips across the field, perhaps by as much as 43 percent compared to conventional tillage. Crosson stated that this difference depends on the relative importance of labor costs to total costs exclusive of land costs although the effects on profits could be more substantial especially if profit margins are small. Pre-harvest fuel costs are also lower because of fewer passes over the field. No-till specifically requires three to four fewer gallons per acre of diesel fuel as opposed to only one to three gallons for other conservation tillage practices (Triplett and Van Doren). Other studies showed as much as a 70 to 90 percent reduction in fuel use (Jeter; Richey, et al.; Witmus).

Equipment costs are said to be lower with no-till machinery except in cases where serious weed problems exist and conventional tillage is needed on occasion to control weeds (Hudson). Crosson contended that these cases imply that farmers may perceive conservation tillage equipment as a complement to conventional equipment rather than a substitute.

There are conflicting views on whether conservation tillage requires more fertilizer. If such an increase in fertilizer application is required but offset by increased yields, then different requirements between methods will not be a decisive factor in undertaking conservation tillage. For example, some crops grown under no-till require more nitrogen, but it was found that in using a nitrogen-fixing legume in the cover crop for no-till corn there was a substantial increase per acre over an oat or rye cover crop. Leguminous cover crop yields compared favorably with yields fertilized with 100 pounds of nitrogen per acre (Christensen and Norris). Crosson perceived limited bases in the literature for any generalizations about fertilizer comparisons between conservation and conventional tillage. Fertilizers for corn, for example, account for 20 percent of corn production costs, therefore any differences in requirements between different tillage systems may be a major determinant in farmers' decisions.

The case for pesticides is more clear-cut. No-till relies more on the use of pesticides than any of the other conservation tillage systems. Herbicide costs in one study were found to be as great as 350 percent higher for no-till. Reasons for such differences are due to three effects as stated by Crosson. The substitution effect is the compensatory increase in herbicide application for a reduction in weed control when shifting from conventional to no-till. The efficiency effect involves the stifled dissipation of herbicides by necessary crop residue with any conservation tillage method. The third effect is the environmental effect and is also associated with crop residue where moisture is retained and conditions are more conducive to weed germination.

As for differences in management requirements, it is generally assumed that conservation tillage systems require more management skill than conventional tillage systems because of the reduced number of passes across the field which means fewer opportunities to make adjustments, problems with seed placement because of crop residue interference, and complexity of pesticide and herbicide problems. In addition to greater management skill requirements, the cost of time spent acquiring technological information about conservation tillage, especially no-till, should be accounted for along with costs of obtaining information through publications, extension agents, or other information sources. Such costs were what Crosson labeled "learning-by-doing" costs, but he perceived these as not necessarily crucial considerations given the history of American farmers in their ability to readily adopt complex technological innovations.

In summarizing the cost considerations of no-till, it can be shown that lower costs for other inputs generally outweigh the higher herbicide costs of conservation tillage (Crosson; Hudson; Christensen and Norris). Such favorable cost conditions should deem conservation tillage a viable alternative to conventional systems, especially in the case of no-till which exhibits the greatest reductions in fuel and labor costs. The decision by farmers to adopt no-till would therefore be inevitable except that yield variances may be a constraining factor. A decrease in yields could be tolerated up to some point, as long as reductions in costs were offsetting.

B. Yield Considerations and No-Tillage Use Tendencies

Crosson distinguished between long-term and short-term yields. The effect of conservation tillage on long-term yield is beneficial in terms of lower rates of erosion depending upon the degree of difference in the advantages of conservation tillage over conventional tillage, soil conditions, and changes in the amount of topsoil to changes in yields over time. For example, if soils are deep, then the long-term yield advantages are not as great. In some cases the yield effects of erosion can be counteracted by increased fertilization reducing the long-term advantages of conservation tillage, but this is dependent upon fertilizer costs and topsoil conditions (Crosson). Such long-term yield considerations appear to have less of an effect on farmers who rent land because of shorter planning periods and higher discount rates. Studies on short-term yields have shown that conservation tillage affects yields in varying ways. Some report increased yields, some report decreased yields, and others show no effects at all. Varying yield responses are due to differing conditions related to soil, weather, and weeds. In areas where rainfall is a crucial factor, the moisture retaining aspects of conservation tillage make it attractive in the sense of its yield increasing potential. But in areas where moisture is a problem because of poor soil drainage, conservation tillage, especially no-till, is a definite disadvantage. Such conditions promote disease organisms or cause seed decay before germination can take place.

No-till has been found to affect yields positively when used on coarse, sandy soils or loam soils which tend to drain well (Lepper). Clayey soils are not as suitable to the use of no-till and could adversely affect yields. In a study done in Ohio, clayey soils, because of their high shrink-swell tendency, allowed cracks to develop after drying. Corn roots followed the cracks and as rain filled the crack and draining was hampered, a favorable environment for disease organisms developed and attacked the root (Holliday).

No-till can also affect soil temperature since crop residue can reflect sunlight and result in lower temperatures causing delayed growth and ultimately adversely affecting yields. This is related to inhibited uptake of nutrients which can stifle germination.

Weed control has been cited as a major factor in determining the lack of acceptance of conservation tillage, especially no-till systems. Great care must be taken to achieve the necessary degree of weed control with herbicides, not to mention the increased cost of weed control for no-till in general. In some drier areas where moisture retention is crucial, weed control must be completely efficient to maintain yields. Also, some weeds such as johnsongrass or bermudagrass cannot be effectively controlled with the application of chemicals alone and moldboard plowing and cultivation may be needed to attain sufficient control.

In areas with relatively long growing seasons, no-till is especially appealing with double-cropping since no-till allows planting in preceding crop residue immediately after harvest. No-till increases the moisture retention tendency of the soil for the second crop more so than a conventional system along with the possibility that variable costs would be lower and planting more timely.

Crosson asserts that the awareness of yield variations by risk-averse farmers may result in lack of acceptance of no-till and dominating preferences for technologies which have proven lower variations in yields. This is because below-average yields are more noticeable to farmers than above-average yields and if expected yields vary greatly over time, then risk-averse farmers will discount them at higher rates (Taylor, et al.). The complexity surrounding the decision to undertake conservation tillage is heightened when considering the tenancy status of the farmer. Profit incentives are different for renters and owners as was the conclusion of research done in the southeast Washington Palouse region by Hinman, Mohasci, and Young. They found that there are definite conflicts between renters and owners in short-run incentives to adopt minimum tillage. This conclusion was arrived at by incorporating such considerations as cost advantages of different tillage systems and yield penalties associated with minimum tillage systems and observing returns to renters compared with owners.

Profitability analysis of incentives to undertake any conservation practice generally involves consideration for differences in planning periods and discount rates. Ervin and Washburn stated that there is much diversity in research dealing with the soil erosion productivity topic and that there is little agronomic evidence of a relationship between soil erosion and crop yields. They evaluated the effects of productivity losses on long-run profitability of conservation practices given various discount rates, planning periods and cost sharing levels and found that erosion-induced productivity losses do not significantly affect the choice between up and down hill cultivation and contouring. They also found that differences in returns for the two alternatives are relatively small for various discount rate levels, planning periods, and cost-sharing levels. Non-monetary considerations were suggested as factors which might be more important, such as maintaining long-run productivity for an heir. The implication is that the effect erosion rates have on productivity do not necessarily fall differently upon groups with different discount rates or planning periods such as renters versus owners. But some studies show that rented cropland exhibits higher rates of erosion than owner-operated cropland. Williams tested this by comparing treatment status of cropland, land capability classes, and crops grown between rented and operated tracts. The sample was comprised of 400 tracts, 65 percent rented tracts with the remaining 35 percent owner-operated tracts. The treatment status categories included adequate, partial, and none. Twenty-seven percent of the owner-operated tracts were classified as adequately treated compared to only 18 percent for the rented tracts. In the no-treatment category (the most erosive cropland), 32 percent of the total owner-operated tracts as opposed to 44 percent of the rented tracts fell here. Although rented tracts made up 68 percent of the 400 tracts, they accounted for 75 percent of the total tracts with no conservation treatment. Williams also found that land capability classes 6e and 7e (not considered suitable for row cropping) were on 17 tracts of the total owner-operated tracts and 46 tracts of the total rented tracts. Williams also looked at rental arrangements to check for conservation treatment status and found that written, cash, three year or more arrangements enhance treatment status on rented cropland.

Hoover and Wiitala examined participation rates in soil conservation practices in an area where soil erosion is severe. Among their objectives were to assess operators' and landlords' perceptions of soil erosion problems and the need to control erosion and to determine the implication for operator and landlord participation. Two percent of the operators indicated a major soil erosion problem while 40 percent said there was no such problem. SCS classified 82 percent of the farms in the study area as having high soil erosion potential and none without problems. Operators stated that low levels of cost-sharing were one of the major problems with BMPs. They suggested a 90 percent or more cost-sharing level to induce their participation. At the time of publication of their study, Hoover and Wiitala asserted that the most popular practices have not been eligible for past cost-sharing (such as reduced tillage, crop residue management, stubble mulch, etc.), and contend that these practices could be easily incorporated into existing operations without much extra cost, extra labor, or machinery difficulty.

As for improving cost-sharing arrangements for reduced tillage, one study showed that cost-sharing directed specifically at no-tillage will not necessarily induce increased use. Taylor and Young constructed break even formuli to equate income for heavy tillage with no-till under three different policy situations: cost-sharing, price supports, and direct regulation with fines. In each policy scenario, Taylor and Young concluded that it is nearly impossible to induce use of no-tillage systems because of yield penalties which render it noncompetitive with heavy tillage. This conclusion was developed after assessing the costs over planning horizons from 1 to 50 years at discount rates varying from 0 to 10 percent. Taylor and Young assert that there will always be an incentive for farmers to revert back to heavy tillage and that they will do so upon the discontinuance of any policy. The authors felt that a solution rests with reducing yield penalties associated with no-tillage systems through extensive research. They recognized this solution as being long-term and suggested that the short-term should continue to be dealt with through incentives focused on minimum tillage and no-tillage systems.

Observation of an SCS map which identifies patterns of soil orders and suborders in the U.S. shows the Palouse region (southeastern Washington and adjacent areas in Idaho) as being characterized as the soil suborder andepts. Andepts, a suborder of inceptisols, are soils developed from volcanic ash which tend to be granular and highly erosive. Inceptisols in general are usually moist. Such characteristics lead to high soil erosion and lower than average yields under no-tillage conditions. The Palouse study made assumptions about yield penalties that would not be appropriate to areas where conditions for use of no-tillage systems are more favorable. The problems with no-till in the Palouse were apparent in examining the trends of acreage in no-till for the Pacific States in Table 1. Of the regions listed in the table, the Pacific States and the Southern Plains employed the least cropland acres in no-tillage systems. The area adjacent to northeastern Washington in Idaho is also considered to be part of the Palouse. Idaho falls into the Mountain production region in the table and is shown as employing only 241,000 acres in no-tillage systems. The Corn Belt, Appalachia, and the Northeast lead with 2,021,000; 1,994,000; and 1,837,000 acres respectively. Christensen and Norris attributed these regional differences in the practice of no-till to variation in soil types which result in different yield responses and soil temperature. Although the Appalachian region had the second largest percentage of total cropland in no-till systems in 1981, it led the other regions in 1974 with 10.7 percent and maintained steady use over the entire period (Christensen and Norris). Data presented on yields in one state in Appalachia—Kentucky—showed increases in corn yields by changing from conventional to no-till for 11 different types of soil, all loam, which tend to drain well.

The yield responses associated with the transition from conventional to no-tillage systems observed in Kentucky may explain

Table 1. Cropland Acreage in No-Tillage Systems[a]

Region	1973	1974	1975	1976	1977	1978	1979	1980	1981
Northeast	744	805	649	795	809	839	903	970	1,837
Lake States	286	359	345	181	227	264	277	364	440
Corn Belt	1,912	1,919	2,143	3,564	2,793	2,401	2,539	1,911	2,021
Northern Plains	373	450	1,138	476	756	980	957	914	950
Appalachia	1,316	1,598	1,805	1,844	1,925	1,873	2,092	1,866	1,994
Southeast	70	112	159	215	290	405	486	703	899
Delta States	15	22	67	92	99	77	93	143	168
Southern Plains	65	69	143	216	268	152	130	54	52
Mountain States	93	105	14	23	31	113	120	174	241
Pacific States	2	4	6	124	72	38	44	36	52
Total U.S.	4,875	5,444	6,470	7,529	7,269	7,141	7,640	7,135	8,654

[a](In thousands of acres.)

Source: A Comparison of Tillage Systems for Reducing Soil Erosion and Water Pollution, AER 499, ERS, USDA, May, 1983.

the sustained use of no-till over time. It is probable that other regions would also adopt no-till for its cost savings features alone if soil and climate conditions were favorable enough that yield penalties were not offsetting.

As suggested by Taylor and Young, a concentrated effort on overcoming yield penalties through research is emphatic. However, the solution through technological advances may not be forthcoming in the near future. Since soil erosion is a current problem, short-run incentives need to be examined as a temporary solution until the state of the art is perfected to the point of reducing the tendency to maintain conventional tillage methods. No-tillage systems render good erosion-reducing results and constitute a justifiable issue for adoption research. In examining possible relationships between economic, sociological, or physical factors with high adoption rates in those areas where no-till is widely used, conclusions may be drawn about incentives for more efficient use of soil conservation program funds. Further consideration must be given to the tendency toward rented farmland with respect to the factors mentioned above.

The Appalachian region and the sustained use of no-till which it has exhibited over time could provide insight into the adoption factors associated with high practice rates. Research conducted at the West Tennessee Experiment Station in 1979 showed increases in soybean yields with no-till over conventional tillage. Other studies in Tennessee and Kentucky have shown equivalent or higher corn yields. The positive effects on yields are believed to result from increases in moisture retention which encourage plant growth and the timeliness factor. Water loss is reduced and the evaporation rate is slower because of mulch or crop residue. Research in Tennessee shows that "corn yields are reduced one bushel per day for each day past the recommended planning date of May 1" (Hudson). The typical procedure of burning straw, chiseling, and disking with double cropping of wheat and soybeans can cause moisture loss and ultimately delays in planting. Eliminating these steps when a no-till system is used allows more timely planting of soybeans (USDA, 1980).

CHAPTER III

REVIEW OF THE LITERATURE

A. Past Findings and Formulation of No-Tillage Adoption Model

The literature summarized in the section below by no means exhausts the stock of published research related to conservation practice adoption. The research cited here does, however, represent certain concepts which were integral in the development of the no-till model with respect to choice of explanatory variables and their hypothesized effects on the dependent variable.

The significance of the sequence of the review of the literature is associated with the formulation of the model. The first component of the review is relegated to studies which have dealt with conservation practice adoption in general terms. The Prundeanu and Zwerman study and the Dubman and Smathers study both examined adoption factors over a spectrum of characteristics related to personal, economic, and other demographic characteristics. The Ervin and Ervin "decision model" was the more comprehensive of these three studies in that a decision model was used which examined personal, economic, and physical factors as separate and distinguishable in terms of effects on adoption. The Nowak and Wagener study which applied Cancian's thesis to soil conservation implied that economic rank could be significant in explaining adoption willingness. Since the tenure status of the operator might be a determinant of economic rank, then the Cancian thesis application could be used to make assumptions about adoption tendencies of renters and operators. The research done by Nowak and Wagener provided a linkage for this study between literature related to general adoption models with literature related to the more specific examination of factors which might be determined by discount rates and planning periods. The significance of this latter component of the review of the literature lay with the application to differences in adoption tendencies for renters and owner-operators based on the notion that renters may have higher discount rates and shorter planning periods than owner-operators.

The final component of the research reviewed is devoted to studies which directly addressed tenure influence on soil conservation. Ervin examined possible differences in conservation practice use and erosion rates between renters and owner-operators. Special attention was given to profitability of conservation practice use and also to the differences in how erosion was perceived by renters and owners. Studying participation rates for conservation use, Hoover and Wiitala examined factors which were thought to have influenced adoption. Included among these were tenure and other variables linked specifically to renter or owner characteristics.

The first Lee study (1980) dealt with the notion that organizational structure may affect soil conservation. Erosion rates over varying types of organizational structures and the effects of land-ownership were studied. The 1983 Lee study also dealt with landownership, but was specifically addressed to influences on minimum tillage adoption.

The final publication reviewed was the most crucial to this study. Hinman, Mohasci, and Young analyzed variations in returns to renter-operators and landlords for three tillage systems under differing yield situations with estimations in each category. They attempted to show that a possible conflict exists between landlords and renters with regard to short-run incentives. The implications of the results in their study were integral to the hypothesis developed here.

B. Research Using Adoption Models Composed of More General Factors

A study conducted by Prundeanu and Zwerman was concerned with the "economic factors that may influence a farmer to accept recommended soil conservation practices and to win his attitude toward soil conservation" (Prundeanu and Zwerman). The sample was taken from the Cayuga, Ontario, and Livingston Soil Conservation Districts in New York. There were two analytical approaches employed for the study. One approach was aimed at relating individual conservation practices to single economic factors. The other approach divided the farmers into two groups—a high conservation group and a low conservation group. The groups were identified by the percentage of the agreed upon practices which had actually been established. A farmer who had completed more than half the practices was classified in the high group and one who completed less than half fell into the low group.

The results showed that the farmers in the high conservation group had more total acreage but less acres in farmland with less cropland in permanent pasture and less land in woods than the low conservation group. The farmers in the high conservation group also received significantly more PMA payments than the low group (PMA payments were administered as compensation for conservation costs as set up in the provisions of the ACP).

Prundeanu and Zwerman also found that the physical characteristics of the land alone are not necessarily related to the kind and amount of soil conservation practices established by the farmer. The farmers in the Cayuga sample who fell into the high conservation group had a larger number of father-son partnership farm operations. The two groups did not differ regarding total capital investment and equipment value. The loss of information by the "high" and "low" grouping was recognized as a methodological limitation by the authors.

Ervin and Ervin recently examined the factors affecting soil conservation practices. Their 1982 research reflects the refinement of adoption research over the years. Cited as weaknesses in existing research were the ways in which the dependent variable has been measured and the aversion by researchers to use prior study results to build a standard adoption and practice use model. Ervin and Ervin attempted to build a comprehensive model which incorporated personal, physical, economic, and institutional factors into three categories of the decision making steps towards erosion control. The three categories were: (1) the farmer's perception of the degree of erosion (PERCEP); (2) the decision to use conservation practices (NPRAC); and (3) the soil conservation effort (EFFORT). The PERCEP model was a binary measurement with four possible responses ranging from severe to none as perceptions of the degree of erosion. NPRAC was defined as the number of practices used, including possibilities such as terracing, contouring, crop rotation, minimum and zero tillage, and waterways. EFFORT was determined by using the universal soil loss equation to estimate the difference between the erosion rate without conservation practices and the rate with the undertaking of certain practices based on sample information. In using these three different measurements the authors constructed a model based on prior research which had, in the past, mainly focused only one means of measurement. They contended that the singularity of the dependent variable has been prohibitive in attempting to determine the significance of certain factors. With the more comprehensive model, factors need not be excluded as the three models were representative of processes which led to erosion control and all encompassing different characteristics associated with personal, economic, physical, and institutional attributes.

The hypothesized relationships were tested using multiple regression analysis. The PERCEP model results showed only education and erosion potential as significant. For the NPRAC model, education, perception, risk aversion, and cash grain production were significant variables. The relationships for education and perception with NPRAC were positive, and for risk aversion and cash grain production, the relationship was negative. in the EFFORT model, erosion potential, education, perception, and cost-sharing participators were found to be significant variables and were positively related with the dependent variable. Again, cash grain production was found to be significant and inversely related to EFFORT. The authors asserted that the variables found to be significant support their conservation decision process theory, but that most of the variation was left unexplained due to the many insignificant variables. They suggested that the difficulty lay in the necessary use of longitudinal data to explain a dynamic process.

Regression analysis was performed for each of the conservation practices using the explanatory variables. A noteworthy result was that the variables which showed significance were erosion potential and perception with an inverse relationship with minimum tillage for erosion potential and positive relationship for perception. The authors' explanation was that perception of a problem is a sufficient condition to use minimum tillage or that the operators who did perceive erosion as a problem use minimum tillage as a cost savings mechanism.

Dubman and Smathers recently studied characteristics which may change a landowner's willingness to adopt conservation practices. Personal factors other than those stemming from purely economic factors were stressed. The model used race, sex, age, education, current conservation practices, and farm size as independent variables. The authors' hypothesis concerning the relationship of age with adoption of conservation practices is of interest. Dubman and Smathers apply the consumption function theory of Ando and Modigliani to hypothesize a life-cycle theory for age. The basis for application of the theory is that younger farmers who are confronted with uncertainty may be unwilling or unable to undertake a soil conservation investment and that older farmers may have necessarily shorter planning periods if a transfer of ownership is imminent. Age was therefore predicted to initially have an increasing effect, then a gradual effect, on adoption willingness.

Ordinal probit and least squares were used to determine the significance of the six variables in explaining changes in four different conservation practices: contour plowing, terraces, reduced tillage, and grassed waterways. Race and sex were shown to be insignificant. Farm size was found to be highly significant for all four practices but negative, showing that small farms favor conservation practices more than large farms. The authors' explanation is that a possible limitation is posed by machinery since equipment for large operations may not be conducive to contouring, terracing, or grassed waterways. They did not suggest why such a negative relationship existed between reduced tillage and farm size. The age variable exhibited a significant non-linear relationship as predicted. Education was positive in all four equations but was not significant. Whether or not a farmer was using a current practice was found to be significant and positive in all equations except reduced tillage.

The extent that risk and social position affect conservation practices was examined in a study by Nowak and Wagener. The thrust of the research was based on the authors' contentions that attitudes are influenced by socioeconomic environment. They used Cancian's thesis to test the theory that risk orientation, when considering early adoption of an innovation, is affected by economic rank and the time in which action occurs. Cancian's thesis was that economic rank was viewed as being more important than any psychological characteristic singularly identified with the individual in explaining adoption tendencies. It is built upon three assumptions: (1) high rank is preferred to low rank; (2) risk-taking or risk-aversion motivations depend upon achievement or maintenance of high rank status; (3) uncertainty and risk are separate and early adoption encompasses more uncertainty than risk, and under different levels of stratification actions taken may vary. This idea conflicts somewhat with traditional theory which posits that a direct linear relationship exists between economic rank and early adoption.

The relationship developed in Cancian's thesis embodied two tendencies identified as the facilitating effect and the inhibiting effect of economic rank. The facilitating effect of rank was consistent with the traditional linear relationship theory. The inhibiting effect departed from traditional theory and contributed to the curvilinear effect. It was based on the notion that in order for high rank to be maintained, adoption will be avoided because of uncertainty. But with low rank, adoption is likely to occur in an attempt to improve rank. Cancian contended that uncertainty is less threatening to those at the lower end of the socioeconomic structure since potential losses do not greatly affect the rank of this group.

Nowak and Wagener employed Cancian's thesis to study the effects of economic rank on the adoption of reduced tillage. The research procedure measured economic rank in both total acres of land operated and average gross income. The independent variable was the reported usage of a reduced tillage system. The results showed that when rank was based on income, there was support for Cancian's thesis; but when rank was based on the other method, land distribution, there was little support for Cancian's thesis. However, the authors felt that, overall, the data supported Cancian's thesis that there exists an "upper-middle class conservatism in agricultural communities" and concluded that the traditional notion that rank has a constant effect on adoption should be questioned.

Generally speaking, the influence of rank may in fact affect the adoption of conservation practices to a greater extent than variables which are exclusively related to the individual. But variations within the economic ranks may arise as a result of restrictive institutional factors such as tenure status or leasing arrangements which confound the assumptions of existing adoption theory.

Studies have been done which show erosion rates to be higher on rented land. In some cases this was observed where the potential was found to be less on rented land than owned land. The implication is that soil conservation policy may need to recognize renting versus owning land in conservation decisions to facilitate effective distribution of public funds.

C. Research Using Models Composed of More Specific Factors and Linked to Tenure

Ervin cited two themes which pervaded early research dealing with the influence of tenure on soil conservation: tenure insecurity and unequal distribution of costs and returns to conservation practices between tenants and landlords (September, 1982). These obstacles to undertaking conservation practices are partially a result of leasing arrangements. Another obstacle which may exist is the lack of information about erosion problems and conservation practices. One study showed landlords underestimated the severity of erosion problems when their perceptions were compared with those of the tenants. Regarding profitability as an obstacle, landlords may have shorter planning periods and higher discount rates than owner-operators stemming from such factors as age (landlords generally may be older) or education. Ervin tested for differences in uses of conservation practices between renters and owner-operators. He found that the average sample erosion rate for cropland and permanent pasture was 40 percent higher on rented than owned land. The degree of difference in use of conservation practice between renters and owner-operated land was also measured. It was shown that the percentage of owner-operated land in each conservation practice exceeded the corresponding percentage for rented land. Ervin contended that the significantly higher erosion rates on rented land imply that factors other than higher erosion potential were responsible for such differences. He suggested that tenure may also be important.

From the same study, an interesting point relevant to the cost reducing merits of conservation tillage was the observed lack of difference between renters and owner-operators. This reinforced the notion that the cost considerations of conservation tillage encouraged its use as opposed to its erosion control benefits.

When testing for the effects of certain explanatory factors associated with rented cropland erosion rates, Ervin found only physical erosion potential and cost-sharing provisions to be significant in explaining erosion rates. He concluded that, based on the findings, state and federal programs should contain features designed for renter-operators. Also suggested was promotion of more equitable cost-sharing arrangements between landlords and tenants. In light of landlord absenteeism, which implies shorter planning periods, it may be better to focus on nonstructural conservation practices such as conservation tillage and possibly make annual cost-sharing payments available to the same rented lands to undertake such practices.

Hoover and Wiitala studied participation rates in conservation practices in the highly erosive area of northeast Nebraska. Special consideration was given to: the use of different kinds of conservation practices and tillage methods; comparisons between landlords' and operators' perception of soil erosion; the influence of certain factors on adoption and what role these considerations taken together may play in reducing soil erosion. The analytical framework for the research was divided into three parts: the first part involved the perspectives on soil erosion in the study area with attention given to differences which might occur between operators and SCS findings; the second component was aimed at those who indicated an erosion problem and focused on their willingness to adopt more practices; the final component identified those who indicated the existence of an erosion problem and the influencing factors leading to the adoption of conservation practices. Since operator, landlord, and farm characteristics were thought to influence adoption, factors which were associated with those characteristics were tested for significance. The authors examined age, tenure, off-farm employment, disposal of farm, type of farm, land use and size, type of farm organization, and soil erosion potential. They found that with regard to age, landlords were generally older and that younger operators were less likely to have been cooperators in conservation programs with the ASCS or SCS during the past 5 years previous to the study. Regarding tenure, it was found that two-thirds of the tenants had been on the current farm less than 10 years and that two-thirds of the full owners had been on the current farm at least 25 years. Off-farm employment was not found to be a factor in SCS cooperation. Eighty percent of the owner-operators did not have plans to dispose of their farms within the next 5 years. Fifteen percent of the operators did plan to stop farming within the next 5 years and most of the farmers in this group were 55 years of age or more. Cash grain and livestock typified the major farm operation in the study area but there was no significant difference between type of operator and type of farm.

Full owner-operator farms tended to be smaller than part-owner farms and part-owners rented more acres to increase the size of operation. The primary type of farm organization was the individual or family farm. Regarding soil erosion potential, 2 percent of the operators indicated a major problem but 40 percent expressed no problem. SCS classified 82 percent of the farms in the area as having a high soil erosion potential and none without problems. In addressing the type of conservation practices and the extent of use, half of the operators indicated that there were practices they should use but were not using at the present. Terraces, dams, reduced tillage, contouring, and grassed waterways were the BMPs which would be most readily received if cost-sharing were available. The major obstacles to increasing the use of BMPs as indicated by the tenant were landlord's objections, extra work, machine difficulties, and low levels of cost-sharing. About 50 percent of the operators advocated increases in cost-sharing. Eighteen percent of the operators and 20 percent of the landlords chose tax credits as a cost-sharing means. Sixteen percent of the operators and 9 percent of the landlords preferred low interest loans as a cost-sharing method. Hoover and Wiitala believed that as long as soil productivity is maintained with fertilization and adequate rainfall, there will be no foreseeable need to adopt conservation practices despite erosion losses. The situation would likely continue until increases in fertilizer prices affect the tradeoff between soil loss and increased fertilization.

The fact that the organizational structure of agriculture is changing may be perceived as having adverse consequences for soil conservation. Lee studied the notion that a larger, more corporate agricultural industry is less likely to pursue soil erosion reductions. The study addressed differences in organizational structures with regard to erosion rates. She also examined landownership and soil erosion from a broader perspective than previous research. The second research objective, according to Lee, was due to the narrower geographic focus of past research. She contended that past studies may not have accurately evaluated factors which truly influence conservation decisions because of the narrow scope of the studies and also that many have been conducted only in the Corn Belt region. In response, Lee examined structural and landownership influences on a regional and national basis. Data for the analysis were taken from the 1977 National Resource Inventory and 1978 Landownership Survey. One model focused on variables associated with landownership

The second model was constructed of varying income levels of full owner-operators to represent different tenure groups. The analyses did not show significant differences in erosion rates at the national level nor in most of the regions. Only in the Northeast region were erosion rates significantly greater for full landlords than for full owner-operators. The only relationship observed between higher levels of income and lower mean erosion rate levels occurred in the Southern Plains. Lee found that the tenure category of the landowner was the major determinant in the relationship between net income and mean erosion levels. Higher income levels were found to be associated with lower rates of erosion for full owner-operators nationally and in five out of the 10 production regions. The influence of off-farm income and total income on erosion rates were tested by tenure groups; however, no significant differences were observed.

A later study by Lee (1983) dealt with the relationship between landownership and minimum tillage adoption. Data were obtained from the 1977 National Resource Inventories and the 1978 Landownership Survey. Four categorical variables were considered: tenure status, erosion hazard, region, and organizational structure. Logit analysis was used to model the relationship of these variables and minimum tillage rates. Lee's justification for this method was based upon the large number of parameters to be estimated. Results showed that adoption was lowest among full owner-operators. The tenure effect was also significant across all regions. Lee observed no interaction effect between tenure and region and suggested that leasing arrangements did not affect the relationship between tenure and the adoption of minimum tillage. The results also showed that small farm size may inhibit minimum tillage adoption as hypothesized. Not supported by the findings was that minimum tillage differences among landownership groups were accounted for by differences in land quality or regional location. But, regional effects alone were found to be more important in explaining minimum tillage adoption. The author suggested that crops, reduction in yields, erosion problems, and local attitudes may explain many of such regional adoption differences. After accounting for tenure classification and farm size, the analysis indicated minimum tillage adoption was slightly more likely to occur on less erosive lands. The conclusion drawn by Lee from these findings was that the adoption of minimum tillage was in fact a decision not primarily related to soil conservation, but as a cost-savings motivation.

In a study conducted in the Palouse region by Hinman, Mohasci, and Young, differences in short-run incentives for landlords and tenant operators were shown to exist. The analysis incorporated considerations for yield reduction penalties for minimum tillage and no-tillage at the 0, 50, and 100 percent levels. Also considered was the extended machinery life (EML) cost-savings feature of minimum and no-tillage systems. Returns to operator and landlord were examined using conventional, minimum, and no-tillage systems at varying tenure levels (0-100 percent land leased) under a crop share arrangement. The assessment showed that under full penalty yields, with normal machinery life, minimum and no-tillage systems are not economically competitive. The reduction in gross receipts imposed by minimum tillage more than offset cost-savings. No-till imposed the same constraint but was even less desirable because of increased production costs associated with pesticides. No-till remained unprofitable under EML and zero yield penalties. With the cost-savings generated by EML and a 50 percent yield penalty level, minimum tillage was the most profitable system for all tenure situations in the analysis. The greater the percentage of land leased, the greater the incentive for tenant operators to adopt minimum tillage since the operator could capture the full value of machinery cost savings. In a crop share situation, the tenant operator suffered full yield penalties. The landlord's penalty came in the form of reduced crop share rent value.

The comparison of returns to labor and management to land between conventional and minimum tillage (under 50 percent yield penalty) showed that operator returns were consistently reduced under minimum tillage but such declines were more than offset by the cost-savings of minimum tillage due to EML. Since landlords did not participate in such production endeavors that entail cost savings, there was no incentive to adopt minimum tillage. Short-run landlord profits were therefore maximized by maintaining conventional tillage practices. The authors suggested that an internal conflict may exist between short-run and long-run incentives for the adoption of conservation practices. The long-run incentives for landlords are embodied in longer time horizons because of tenure security and also in prospect of higher future yields. Also, landlords may benefit from higher land values if the quality is maintained. These findings led the authors to conclude that conservation incentive programs should be designed to consider landlords' and operators' interests. They suggested focusing on long-run returns in programs directed toward landlords and emphasizing short-run and long-run returns to operators.

CHAPTER IV

METHODS AND PROCEDURES

A. Justification of Method

A significant amount of research has been directed toward examination of conservation tillage practices. In this study, the focus was narrowed specifically to no-till production practices. However, hypothesized relationships draw heavily from previous research. The research reported here was part of a two-phase project. The first was to evaluate (and ultimately predict) the decision of whether or not to adopt no-till practices. In the earlier research, the dependent variable was dichotomous and logit analysis was used. In this research, the intent was to explain the extent of no-till use by the subset of farm operators who adopted the practice. The dependent variable was measured as the proportion of cropland on which no-till practices were used. In this case, multiple regression was used to evaluate whether a relationship existed between the dependent variable and a set of independent variables which were hypothesized to affect the proportion of cropland on which no-till was used.

B. Study Area

The study area was in Henry County in West Tennessee, a highly productive but highly erosive area. Average rates of erosion on cropland in the area exceed the national average by about 10 times.

This can be attributed to relatively intensive row crop production on the gentle, rolling topography of the land coupled with deep loess soils in the area. Loess soils are characterized by their generally granular, silty texture and transport easily when exposed to rain. The soils in this particular region of Tennessee of the alfisol order are also well-drained and usually moist, but somewhat dry during the warm season (USDA, 1980).

C. Sample

The sample was developed from a random block design. Henry County was divided into 50 blocks with an approximately equal number of rural households. The blocks were chosen randomly. All rural residences within chosen blocks were visited and interviews were conducted with the heads of households.

An observation had to meet the following criteria to be included in the sample: (1) the respondent must have been actively engaged in crop farming at the time of the interview; (2) the respondent carried the primary responsibility for farm management decision making; (3) the respondent owned at least some cropland.

For the entire study, 120 observations were obtained. Of these, 101 observations were usable in this study. (For more information on descriptive statistics for the sample, see Jamnick.)

The questionnaire for the interview was developed with emphasis on variables identified in recent innovation adoption research. Information was collected on such factors as farmers' attitudes, personal attributes, and experiences with and opinions toward no-till. Attention was also given to physical characteristics of the land and economic factors. Detailed information regarding leasing arrangements and organizational structure was not obtained though some variables in the model were related to tenure and organizational characteristics.

D. Description of the Survey Instrument

The questionnaire was divided into five major topic categories which addressed farm characteristics, characteristics of the individual farmer, sources of communication, attitudes toward erosion, and finally, income or income related questions.

Under the topic of farm characteristics, questions were directed at how much acreage was farmed as an owner or a renter. Information on no-tillage acreage by crop (corn, soybeans, wheat, and soybeans and wheat double-cropped) and tenure status was also obtained. Other questions in the farm characteristic category were directed at type of farm organization, length of time the farm was owned or rented, expectation of transferral, level of decision-making authority, perception of erosion, and conservation practice or practices currently being used.

Under the heading of farmer characteristics, individuals were asked whether farming was their primary occupation, their secondary job or occupation, number of years farming, father's occupation, education, and age.

Subsumed under the third topic, communication sources, were questions regarding use of various sources of information which may have assisted in opinion formation toward no-till farming. Other questions addressed communication with SCS or an extension agent.

Farmers' attitudes were addressed with questions directed at whether farmers considered erosion to be a serious problem, and whether they advocated cooperation in soil erosion reduction.

The income portion of the survey asked for annual crop sales, listed certain household appliances to check if owned, and also asked for the investment value of land, buildings, and equipment.

E. Model for Examining the Adoption of No-Tillage Practices

The multiple linear regression model was specified as:

$$y = (x_1, x_2, x_3, \ldots, x_8)$$

where y = NTACRES, or ratio of acres in no-till to total cropland acres;

x_1 = LAGE, or age of respondent in years;

x_2 = EDUC, or the cumulative years of education of the respondent;

x_3 = SECOCC, or whether the respondent had an occupation secondary to farming;

x_4 = CRPSALE, or total sales of crops in 1980;

x_5 = PEROWNAC, or percentage of acreas owned;

x_6 = TRANSFER, or whether the farmer had plans to transfer ownership of the land within the subsequent 5 years;

x_7 = SLOPE, or the percent of farmland which was thought by the farmer to be greater than 5 percent;

and

x_8 = NOSCS, or the number of times a farmer had talked with an SCS agent in the past 2 years.

The null hypothesis tested was that no relationship exists between the explanatory variables and the dependent variable; i.e., that none of the variation in the dependent variable can be explained by variation in the independent variables.

The Dependent Variable

The dependent variable measured the proportion of percentage of total acres of cropland which are operated under a no-tillage system (NTACRES). The ratio was constructed by combining the response to the number of acres in no-tillage systems for corn, soybeans, wheat and double-cropped soybeans and wheat in 1981 for the numerator, and for the denominator, total acres as the combined response to total cropland owned and operated and rented and operated.

Explanatory Variables

The effects of age on NTACRES were included in the model. A nonlinear relationship was hypothesized on the findings of Dubman and Smathers and their application of the Ando-Modigliani life cycle theory to the adoption of conservation practices. Younger farmers were hypothesized to be less likely to adopt conservation practices due to economic restraints, and older farmers because of shorter planning periods due to the possibility of transfer of ownership. Lee (1980) found that older farmers having no heirs operate under shorter planning periods than younger farmers. Christensen, Lee, and Norris found that young farmers were either unwilling or unable to invest in conservation practices. Seitz and Swanson supported this with findings that, although younger farmers saw a need to employ conservation practices, they were less willing to adopt. The age variable LAGE was in logarithmic form to allow for nonlinearity. The responses ranged from 22 to 74 years of age at the time of the interview with a mean age response of about 49 years.

Education (EDUC) was measured as the highest grade completed in school on a cumulative basis. Thirty-six percent of the respondents stated that they finished high school and 18 percent said that they finished up to grade eight. The hypothesized relationship between EDUC and NTACRES was positive. The findings of Ervin and Ervin support this hypothesis in that education was found to significantly affect the number of conservation practices adopted and the soil conservation effort. Carlson, et al. also found that a positive significant relationship existed between education and conservation practice adoption. Responses ranged from 3 years of education completed to 18 years with a mean response of approximately 11 years.

Off-farm income was represented by SECOCC (secondary occupation) in which respondents were asked if they had occupations other than farming. Twenty-seven percent responded that they did in fact have jobs other than farming, which implied those operators were supplementing their farm incomes. With this in mind, it was believed that due to economic constraints, those farmers with off-farm income would be less likely to adopt conservation practices. Therefore, an inverse relationship between SECOCC and NTACRES was hypothesized. Off-farm income has generally not been useful in predicting changes in conservation practices in the literature, although Blase (1960) found it to be significant in explaining reductions in soil loss in Western Iowa. SECOCC was specified by using dummy variables for the following responses to the question of whether the respondent had a second job or occupation: 1 = occupation secondary to farming; 0 = no secondary occupation.

The variable CRPSALE represented the response to the total sales of crops in 1980. Approximately 29 percent of the farmers responded that they had over $100,000 in crop sales in 1980. CRPSALE was hypothesized to be directly related to NTACRES. CRPSALE was specified for eight income ranges as follows: 1 = $0-10,000; 2 = $10,001-20,000; 3 = $20,001-30,000; 4 = $30,001-40,000; 5 = $40,001-60,000; 6 = $60,001-80,000; 7 = $80,001-100,000; and 8 = over $100,000. The direct relationship of CRPSALE with NTACRES as hypothesized was consistent with Lee and Stewart who associated low net farm income with higher time preference rates (or higher discount rates) and therefore less tendency to adopt minimum tillage practices. Anderson, McNall, and Inman found that higher incomes were associated with higher degrees of soil conservation in the midwest. As a proxy for size, the predicted relationship was also positive. Prundeneau and Zwerman found that higher conservation groups had higher total acreage and more cropland. Lee (1983) found that small operating size posed more of an obstacle to minimum tillage adoption than separation of ownership at national and regional levels. Miller, Rosewald, and McElroy found that small farm size was associated with low volume production, higher per unit costs and low net farm incomes which would subsequently lead to higher discount rates, thus discouraging conservation practice use.

The percentage of acres which were owned was designated as PEROWNAC. The data shows that 47.5 percent of the respondents stated that they rented no cropland at all. All the respondents owned some cropland with acreage ranging from 10 to 800 acres. The mean of PEROWNAC was approximately 69 percent. The hypothesized relationship of PEROWNAC with NTACRES was positive. Separation of ownership has been found to be an obstacle to adoption of conservation practices in that landlords tend to have higher discount rates or shorter planning periods than their tenant operators. Also, absentee landlords have been found to lack knowledge concerning the extent of an erosion problem. The landowners in this study were all owner-operators and were thus removed from such characterizations of the absentee landlord.

Williams found that soil erosion rates were higher on renter-operated land than owner-operated land and that although 68 percent of the surveyed tracts were rented land, those tracts accounted for 75 percent of the total tracts with no conservation treatment. Lee (1983) found that full owner-operators and landowners with small holdings had lower minimum tillage adoption rates. Ervin found that the percentage of owner-operated land in each of a given number of conservation practice categories exceeded the corresponding percentage for renter-operated land.

An indication of how the possibility of the shorter planning period might affect conservation decisions is subsumed within the farmer's future plans regarding transfer of ownership. The respondent was asked if he expected to transfer, sell, or rent out the land in the next 5 years current to the interview. The response was represented by the TRANSFER variable. The variable was specified by dummy variables with 0 representing a negative response and 1 representing a positive response, or 0 = no plans to transfer and 1 = plans to transfer in the next 5 years. An imminent transferral of ownership implies a probable tendency not to adopt a conservation practice because of unrealized future benefits. TRANSFER was therefore predicted to be inversely related to NTACRES. Although Ervin and Washburn contended that the maintenance of long-run productivity may be an important consideration on a farm to be interited by a family member, it was thought that the TRANSFER variable would not be affected by such an influence because of the extent of rented cropland in the area.

The perception of erosion as a problem has been found to be an important factor in explaining conservation practice use. The proportion of farmland which was thought to have a slope greater than 5 percent, SLOPE, was used to represent this perception. The response ranged from 0 percent to 99 percent with a mean response of approximately 64 percent. SLOPE was hypothesized as having a direct relationship to NTACRES. In spite of the high occurrence of rented farmland in West Tennessee with the likelihood of non-adoption related to tenancy, the area has over the years been heavily involved in conservation programs. It was therefore thought that the general awareness of the consequences of erosion of farmers in the area is higher relative to other areas where such programs are not met with as much enthusiasm. Blase found the perception of soil erosion to be statistically significant in explaining reductions in soil loss. Hoover and Wiitala found that operators indicating a soil erosion problem were more likely to be receptive to the use of conservation practices.

The question of program effectiveness has been addressed often in conservation practice adoption research. The variable NOSCS was defined as the number of times the farmer had talked with an SCS agent within the past 2 years. The responses ranged from 1 to 10 with a mean of about 7. NOSCS was hypothesized to be positively related to NTACRES, as periodic contact with an SCS agent or participation in an existing program would seem likely to prompt additional conservation efforts. Williams found that conservation treatment status was highest on tracts where both landowners and renters were program participants and lowest on tracts where neither participated.

F. Correlations Between Explanatory Variables

Concern for potential problems with multicollinearity prompted careful consideration of which variables to include in the final model. An explanation for the adjustment follows.

Based on Table 2, two variables which were thought to have been highly correlated with other variables were deleted from the model. The INVEST variable represented the response to the dollar amount of investment in farm land, buildings, and equipment. INVEST was specified as 1 = \$0-50,000; 2 = \$50,001-100,000; 3 = \$100,001-200,000; 4 = \$200,001-300,000; 5 = \$300,001-400,000; 6 = \$400,001-500,000; and 7 = over \$500,000. About 13 percent of the responses were in the \$0-50,000 range, 16 percent in the \$50,001-100,000 range, 24 percent in the \$100,001-200,000 range, 9 percent in the \$200,001-300,000 range, 10 percent in the \$300,001-400,000 range, 6 percent in the \$400,001-500,000 range, and 22 percent in the over \$500,000 range.

The INVEST variable was shown to be highly correlated with CRPSALE (gross farm income from crops in 1980) with a coefficient of .78. This may have been an indication that the larger tracts in the study generated the most income, assuming that the total investment figure given was mostly attributed to equipment and buildings. The problems with this theory was that observation of Table 2 showed that INVEST and PEROWNAC (percent of acreage that is owned) were negatively correlated with a coefficient of -.06. This implied that owner-operators may be less likely to make large investments, therefore the argument that responses of large

Table 2. Correlation Coefficients for Variables in No-Till Adoption Model Prior to Deletion for Multicollinearity.

	LAGE	EDUC	SECOCC	CRPSALE	PEROWNAC	TRANSFER	SLOPE	NOSCS	INVEST	YRSFRM
LAGE	1.00	-0.46	0.06	-0.23	0.35	0.06	-0.09	-0.00	0.03	
EDUC	-0.46	1.00	-0.12	0.23	-0.19	-0.05	0.02	-0.14	-0.18	-0.50
SECOCC	0.06	-0.12	1.00	0.15	-0.10	-0.13	0.07	-0.14	0.12	0.02
CRPSALE	-0.23	0.23	0.15	1.00	-0.50	-0.18	0.14	-0.11	0.78	-0.14
PEROWNAC	0.35	-0.19	-0.10	-0.50	1.00	0.09	-0.05	0.05	-0.06	0.22
TRANSFER	0.06	-0.05	-0.13	-0.18	0.09	1.00	0.11	0.01	-0.17	0.07
SLOPE	-0.09	0.02	0.07	0.14	-0.05	0.11	1.00	-0.05	0.05	-0.13
NOSCS	-0.00	-0.14	-0.14	-0.11	0.05	0.01	-0.05	1.00	-0.08	-0.00
INVEST	-0.03	0.18	0.12	0.78	-0.06	-0.17	0.05	-0.08	1.00	0.03
YRSFRM	0.69	-0.50	-0.02	-0.14	0.22	0.07	-0.13	-0.00	0.03	1.00

dollar investments were mostly a result of land investment could be refuted. The respondents with large investments could quite possibly have been made up of renter-operators in which equipment investment would have contributed most to the total investment. This may be confirmed by the -.50 correlation coefficient for PEROWNAC and CRPSALE which implied that higher income from crops may have been associated more with renter-operators than owner-operators, hence the .45 correlation coefficient between YRSRO (the number of years rented and operated) and CRPSALE.

Since the high degree of correlation was exhibited between INVEST and CRPSALE, it was decided that INVEST should be dropped from the model due to the complexities of the variable as stated above and that CRPSALE would be more relevant and less restrictive.

High correlation also existed between YRSFRM and LAGE. These represented responses to the number of years the respondent had been farming and the age of the farmer respectively. The correlation coefficient for YRSFRM and LAGE was .69. YRSFRM was dropped due to the high correlation in two cases, the one mentioned above and the correlation with EDUC (years of school completed) at -.50. The negative coefficient implies that older farmers have less education which is consistent with other studies, and was confirmed by the -.46 coefficient for LAGE and EDUC.

CHAPTER V

RESULTS

A. Analysis of Variance

The strength of the overall regression model with all eight independent variables included in shown in Table 3. While the .199 R square value (variance in NTACRES explained by the model) indicates weakness in the model, the overall regression equation is significant at the .01 level (i.e., the hypothesis "H_0: All eight independent variables together do not explain a significant amount of the variation in NTACRES" must be rejected at the .01 level).

Table 3. Overall ANOVA.

Source of Variation	df	Sum of Squares	Mean Square	F	R Square
Regression	8	2.749	0.344	2.89	.198*
Residual	93	11.076	0.119		
Total	101	13.825			

*Significant at the .01 level.

Source: SAS General Linear Model Procedure.

A partial F test of the relative importance of the individual independent variables is presented in Table 4. Using either the Type I or Type II sum of squares analysis, it is noted that the

Table 4. Partial ANOVA.

Source of Variation	df	Type I Sum of Squares	F	Type IV Sum of Squares	F
LAGE	1	.061	0.51	.563	4.73**
EUDC	1	.356	2.99	.170	1.43
SECOCC	1	.001	0.01	.070	0.59
CRPSALE	1	1.826	15.33*	1.221	10.30***
PEROWNAC	1	.011	0.09	.005	0.04
TRANSFER	1	.033	0.28	.070	0.59
SLOPE	1	.280	2.40	.306	2.57
NOSCS	1	.176	1.47	.176	1.47

*Significant at .05 level.

**Significant at .10 level.

***Significant at .025 level.

Source: SAS General Linear Model Procedure.

only variables which are significant in increasing the overall explanatory power of the model are LAGE and CRPSALE.

B. T Test of Significance of Variable Coefficients

The results of the T test for variables coefficients (β_i) are presented in Table 5. For purposes of this study, the .10 level was termed significant. Confirming the partial F test of the significance of individual variables, it is noted that the coefficient for CRPSALE was significant at the .02 level with an estimated coefficient value of .050. With a positive sign as hypothesized, this indicates that a change in CRPSALE by one unit (i.e., from one dollar range to another), NTACRES would change in the same direction by .05 units. The significance of CRPSALE is consistent with studies which show that the existence of income constraints can adversely affect the decision to undertake conservation practices. Thus, as income increases (decreases), the constraints are partially eliminated (restored) with resulting increases (decreases in NTACRES. However, if CRPSALE is construed to represent size, then these findings may conflict with studies which concluded that certain conservation practices are not adaptable to large tracts of land. The easy adaptability of no-tillage systems is likely responsible for the explanatory power of the variable. Further, conservation practices of a more permanent and structural nature might indeed conflict with adoption on larger farms.

LAGE with an estimated coefficient of .318 was found to be significant at the .10 level with a T value of 2.17. Since LAGE was

Table 5. Summary Table of No-Tillage Adoption Model Regression Coefficients.

Parameter	Estimated Coefficient	T
Intercept	-1.563	-2.39**
CRPSALE	0.050	3.21*
LAGE	0.318	2.17***
SLOPE	0.002	1.60
NOSCS	0.011	1.21
EDUC	0.016	1.20
TRANSFER	0.063	0.77
SECOCC	0.061	0.77
PEROWNAC	0.025	0.20

*Significant at .02 level.

**Significant at .05 level.

***Significant at .10 level.

Source: SAS General Linear Model Procedure.

a logarithmic form of the relationship of age to the proportion of no-till acres, this implied that as LAGE increases, NTACRES increases at an increasing rate but at some point begins to increase at a decreasing rate. With a positive sign as hypothesized, this indicated that as age changes by one unit (i.e., from one range to another), the proportion of no-till acres would change by .318 in the same direction. The moderate significance of the LAGE variable supports the hypothesis that age exhibits a curvilinear relationship with the extent that no-till is practiced—that farmers are less inclined to adopt a conservation practice in their early and late years because of higher risk adjusted discount rates reflecting uncertainty for younger farmers and likely shorter planning periods for older farmers. Therefore, it was concluded that the influence of age on conservation practice cannot simply be attributed to the reluctance of farmers to change from familiar techniques to new ones. The implied risk and length of the planning period is an overriding factor.

All of the other independent variables were not significant, confirming the partial ANOVA. Residuals were generated for each variable in the model with NTACRES, but no patterns were discerned.

Overall, the explanatory power of the model as measured by the R square was low at about 20 percent. There are two possible interrelated explanations for the weakness of the model. At the time the survey was conducted, according to an SCS agent, a representative of a private agricultural machinery firm which manufactured no-tillage equipment was allowing farmers to use the machinery on a demonstration basis. If this was the case, then the data may be inadequate for use in an application such as a linear regression. Perhaps the inclusion of a variable related to contact with key people as an influence on usage would have improved the strength of the model. Another explanation for the weakness of the model may have been due to the diffusion of information among farmers that no-tillage systems reduced costs and sometimes positively influenced yields.

Each of these explanations led to the conclusion of the commercial nature of conservation adoption decision-making. In an area shown to be the second leading region in no-tillage usage rates (Table 1, p. 20), a model which was constructed based on past successfully predictive models should be stronger than was shown in the results of the regression procedure. This led to the conclusion that uncertainty associated with yields may be the definitive factor in the decision to adopt no-till. Since the cost feature of no-till is easily made apparent, it is likely that the only obstacle to employing no-till is the possibility that yields will decrease.

CHAPTER VI

SUMMARY AND IMPLICATIONS

In this research the extent of no-till use by farm operators was examined in an attempt to explain the influence of farm level variables. The proportion of cropland subjected to no-till practices increased with the age of the operator and the size of crop sales. Other variables were not found to be significant. However, it cannot be concluded that they had no influence.

In terms of policy implications, it appears that if control of erosion through no-till practices is the desired end, then additional research to explain why small units operated by younger farmers tend not to use no-till is needed. Accordingly, it is possible that policy alternatives may need to be directed toward such operators.

Consistent with the conclusions of Taylor and Young, overcoming obstacles related to decreased yields and increased pesticide costs must be dealt with through scientific research aimed at improving crop resistance to pests. This potential solution may not be imminent. But if soil conservation goals continue to be defined in erosion reducing terms, then short term solutions are needed until technology reaches a stage where incentives are no longer necessary. It is intuitive that maximum benefits for dollars spent on soil conservation, regions differing in soils and climates should be given differing incentive treatment. Soils which tend to retain moisture may not be at all conducive to no-tillage techniques, especially in rainy climates, and may not merit programs designed to encourage its use. In areas where pests are of specific concern, more attention should be given to encouraging no-till by cost sharing for increased use of pesticides and herbicides.

Although the variable associated with ownership was not found to be significant in this study, other studies have shown ownership related variables to be factors in determining the use of conservation practices. The increase in rented cropland in the U.S. supports the need for encouraging minimum tillage and no-tillage because of its appeal over structural practices to individuals with shorter planning periods and higher discount rates. It is suggested that identifying groups distinguished by tenancy status and differences in conservation practice adoption due to soil types and climate be given special attention by researchers to refine the criteria upon which funds are distributed for incentive programs.

If expansion of no-till is desired as a public policy goal, then in establishing future conservation policy, programs should evolve from the notion that farms are economic units and farmers act rationally as managers. With the likelihood that structurally, agriculture is becoming more corporate and ownership is declining, the dependence on the so-called farm ethic (which implies conservation decisions are made separately from concern about net returns) may not be as viable in explaining why conservation practices are undertaken.

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VITA

Marion Lynne Holliday was born in Clarksville, Tennessee, on January 25, 1954. She attended elementary school in that city and later moved to Dover, Tennessee, where she graduated from Stewart County High School in June, 1972. She received a Bachelor of Science degree in Economics in December 1981, at Austin Peay State University and accepted a teaching assistantship there and began work toward a Master's degree in Business Administration. In June, 1982, she transferred to The University of Tennessee, Knoxville, and accepted a graduate research assistantship to begin work on a Master's degree in Agricultural Economics. The degree was awarded in March, 1985.

Ms. Holliday is presently employed at Austin Peay State University as an Assistant Professor teaching economics.