FACTORS AFFECTING THE USE OF SOIL CONSERVATION PRACTICES: AN ANALYSIS OF FARMERS IN MONROE COUNTY, MISSOURI

by

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A RESEARCH PAPER

submitted to

THE DEPARTMENT OF GEOGRAPHY

in partial fulfillment of
the requirements for the
degree of

MASTER OF SCIENCE

June, 1981

Directed by
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ABSTRACT: Literature exploring the use of soil conservation practices has generally lacked a theoretical framework. This study proposes a decision-making model comprised of physical, personal, economic, and institutional factors. Data from Monroe County, Missouri, are used to test the hypothesized relationships of explanatory variables to variations in number of practices used and average farm erosion rates. Multiple regression model results indicate that personal factors, such as perceived profitability of conservation practices and degree of financial risk aversion, are most important in explaining practice numbers. However, variations in soil erosion rates are significantly related to a combination of physical, personal, and economic variables. Study results also indicate that existing governmental technical assistance programs have no significant effect on conservation efforts. Effectiveness may be enhanced by actively targeting different assistance programs to different farmer groups depending on the relevant obstacles they face.

Although the federal government has invested over $20 billion in soil conservation assistance programs since 1935, agricultural soil erosion remains one of the nation's most critical environmental problems.[1] The problem is manifested in decreased soil fertility, increased reliance on energy-intensive practices such as fertilizers and pesticides, pollution of water by sediment and associated chemicals, and eventual loss of productive agricultural land. Yet relatively little research has definitively identified what factors may influence a farmer's decision to adopt or reject soil conservation practices.

A recent survey of farmers in Monroe County, Missouri, provides an opportunity to determine the influence of selected physical, social, economic, and institutional factors upon variations in soil conservation efforts. Specific objectives of this study are to: (1) develop a theoretical framework for explaining soil conservation behavior, and (2) statistically test the influence of hypothesized theoretical factors on alternative measures of soil erosion control. Results provide a case study for comparative analyses of regional variations in erosion control efforts, and may be useful in improving the effectiveness of government assistance programs.

BACKGROUND

Section 208 of the Federal Water Pollution Control Act Amendments of 1972 initiated a planning process to identify pollution problems stemming from diffuse sources such as forest and agricultural lands, and to design remedial control programs. As a result of this planning process, Missouri identified agricultural soil erosion as its most serious nonpoint water pollution problem.[2] Corresponding declines in natural soil productivity resulting from erosion have been temporarily offset by intensive cultivation and increased use of fertilizers and pesticides. State officials are concerned, however, that continued high rates of soil loss will ultimately threaten the viability of agriculture as the state's largest economic sector, and therefore undermine the rural quality of life for many Missouri citizens.

As part of Missouri's 208 planning efforts, the University of Missouri undertook a comprehensive study of farmers to help design a successful public program for reduction of agricultural soil erosion. In consultation with the Missouri Department of Natural Resources, Monroe County was selected as the appropriate study area due to its location within the highest priority river basin and because of its diversity in agricultural enterprises and topography. Results from the survey of Monroe County farmers provide the data for this research effort, which represents one component in several ongoing studies underway at the University of Missouri and within state natural resource agencies.

Federal programs designed to promote soil and water conservation practices on agricultural lands are generally service-oriented, responding to voluntary requests for technical and cost-sharing assistance. Missouri farmers have received cost-sharing payments totaling $166,406,767 from 1944 to 1977 from the Agricultural Stabilization and Conservation Service (ASCS) alone, with additional technical assistance from the Soil Conservation Service (SCS).[3] In addition, the Missouri Soil and Water Districts Commission has now developed a state cost-share program to supplement federal assistance. But public discussion has intensified regarding the effectiveness of such voluntary approaches in light of past results and competing demands for general revenues.

Integral to the design of effective conservation assistance programs is knowledge of the farmer's decision-making process regarding soil erosion control. Several questions naturally arise that are necessary to understanding that process. For example, do farmers with more erosive lands use proportionately more practices? What personal characteristics influence the decision to adopt practices? Is lack of information regarding soil conservation practices a major obstacle to practice use or do financial constraints overcome a farmer's knowledge and preference to adopt needed practices? As the following review of literature demonstrates, these types of questions have a lengthy history of investigation but unfortunately many of the answers are far from clear.

LITERATURE REVIEW

Research in the area of conservation practice adoption largely originated with a series of surveys taken of Iowa farmers during the 1950s. Repeating similar survey methodologies for the same sample of farmers, researchers evaluated both obstacles preventing farmers from adopting soil conservation plans and factors associated with variations in soil loss. In the last survey taken, Blase identified the following factors to be significantly related to reductions in soil loss: off-farm income (interpreted as a means to overcome financial constraints), perception of soil erosion as a problem, participation in the local conservation district, and ability to borrow funds.[4] This research was the only literature reviewed which used actual soil erosion rates as a measure of conservation behavior.

A 1958 study of farmers in New York may represent the earliest published literature in this field.[5] This sample was restricted to farmers on a particular soil association who had signed cooperative agreements with the local soil conservation district. The following factors were found to affect adoption of a wide variety of practices often related to soil conservation: farm size, cropland acreage, woodland acreage, farm type, perceived importance of soil conservation, and cost-share payments. Of most relevance to this present research, however, was the author's contention that selection of an accurate measure of conservation accomplishment was the most important challenge facing future research endeavors--an issue not sufficiently addressed in the following literature.

Recent investigations have been stimulated by nonpoint pollution source studies required by the 1972 federal legislation. Carlson et al. surveyed farmers in the highly erosive Palouse region of Idaho and Washington.[6] Unlike Blase's research, the survey was exploratory and did not employ an adoption model based on constructed hypotheses. Larger farm size, higher gross income, and education level were found to be positively associated with higher numbers of erosion control practices. Interestingly, younger farmers tended to adopt more practices but that influence was countered by the more significant variables of income and farm size which tend to increase with age. Because of the modest level of total variation explained, the authors suggest that factors other than farmer and farm characteristics may be more important in explaining adoption rates (e.g., attitudes, values). The authors also found that 79 percent of those farmers using fewer practices tend to perceive themselves as doing all they can to control soil erosion, but this finding may be subject to interpretation error because nonapplicable practices for each farm operation were not eliminated.

Preliminary findings are also available from Hoover and Wiitala based on their survey of farmers within the Maple Creek watershed of northeastern Nebraska.[7] This watershed also displays severe erosion rates and is the site of a federal demonstration project to accelerate voluntary adoption of conservation measures. Again, no hypotheses were formulated for this exploratory research. Three separate analyses were conducted: (1) factors affecting perception of soil erosion as a problem, (2) willingness to adopt additional measures, and (3) number of practices used. Problems in interpreting the data result from changes in statistical methodologies and explanatory variables across the different analyses.

Discriminant analyses selected only age and farm experience to differentiate farmers who do and do not perceive soil erosion as a problem. A greater proportion of younger operators with less farm experience agreed with erosion assessments made by SCS agents, which may be consistent with Carlson's finding. The authors then found that perception was positively related to willingness to adopt additional practices. However, one-third of those recognizing a soil erosion problem did <u>not</u> indicate a need for more erosion control, and this reluctance was apparently not related to the level of practices already used.

Finally, perception did not significantly explain variation in number of practices used but this finding is inconclusive because of the statistical test used. Based on a stepwise regression model, only the existence of a farm plan and receipt of federal conservation assistance were retained as significant variables, but these factors could also be viewed as surrogate measures of conservation behavior. Inclusion of such factors as independent variables would be most questionable using stepwise regression alone.

A recent analysis of Australian farmers represents the first attempt to use socio-economic factors in a predictive function for soil conservation intention.[8] Using discriminant analysis to classify farmers according to whether or not a farmer had carried out soil conservation on his farm, Earle et al. found that five variables successfully predicted class membership: farm size, perception of soil erosion importance, double-cropping (as an indicator of management efficiency), increasing income, and education. Specification of the dependent variable was not explained in this publication.

A different approach to adoption behavior is evident in the rural sociology literature which has addressed the problem of low adoption rates within the framework of innovation diffusion theory. The traditional model of agricultural innovations, which has successfully explained adoption patterns of commercial practices, has recently been questioned regarding its applicability to environmental innovations. Pampel and van Es found that of three explanations of adoptive behavior--psychological innovativeness, profitability orientation, and orientation to farming as a way of life--farming orientation may best explain adoption of soil conservation practices.[9] In their survey of Illinois farmers, adoption of commercial factors was much more successfully explained by selected farm and farmer characteristics than were environmental practices. Moreover, variables that significantly predicted use of environmental practices differed from those predicting commercial practices. Farm experience was the single most important predictor which is not supported by the findings of Carlson et al. and Hoover and Wiitala.

Taylor and Miller, however, believed that rejection of a single adoption mode was premature, noting that Pampel and van Es did not include certain social and institutional variables which commonly operate in the traditional adoption model literature (e.g., agency contacts, perception).[10] By modifying the traditional model to incorporate hypotheses derived from Pampel and van Es, Taylor and Miller found that it satisfactorily explained adoption of these environmental innovations. These hypotheses were that adoption would be positively associated with farm orientation and lower socio-economic status to reflect the noncommercial nature of environmental practices. However, their distinction of Amish versus non-Amish as a measure for farm orientation is subject to criticism. The authors also found that knowledge of the demonstration project, persuasion toward the project, and decision to adopt practices--tested at different stages in the adoption process--were significantly interrelated, with a strong positive relationship also drawn between all stages of the process and perception of soil erosion as a problem.

Nevertheless, research results within the diffusion theory framework remain inconclusive as discussed by Novak and Korsching.[11] Adequate measures of monetary incentives, farming orientation, and physical need for soil conservation practices were not available in either study.

In summary, three general observations drawn from the literature cited above are useful in developing the analytical framework to evaluate soil conservation efforts by farmers in Monroe County. Several recent studies lacked a theoretical basis by which to select explanatory variables, develop hypotheses, and to help evaluate research results. There also appears to be little consistency in the selection and specification of the dependent variables which may significantly affect results and attendant implications for soil conservation programs. Dependent variables ranged from actual erosion rates to binary classes of conservation behavior to the number of practices adopted by farmers--either adjusted or not adjusted for the possibility that practices are not always appropriate for all farming operations. Finally, several studies did not consider physical indicators of soil erosion potential as a factor which should influence conservation behavior.

MODEL AND HYPOTHESES FORMULATION

The use of soil conservation practices may be conceptualized as a decision-making model with four components. First, physical characteristics of the land (i.e., degree of slope, slope length, and soil erodibility) define the potential for soil erosion. Second are the personal attributes of the farmer which may translate into a disposition to recognize and control erosion. Important attributes may include age, education, profitability orientation, risk aversion, etc. The third component can be described as the economic profile of the farm enterprise. This profile may serve to facilitate action stemming from one's disposition to control erosion or may produce constraints to actual implementation. Finally, the decision to adopt may be influenced by public institutions which may intervene to alter a farmer's disposition toward soil erosion control and/or to offset economic or technical management constraints to practice use. The following discussion details each variable corresponding to elements of this conceptual framework, including hypothesized relationships with measures of soil conservation efforts. Appendix A provides a detailed description of each variable as derived from the Monroe County survey instrument.

Independent Variables and Hypotheses

Physical Factors

University investigators provided a measure of the "natural" soil erosion potential of each farm measured as average tons/acre/year. This measure was based on soil erodibility, slope length, and slope percentage characteristics. It is hypothesized that a farmer's propensity to control erosion will vary directly with soil erosion potential (X_1) since high erosion potential translates into high productivity losses if not treated. However, it should be noted that high erosion potential may also be associated with those farmers least capable of adopting practices. If the latter situation predominates, then an inverse relationship may be observed.

Personal Factors

Most studies have hypothesized that personal factors may significantly affect a farmer's propensity to adopt conservation measures, although not all investigators were able to empirically test the relationships expected.[12] A positive relationship between education levels and conservation behavior is one of the most consistent findings of previous studies. Education levels (X_2), therefore, should be associated with greater information on conservation measures and long-term consequences of soil erosion, in addition to higher levels of management expertise.

Perception of the degree of soil erosion as a problem (X_3) can be hypothesized as a prerequisite to undertaking remedial action. This variable is intended to measure perception as it applies to the individual farm, recognizing also that a farmer may interpret "problem" within the context of operational difficulties caused by soil erosion rather than a more public context. To help differentiate between perception of soil erosion as a problem peculiar to a given farm and perception as a measure of broader public concern, a "conservation attitudes" index (X_4) was constructed. The index reflects an individual's predisposition toward issues such as concern over agricultural soil erosion, water quality impacts, general trends in soil erosion, and appropriate role of the government in conserving soil to maintain long-term productivity of the resource. In general, positive responses to the conservation attitudes index should be associated with higher levels of conservation efforts.

Sociological literature reviewed in this study strongly suggested that an individual who chooses to farm primarily for noncommercial reasons is more likely to adopt practices that are not always profitable. Unfortunately, measures of such farm orientation have been weak (e.g., Amish versus non-Amish, off-farm employment).[13] An index to farm orientation (X_5) was constructed to help evaluate weights farmers gave to various reasons for farming relative to income motivations in an attempt to explicitly measure commercial/noncommercial divergences.

A farmer's perception regarding the profitability of conservation practices (X_6) is an important factor not addressed in several recent studies. It is hypothesized that farmers who indicate that most practices are cost-effective without government cost-share assistance should be more likely to adopt higher numbers of practices.

An index was also constructed for several questions used in the survey to measure general predilections toward risk aversion (X_7). Such a tendency toward avoiding economic risk is interpreted as a farmer's reluctance to forego immediate and more certain income rather than invest in conservation practices which may yield long-term or uncertain benefits. It is recognized that both profitability and risk aversion factors may be associated with economic constraints in farm management, and could conceivably be grouped with the economic factors discussed below. However, it must be argued that a variety of personal and social attributes affect a farmer's perception of those economic constraints leading to differing management practices.

Economic Factors

The influence of economic status on adoption of conservation practices has been hypothesized differently by different investigators. For example, it has been suggested that adopters of environmental innovations tend to have lower levels of socio-economic status.[14] It has more commonly been suggested that higher socio-economic status allows a farmer to overcome financial constraints to adoption. Because government cost-share programs are based on this latter view--that farmers require immediate economic incentives to adopt practices which may yield primarily long-term benefits--this analysis assumes that measures of economic wealth are positively related to levels of soil erosion control.

Total cropland owned (X_8), both within and outside Monroe County, was selected as the primary measure of economic wealth. More direct measures, such as gross farm sales or present net worth, were difficult to obtain from farmers in this study and would nonetheless have to be interpreted as measures of farm size operations in any case. In addition, total cropland is preferred to total acres because it reflects income producing potential; substantial tracts of farmland in woodland and pasture in Monroe County would have biased total acres as a measure of economic wealth. A simple regression test confirmed the high correlation between the selected variable and gross farm sales.

In contrast to previous research, the relative contribution of off-farm income to total income (X_9) is not viewed as a measure of farm orientation nor as supplemental income facilitating expenditures for conservation practices. Rather, it is suggested that relatively larger contributions of off-farm income reflect need for supplemental income and less time available to adopt and maintain unfamiliar practices. A negative relationship with soil erosion control is therefore postulated. Concern over debt (X_{10}), not measured in most previous studies, should most likely be characteristic of younger farmers who have the most need for immediate income and who can least afford long-term investments in soil conservation.

Finally, SCS county personnel indicated that type of farming operation, cash grain or other (X_{11}), may also reflect degree of farming orientation and, therefore, interest in controlling erosion. The argument in this case is that those farmers with livestock operations managed their cropland less intensively, whereas cash grain only operators were characterized as interested mostly in short-term profit maximization. Under these circumstances, cash grain operators would be expected to have lower erosion control efforts.

Institutional Factors

To test the influence of SCS programs on practice adoption, two variables were created to reflect increasing degrees of participation. The first level indicates whether a farmer was a signed cooperator with the SCS county office (X_{12}). The second and higher level indicated whether the farmer had SCS prepare a comprehensive farm conservation plan for his operation (X_{13}). A positive relationship is expected to reflect conservation initiative and access to technical assistance in designing individual conservation programs.

Monroe County has four organized watersheds out of a total of eleven. One can argue that the collective farmer interest and commitment leading to formation of the watershed district should reflect higher interest in efforts to control erosion. For these reasons, whether a sample farm was located in an organized watershed (X_{14}) was expected to be positively related to erosion control efforts.

Dependent Variables

The ultimate goal of public soil conservation programs is to reduce soil erosion. An ideal measure for evaluating the effectiveness of these programs as well as factors leading to comprehensive soil conservation efforts would, therefore, provide an index to the amount of soil conserved given physical factors of erosion potential. Comparative analysis of previous research findings has been hampered by use of inadequate and/or inconsistent measures of soil conservation efforts. Beyond the problems of interpreting findings as influenced by regional circumstances, differing explanatory variables and research methodologies, it is not always clear whether studies have used satisfactory measures of conservation behavior or whether alternative measures are substitutable across studies for interpretation purposes. One objective of this study was to measure the influence of the same set of explanatory variables on alternative dependent variables. This could provide insight to both the adequacy of alternative measures and the degree of substitution between models. Three measures of soil conservation efforts were selected for this study: (1) number of practices adopted, (2) number of practices adjusted for applicability to individual farm operations, and (3) average soil erosion rates for each farm. Appendix B provides a detailed description of each dependent variable.

Farmers were assigned numerical scores based on the number of practices adopted for the first dependent variable, Y_1. A total of six conservation practices most relevant to erosion control on cropland were possible: terraces, contour planting without terraces, rotations with grasses or legumes, minimum tillage, zero tillage, and grassed waterways. Several practices with less relevance to cropland erosion control were not included because of incomplete information: diversions, gully stabilization structures, and ponds. In addition, county SCS personnel indicated that strip cropping is not an appropriate practice for farm operations in this study area and was, therefore, not included.

The second dependent variable, Y_2, similarly used number of practices but the numerical score was adjusted according to farmers' assessments of applicability to their farm operations. This approach may mask individual biases against certain practices. However, a random check of actual physical constraints to individual practice use (e.g., degree of slope) suggested that the level of farmer responses in the nonapplicable category reasonably conformed to the incidence and areal extent of physical constraints which exist in Monroe County. Farmers thus received scores based on the percentage of applicable practices adopted.

The third dependent variable, Y_3, was selected to provide a physical measure of average soil erosion rates (tons/acre/year) on owned cropland. Soil loss rates were calculated by University of Missouri investigators using the universal soil loss equation.[15] These values are functions of rainfall intensity, soil erodibility, length of slope, degree of slope, plant or residue cover, and use of conservation practices. This measure provides an opportunity to consider the extent and effectiveness of practice use otherwise unavailable in Y_1 or Y_2. Under those alternatives, a farmer may receive full credit for a practice used irrespective of the degree to which it may be effective and/or needed across total cropland acreage.

STATISTICAL METHODOLOGY AND RESULTS

Monroe County Survey

Data were drawn from a random sample survey of 136 Monroe County farmers, which constituted approximately 10 percent of the population. University of Missouri investigators supplemented questionnaire data with detailed soils information using aerial photographs and soil survey maps. A subsample of 92 farm operators was selected for this analysis to restrict consideration to those who own and operate cropland (excluding continuous pasture) in Monroe County. This subsample thus focuses on farmers who exercise direct control over land management decisions versus tenants whose actions may be affected by landowner arrangements.

Statistical Methodology

The primary objective of this data analysis was to evaluate the relationship of selected variables to soil conservation efforts. Multiple regression was selected to test the null hypothesis that no linear relationship existed between soil conservation efforts and selected physical, personal, economic, and institutional factors. A secondary objective of this study was to evaluate three alternative measures of conservation behavior (Y_1, Y_2, Y_3). Comparison of multiple regression results for each model would provide insight to any significant differences which might exist. Prior to conducting the final regression test, an evaluation of all simple correlation coefficients indicated that no problems of multicollinearity appeared to exist in which some of the independent variables would have been highly intercorrelated.

Analysis of Statistical Results

Multiple regression coefficients for each of the three models are presented in standardized form to allow comparison of the relative effects of each independent variable (Table 1). Additional statistical characteristics for each variable (including mean, standard deviation, and range) are provided in Appendix C. Several general observations can be drawn from the regression results:

1. The null hypothesis was rejected for all models at high levels of significance (<.02).

2. Each of the models accounted for satisfactory levels of total variation explained. R^2 values were 36, 28, and 30 percent for models Y_1, Y_2, and Y_3, respectively. These values are considerably higher than most previous studies reviewed.

3. While the alternative models produced similar overall results, the relative importance of variables often varied among models.

4. Only one variable--perceived profitability of practices--was highly significant across all models. Other

TABLE 1.--STANDARDIZED MULTIPLE REGRESSION COEFFICIENTS (AND LEVELS OF SIGNIFICANCE) OF FARM AND FARMER CHARACTERISTICS FOR ALTERNATIVE MEASURES OF SOIL CONSERVATION EFFORTS

Independent Variable	Y_1 Number of Practices	Y_2 Percent of Applicable Practices	Y_3 Soil Erosion Rates
* X_1 Erosion potential	-.13 (.21)	-.08 (.45)	.34 (.002)
X_2 Education	.14 (.20)	.13 (.25)	.12 (.31)
* X_3 Perception	.18 (.09)	.04 (.76)	-.03 (.84)
X_4 Conservation attitudes	-.01 (.88)	-.03 (.78)	-.08 (.46)
X_5 Farm orientation	.06 (.57)	.08 (.43)	-.01 (.94)
* X_6 Profitability of practices	.28 (.01)	.34 (.004)	-.32 (.006)
* X_7 Risk aversion	-.17 (.10)	-.21 (.07)	.04 (.74)
X_8 Total cropland	.07 (.59)	.01 (.92)	-.16 (.20)
X_9 Off-farm income	-.12 (.28)	-.14 (.26)	.00 (.98)
X_{10} Debt concern	.08 (.45)	-.03 (.77)	.07 (.49)
* X_{11} Type of farm	-.14 (.18)	-.04 (.75)	.18 (.10)
X_{12} SCS operator	-.05 (.67)	.05 (.65)	-.05 (.65)
X_{13} SCS farm plan	.10 (.36)	.07 (.52)	.03 (.79)
X_{14} Organized watershed	-.08 (.43)	.05 (.67)	-.07 (.50)
R^2 (and overall level of significance)	.36 (.001)	.28 (.02)	.30 (.008)

* Significant at <.10 level in one or more models.

variables which were significant in at least one model were: risk aversion, type of farm, perception of soil erosion as a problem, and erosion potential. The hypothetical direction of influence was confirmed for each of these variables.

Closer examination of the results prompted the need for additional statistical analysis. Of particular interest was the observation that perceived profitability and risk aversion had never been measured as such in previous studies, while other significant variables were not commonly used. The possibility therefore existed that these variables were capturing explanatory information from more commonly measured factors. Because of the notably high significance of profitability as a hitherto unmeasured variable, it was deemed important to identify which variables might differentiate between farmers who could be further classified as having either low or high profitability scores. An analysis of variance test isolated education and perception as the only discriminating variables significant at the .05 level. This result indicates that those farmers with higher levels of education and perceiving erosion problems believe most practices are profitable without cost-share assistance.

An additional multiple regression test was then performed on a reduced set of five variables most often considered important by previous investigators: farm experience, education, perception of soil erosion, total cropland, and off-farm income. Explained variation was significantly reduced using the reduced model (see Table 2). Furthermore, the relative significance of the selected variables did not appreciably differ from the expanded model, implying that variable influence had not been effectively weakened through intercorrelation. One exception, however, was education which became highly significant in Y_1 and Y_2. This result was not altogether surprising given the earlier discovery that education served to differentiate low and high profitability scores.

Conspicuously absent from the set of significant variables are institutional factors which should serve to intervene in the postulated decision-making process. There is no statistical evidence to suggest that soil erosion rates or adoption of practices are influenced by a farmer's decision to become a cooperator with the SCS office, to have a SCS farm conservation plan prepared for his farm, or his location within an organized watershed. The influence of debt concern, usually associated with younger farmers who cannot afford conservation practices, is also insignificant in all measures of conservation efforts. The farm orientation index lacked any explanatory power, suggesting that either the measure is inadequate or that one's reasons for farming relative to income are irrelevant to soil erosion control. Likewise, the conservation attitudes index

TABLE 2.--STANDARDIZED MULTIPLE REGRESSION COEFFICIENTS (AND LEVELS OF SIGNIFICANCE) FOR REDUCED MODELS

Independent Variable	Y_1 Number of Practices	Y_2 Percent of Applicable Practices	Y_3 Soil Erosion Rates
Farm experience	-.10 (.38)	-.02 (.88)	-.07 (.58)
Education	.21 (.07)	.25 (.03)	.06 (.60)
Perception	.19 (.08)	.03 (.76)	.001 (.997)
Total cropland	.11 (.35)	.09 (.43)	-.24 (.05)
Off-farm income	-.16 (.18)	-.08 (.49)	-.02 (.85)
R^2 (overall level of significance)	.18 (.004)	.10 (.10)	.06 (.39)

was consistently weak in explanatory power which may have interesting implications. General attitudes toward the problems of agricultural soil erosion and water quality may have little bearing on whether a farmer acts to control erosion on his own land. Instead, perception of the problem as it directly affects his private property appears to motivate a farmer to adopt practices.

To determine the relative contribution provided by each variable to the different measures of soil conservation effort, stepwise regression was next used. In general, significant levels of total variation were explained by relatively few factors in all models (Table 3). Analysis of these statistical results in conjunction with the decision-making model illustrates the difference between models.

Numbers of conservation practices (Y_1) are largely explained by personal factors. Practice use is directly related to perceived profitability, propensity to accept short-term risk, and perception of soil erosion as a problem. It should be noted that these personal factors, as well as education, have moderately significant inverse correlations with years of farming experience, indicating that less experienced or younger farmers are perhaps more inclined to accept the merits of more conservation practices. It should be noted also that suggested age profiles are apparently not explained by differences in farm operations;

TABLE 3.--SUMMARY OF STEPWISE REGRESSION SOLUTION[a]

Model	Step Number	Variable Entered	Significance of Variable (%)	R^2
Y_1	1	Profitability of practices	.0004	.13
	2	Risk aversion	.0042	.21
	3	Off-farm income	.0259	.25
	4	Perception	.0585	.28
	5	Type of farm	.0868	.31
	6	Off-farm income (deleted)	----	.29
Y_2	1	Profitability of practices	.0003	.13
	2	Risk aversion	.0022	.22
Y_3	1	Erosion potential	.0004	.13
	2	Profitability of practices	.0026	.22
	3	Type of farm	.0537	.25
	4	Total cropland	.0979	.27

[a]No other variables were entered within preestablished significance level of <.10.

years of experience do not account for significant differences in total acreage, type of operation, or soil erosion potential according to correlation coefficients. These relationships indicate that more experienced or older farmers may generally require technical information programs to educate them to the potential benefits of conservation techniques if they are to adopt a wider range of practices.

Variations in farm erosion rates, although significantly correlated with number of practices (simple r = .43), are explained by physical, personal, and economic factors. Erosion rates as calculated by the universal soil loss equation are a function of physical characteristics of the cropland and management decisions regarding crop rotations, tillage methods, and other conservation practices. The significance of soil erosion potential is thus easily seen given its role in calculating erosion rates. The remaining significant variables--perception of practice profitability, livestock/cash grain farm, and size of cropland base--can be interpreted as affecting the management decisions regarding conservation practices. These results suggest that explanation of erosion rate variations is a more complex process than use of practices and, more importantly, a different process. For example, total cropland as a measure of financial capacity may not influence practice numbers but may determine the extent to which practices are employed over the cropland base thus affecting the average farm erosion rate.

CONCLUSIONS

The study results may have several implications for improving the effectiveness of soil conservation programs. While technical assistance programs should serve to reduce obstacles to soil erosion control efforts, statistical results indicate that voluntary participation does not necessarily result in either use of more practices or lower soil erosion rates. It would appear then that programs would be more effective if targeted to farms with higher soil erosion potential and designed to provide information regarding (1) the existence and effects of soil erosion on individual farms, (2) the potential profitability of remedial practices, and (3) the role of farm enterprise diversification. The potential efficacy of such a reorientation from the current passive approach which relies on voluntary participation to a more active program designed to overcome specific obstacles is consistent with recommendations developed by the U.S. General Accounting Office.[16]

Data also suggest an age profile associated with different components of the decision-making model. Younger farmers may be more receptive to practices as affected by higher education levels, perception of soil erosion problems, greater awareness of practice profitability, and willingness to accept risk, but may require cost-share assistance to encourage extensive application of practices. On the other hand, older farmers may derive more benefit from information programs which improve their receptiveness to adopting nontraditional practices. Methods to isolate the effects of farm experience (or age) from numerous other variables should be addressed in future research.

The effect of cost-sharing assistance in explaining conservation efforts also needs to be incorporated into future studies. However, this presents a conceptual problem in that receipt of past or current governmental financial assistance is probably closely correlated with use of practices (i.e., practice numbers), and therefore somewhat redundant theoretically. This problem does not occur with the erosion rate model since cost-sharing assistance may help explain the extensiveness of practice use over the entire cropland base, and thus reflect a depressing influence on average farm erosion rates.

The problem of properly incorporating cost-sharing assistance into the different models points to the most important theoretical implication of this work. This study indicates that alternative measures of soil erosion control, and resulting research implications, are not necessarily substitutable. While prior research has largely focused on explaining the adoption and use of practices, that process is largely affected by personal factors according to the Monroe County data. However, use of the practice numbers model for policy design may miss the ultimate objective of soil conservation programs--reduction of soil erosion. Explanation of the latter is a more complex process involving physical, economic, and personal factors. Future research would lend greater information to policy makers if based on a theoretical decision-making framework and incorporating measures of soil erosion control comparable across varying study regions.

FOOTNOTES

1 Council on Environmental Quality, Environmental Quality-1979: The Tenth Annual Report (Washington, D.C.: U.S. Government Printing Office, 1979), p. 389.

2 State of Missouri, Department of Natural Resources, Missouri Water Quality Management Plan: 1979 (Jefferson City: Department of Natural Resources, 1979), pp. 47-56.

3 State of Missouri, op. cit., footnote 2, p. A-1 (Appendix).

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7 Herbert Hoover and Marc Wiitala, Operator and Landlord Participation in Soil Erosion Control in the Maple Creek Watershed in Northeast Nebraska (Washington, D.C.: U.S. Department of Agriculture, Economics, Statistics, and Cooperatives Service, 1980), pp. 1-65.

8 T.R. Earle, C.W. Rose, and A.A. Brownless, "Socio-economic Predictors of Intention towards Soil Conservation and Their Implication in Environmental Management," Journal of Environmental Management, Vol. 9 (1979), pp. 225-236.

9 Fred Pampel, Jr., and J.C. van Es, "Environmental Quality and Issues of Adoption Research," Rural Sociology, Vol. 42 (1977), pp. 57-71.

10 David L. Taylor and William L. Miller, "The Adoption Process and Environmental Innovations: A Case Study of a Government Project," Rural Sociology, Vol. 43 (1978), pp. 634-648.

11 Peter J. Novak and Peter F. Korsching. "Preventive Innovations: Problems in the Adoption of Agricultural Conservation Practices," in Sociological Factors in the Adoption of Best Management Practices, Annual Report to the U.S. Environmental Protection Agency (Ames: Iowa State University, 1980).

12 Many studies have included "years of farm experience," as a personal factor affecting adoption of practices. However, this variable tends to reflect several factors measured separately in this study. For example, farm experience should reflect exposure to available assistance programs (Y_{12}, Y_{13}, Y_{14}), heightened perception of soil erosion as a problem (X_3) and financial ability to adopt needed practices (X_8, X_9, X_{10}). A negative relationship with adoption might alternatively suggest the effects of lower education levels (X_2) or an ideological distance from environmental concerns which are often associated with younger age groups (X_4). In an attempt to isolate these multiplicative effects, farm experience was therefore excluded from the set of independent variables.

13 Taylor, op. cit., footnote 10, pp. 634-648.

14 Taylor, op. cit., footnote 10, p. 644.

15 W.H. Wischmeier and D.D. Smith, Predicting Rainfall Erosion Losses--A Guide to Conservation Planning (Washington, D.C.: U.S. Department of Agriculture, Agriculture Research Service, Agriculture Handbook No. 537, 1978).

16 U.S. General Accounting Office, To Protect Tomorrow's Food Supply, Soil Conservation Needs Priority Attention (Washington, D.C.: Government Printing Office, CED-77-30, February 14, 1977).

APPENDICES

APPENDIX A.--DERIVATION AND DESCRIPTION OF INDEPENDENT VARIABLES FROM MONROE COUNTY SURVEY

Variable No. and Name	Source and Coding Methodology
X_1 Erosion Potential	Slope, slope length, and inherent soil erodibility characteristics were identified for each cropland field that the respondent owned in Monroe County. Weighting each field by its percentage of the farm's total owned cropland, a weighted average of these physical factors was constructed to reflect "raw" soil erosion potential.
X_2 Education	Could you please indicate which group includes the years of formal education that you have completed? Code 0-6 years — 3 7-9 years — 8 10-12 years — 11 over 12 years — 14.5
X_3 Perception	Is soil erosion a problem on the land you own considering the cropping and tillage practices used? Code no problem — 1 slight problem — 2 moderate problem — 3 severe problem — 4
X_4 Conservation Attitudes	Section 208 of Public Law 92-500 calls for the control of nonpoint sources of water pollution from agricultural land so that all streams and rivers are fishable and swimmable by 1983. Soil erosion has been identified as one of the most important sources of nonpoint water pollution. It is possible that Missouri, as well as several other

APPENDIX A.--CONTINUED

Variable No. and Name	Source and Coding Methodology
	states, will set a goal to reduce soil erosion to a specified number of tons per acre per year. For example, Iowa currently has a 5-ton loss goal. Soil is naturally regenerated in this area at the rate of 3 to 5 tons per acre per year. However, the current average soil erosion for cropland in Monroe County is estimated at approximately 21 tons per acre per year.
	a. Do you feel that it is appropriate for the government to establish soil loss limits? Code: Yes and don't know = 1; No = 0
	b. Do you think control of soil erosion is needed for the achievement of improved water quality in your area? Code: Yes = 1; No and don't know = 0
	c. Do you feel that improved water quality is needed in your area? Code: Yes = 1; No and don't know = 0
	d. During the past 10 to 20 years, do you think soil erosion in this area has: Code increased substantially 1.00 increased slightly .80 stayed about the same .60 decreased slightly .40 decreased substantially .20

APPENDIX A.--CONTINUED

Variable No. and Name	Source and Coding Methodology
	<u>Conservation score</u>: average coded response for questions a. through d.
X_5 Farm Orientation	There are undoubtedly many reasons why people farm. What we would like to find out from you are the reasons that are most important to you. To do this, we will give you a base issue. We will arbitrarily assign 100 points of importance to this base issue. The value of 100 is important only because it will give you something with which to compare remaining issues. Base Issue: Provides Good Income Now rate all of the other issues following in terms of the base issue. For example, if you feel that a given issue is three times as important as "Provides Good Income" assign it a value of 300 points. If you feel an issue is one-half as important, assign a value of 50 points. If you feel a reason is totally unimportant, assign a value of zero points. You may use any number you wish but always compare each issue with the base issue when assigning points. a. Provides opportunity for a better home and family life. b. Provides opportunity to see the results of my efforts. c. Provides opportunity to be my own boss.

APPENDIX A.--CONTINUED

Variable No. and Name	Source and Coding Methodology
	d. Provides opportunity to feel I am doing something worthwhile.
	e. Gives me a chance to work in the natural environment.
	Farm orientation score: average values for responses a. through e.
X_6 Profitability of Practices	If you did not receive any governmental financial assistance, would the economic returns outweigh the costs for each of the following soil conservation practices: terraces, contour planting without terraces, crop rotations with grasses or legumes, minimum tillage, no till planting. Code: Yes = 1; No = 0
	Profitability score: average coded responses for all practices.
X_7 Risk Aversion	Please indicate whether you strongly agree (1), agree (2), disagree (3), or strongly disagree (4) with the following statements:
	a. I regard myself as the kind of person who is willing to take more risks than the average farmer.
	b. I would rather take more of a chance on making a big profit than be content with a smaller but less risky profit.

APPENDIX A.--CONTINUED

Variable No. and Name	Source and Coding Methodology
	c. It's good for a farmer to take risks when he knows his chance of success is fairly high. d. Farmers who are willing to take chances usually do better financially. <u>Code</u>: 1,2,3,4 as noted above for questions a. through d. <u>Risk aversion score</u>: average coded response for questions a. through d.
X_8 Total Cropland	How may acres do you own that you operate in (a) Monroe County and (b) outside Monroe County? <u>Code</u>: Number of acres of owned cropland (excluding continuous pasture) as derived from survey and detailed farm maps.
X_9 Off-farm Income	Approximately what percent of your family income comes from the farm? <u>Code</u>: 1 - (percent from farm)
X_{10} Debt Concern	How concerned are you with the debt of your farm? Code not concerned — 1 somewhat concerned — 2 very concerned — 3
X_{11} Type of Farm	<u>Code</u>: Cash grain only = 1; cash grain/livestock combination = 0.
X_{12} SCS Cooperator	Information obtained from Monroe County SCS office. <u>Code</u>: Yes = 1; No = 0.

APPENDIX A.--CONTINUED

Variable No. and Name	Source and Coding Methodology
X_{13} SCS Farm Plan	Information obtained from Monroe County SCS office. Code: Yes = 1; No = 0.
X_{14} Organized Watershed	Information obtained from Monroe County SCS office. Code Otter Creek 1 Middle Fork 1 Crooked Creek 1 All other watersheds 0

APPENDIX B.--DERIVATION AND DESCRIPTION OF DEPENDENT VARIABLES FROM MONROE COUNTY SURVEY

Variable No. and Name	Source and Coding Methodology
Y_1 Number of Practices	For each of the following soil conservation practices, would you first indicate which of the categories best describes your situation. a. I am now using the item. b. I have used before but not now. c. I have decided to use the item but am not using now. d. I am interested in using the item but not sure about it yet. e. I have heard about the item but not interested in it. f. I have not heard about the item. g. It is not applicable to my operation. <u>Code</u>: Response a. = 1; all other responses b. - g. = 0. <u>Practice number score</u>: Summation of all code 1 responses.
Y_2 Percent of Applicable Practices	<u>Code</u>: Same as Y_1 above with exclusion of any practice receiving a response g. <u>Practice number score</u>: percent of all applicable practices.
Y_3 Soil Erosion Rates	Using the universal soil loss equation (USLE) methodology, the following characteristics were measured from soil survey maps and survey information for each

APPENDIX B.--CONTINUED

Variable No. and Name	Source and Coding Methodology
	cropland field owned in Monroe County: (1) K - inherent erodibility characteristics of predominant soil; (2) L - slope length of predominant soil; (3) S - slope percentage of predominant soil; (4) C - cover and management factor reflecting crop rotation and tillage methods used; and (5) P - support practice factor reflecting the influence of contouring. A rainfall factor (R) value of 200 was assumed applicable to soil fields. After the soil erosion rate (tons/acre/year) was calculated for each field, the average farm erosion rate on owned cropland was calculated by everything each field by its percentage of the farm's total cropland acres.

APPENDIX C.--SELECTED STATISTICAL CHARACTERISTICS OF VARIABLES

Independent Variable	Mean	Standard Deviation	Range		
Erosion potential	.20	.07	.07	-	.43
Education	10.76	2.15	3.00	-	14.50
Perception	2.12	.99	1.00	-	4.00
Conservation attitudes	1.63	.31	.80	-	2.00
Farm orientation	169.25	139.46	0	-	957.60
Risk aversion	.54	.12	.25	-	.88
Profitability of practices	.57	.25	0	-	1.00
Total cropland	296.08	318.61	5.00	-	1656.
Off-farm income	25.41	32.38	0	-	100.00
Debt concern	1.78	.85	1.00	-	3.00
Type of farm	.16	.37	0	-	1.00
SCS cooperator	.33	.47	0	-	1.00
SCS farm plan	.23	.42	0	-	1.00
Organized watershed	.38	.49	0	-	1.00
Dependent Variables					
Number of practices	2.14	1.31	0	-	6.00
% of applicable practices	.42	.25	0	-	1.00
Soil erosion rates	9.78	6.33	2.03	-	31.42

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