Investments in Soil Conservation Structures: The Role of Operator and Operation Characteristics

By C. Edwin Young and James S. Shortle*

Abstract

Targeting soil conservation programs to specific problem areas implies that individual landowners are targeted for program participation A better understanding of how the characteristics of individual landowners and their farm operations influence conservation investments can help policymakers design more effective voluntary conservation programs This article uses the estimates of a logit model to study how these relationships apply to soil conservation structures

Keywords

Soil conservation, owner characteristics, logit

The Soil and Water Resources Conservation Act (RCA) of 1977 directed the Secretary of Agriculture to appraise the condition of the Nation's soil and water resources and to develop a national program to guide the conservation programs of the U S Department of Agriculture (USDA) As a result of this assessment, USDA is redesigning its soil conservation programs to focus on specific problem (targeted) areas, thereby achieving greater conservation gains at lower costs

It now seems that the voluntary approach, which characterizes erosion control policy, will be a principal feature of future initiatives The success of these initiatives will, therefore, depend on their ability to elicit effective voluntary responses from farm decisionmakers in targeted areas The problem of encouraging farmers to voluntarily use conservation practices is essentially a technique adoption problem Farm operations are highly complex entities, and adoption research generally suggests that individual characteristics influence observed adoption decisions (*7*) [1] This research also suggests that the use of information on relationships between these characteristics and observed behavior can enhance public policies encouraging adoption Thus, an understanding of how individual characteristics tend to influence conservation decisions can improve the effectiveness of voluntary soil conservation programs in targeted areas

In this article, we present the results of our investigation of the relationship between investment in conservation structures and the characteristics of farm decisionmakers and their operations We emphasize the potential complementarity between investments in conservation structures and other land improvement investments The results are based on a logit probability model

Background

Most previous research on conservation practices has employed operations research methods (*5*) Inherent in these studies is the assumption that farm decisionmakers are not only profit maximizers but also equally competent profit maximizers This assumption implies that the characteristics of individuals have no bearing on investment behavior However, characteristics do have a bearing for the simple reason that individuals are not uniformly alike, they vary in management skills and management objectives This observation is not important to policy analysis and policy design if the behavior of individuals in target areas is consistent with the behavioral responses inferred from models of representative profit-maximizing enterprises However, it is argued that individual characteristics are important and do influence responses to voluntary programs (*12*)

*Young is an ERS project leader stationed at The Pennsylvania State University, University Park, and Shortle is an assistant professor of agricultural economics at The Pennsylvania State University, University Park

[1] Italicized numbers in parentheses refer to items in the References at the end of this article

The proposition that individual characteristics are important has led to an alternative line of research focusing on observed, rather than assumed, behavior Work in this area is just now getting underway, partly because of a severe scarcity of data on the characteristics of individual farm decisionmakers and their use of conservation practices and structures (*2, 6, 8, 10, 12, 13*)

The major feature of this research is its positive nature The research attempts to relate observed behavior to observable characteristics of farm decisionmakers and their operations Analysts have generally classified these characteristics as personal, physical, institutional, and economic (*6, 8*) Personal variables are included to allow for variation in human capital and management objectives For example, years of formal schooling often serve as a proxy for management skills Age is often used to reflect life cycle considerations under the hypothesis that individuals' management objectives vary throughout their lives Physical factors, principally measures of the erosivity of farmland, are included under the assumption that conservation practices are adopted to diminish erosion problems and are, therefore, more likely on more erosive land The benefits and costs of such investments are contingent upon economic characteristics of the farm operation and institutional factors Consequently, these studies also include variables reflecting economic characteristics, such as farm size, farm income, and institutional factors

Previous research on the adoption of conservation measures has focused on nonstructural practices Our study focuses on structural practices We generally propose that the factors identified in the research on adoption of nonstructural practices will also affect the adoption of structural practices To specify the model, we adopted a variables list analogous to that in previous research We expanded this list to include other land-improving investments Structural measures often entail major expenditures of funds, substantial modifications in the logistics of farm management, and careful prior planning Other land-improving investments compete for investment funds Conversely, landowners who are upgrading their land resources through investments, such as clearing and draining land, may find that concurrent investments in conservation structures are complementary Conservation investments will naturally tend to protect the improved land resource Cost savings may also be encountered through simultaneous construction

Model Specification and Regression Data

Linear probability models estimated by ordinary least squares are common in the agricultural and general adoption literature because these models permit researchers to relate the probabilities of individual adoption to relevant characteristics based on the common types of data on adoption—that is, on binary data indicating that an individual either has or has not adopted However, the use of linear models poses a number of difficulties The logit type of probability model has found increasing use be cause it overcomes the more serious of these difficulties The logit model is of the form

$$P_i = \frac{1}{1 + e^{-Z_i}}$$

where

P_i = the probability of individual i choosing one or two options

and

$$Z_i = \sum_{k=1}^{m} \beta_k X_{ik}$$

where

X_{ik} = the value of the kth attribute of the ith individual

In this analysis, P_i is the probability of adoption of conservation structures and the attributes are individual and farm characteristics

We derived data for this analysis from the Landownership Survey (LOS) which the Natural Resource Economics Division of the Economic Research Service conducted in 1978 The LOS was a nationwide survey providing information on characteristics of landowners Daugherty and Otte summarized survey results for farmland owners, while Lewis sum marized the results for all landowners (*4, 11*)

LOS respondents were asked whether or not they invested in a soil conservation structure (for example, terrace, grass waterway, or gully control structure) during the 1975-77 period The survey covered more than 1 year to improve the reliability of the survey A subsample of those landowners who invested in a conservation structure was re-surveyed to determine the nature of their investments Of those landowners investing in soil conservation structures, 46 percent installed grass waterways, 41 percent installed gully control structures, and 27 percent installed terraces (*15*)

Of the estimated 6 9 million owners of farmland in the contiguous United States, 8 4 percent invested in at least one type of soil conservation structure in the 1975-77 period Most of these owners lived in the Corn Belt, the fewest lived in the Lake States Average farm size for landowners who invested in soil conservation structures was generally twice that for other farmland owners

The dependent variable is whether or not a farmland owner invested in a soil conservation structure between 1975 and 1977 The regressors are characterized as personal, economic, institutional, and physical factors (*6, 8*) A subsample of 14,600 owners was selected from the LOS About 45 percent of the original data from the LOS were excluded from the analysis because of nonresponse to critical questions such as value of farmland, income, and conservation investment Our examination of means, medians, ranges, and variances of the full data and the reduced data did not reveal major differences

Personal Factors

The age of the landowner was included in the model to represent life cycle impacts on investment behavior Age may also reflect experience and the vintage of knowledge attained by formal education The years of formal education are also included in the model Higher levels of formal education are assumed to reflect greater management capabilities and a better understanding of the benefits and costs of soil conservation The sex of the landowner was also included

Economic Factors

A variety of data are available representing the economic situation of the farmland owner Farm income is entered as the midpoint of an income range The value of farmland is entered on a per-acre basis These variables are included to represent the landowner's ability to finance conservation investments

The use of owner and rented lands for crop production influences the likelihood of conservation investments (*1, 8*) The following four variables represent tenure relationships acres of farmland owned, acres of farmland rented from others, acres of farmland rented to others, and the use of share leases for land rented to others Banks and others concluded that farm operators who utilize share leases are more likely to use less erosive practices (*1*)

We evaluated the influence of other complementary investments occurring simultaneously with conservation investment by using three zero-one variables for land clearing, land draining, and converting land to cropland These variables indicate whether or not these other types of land improvements were made

Institutional Factors

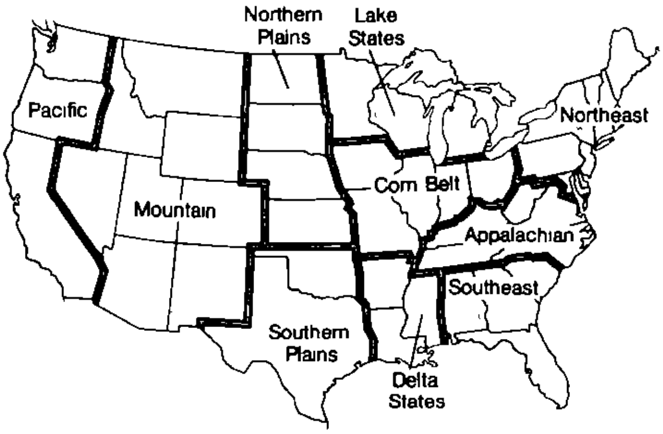
The only institutional factor for which data are available is whether or not a portion of the landowner's land is enrolled in a special property tax assessment program Participation in a special assessment program was measured in a "yes-no" format

Physical Factors

The primary physical factor influencing investments in soil conservation structures is erosivity of the land in question Through a merger of LOS data with Soil Conservation Service's National Resource Inventory (NRI) data, we derived an estimate of soil erosion for the NRI sampling point The erosion estimate is based on the Universal Soil Loss Equation (USLE) (*17*) However, there is no reason to expect that conservation investment occurred on the same parcel of land for which the erosion estimate was computed In a large data set such as the LOS, an erosion estimate for a point will probably fairly represent the average erosion for the entire farm

We included the farm production regions of the Nation to account for broad differences in topography, climate, and agricultural practices (see figure) The regions were entered as dummy variables, and the Lake States were omitted as a variable

Farm Production Regions



Regression results

Variable	Parameter estimates and X^2 statistics
Intercept	-3 490[1] (259 24)
Age	- 009[1] (19 80)
Education	062[1] (54 23)
Sex (male = 1)	346[1] (15 41)
Farm income	13×10^{-5} (01)
Land value ($1,000/acre)	- 006 (53)
Special property tax assessment (yes = 1)	069 (76)
Sharelease (yes = 1)	154[1] (5 08)
Cleared land (yes = 1)	1 234[1] (402 88)
Drained land (yes = 1)	1 739 (838 45)
Converted land to cropland (yes = 1)	241[1] (13 68)
Erosion (100 tons/acre/year)	004 (2 69)
Land owned (100 acres)	240×10^{-5}[1] (26 62)
Land rented out (100 acres)	-309×10^{-5}[1] (6 17)
Land rented in (100 acres)	102×10^{-5} (1 77)
Northeast	279[2] (3 74)
Corn Belt	663[1] (31 34)
Northern Plains	1 146 (85 31)
Appalachian	404[1] (9 34)
Southeast	723[1] (28 48)
Delta States	592[1] (17 13)
Southern Plains	1 317[1] (115 94)
Mountain	1 047[1] (71 73)
Pacific	492[1] (9 94)
r_s[3]	551

[1] Significant at the 5 percent level
[2] Significant at the 10 percent level
[3] Spearman's rank correlation coefficient between predicted probability and the actual response

Results

The table presents the regression results The parameters for the clear, drain, and convert variables are positive and significant The large magnitude of the chi-square statistics on the clear and drain variables indicate an association between investments in conservation structures and other land-improving investments Furthermore, the positive signs on the clear, drain, and convert parameters suggest the relationship is complementary That is, conservation investments tend to be more likely when other land-improving investments are undertaken One policy implication of this finding is that programs encouraging the adoption of soil conservation structures may be more successful if accompanied by incentives encouraging land improvement Furthermore, when areas are targeted for program efforts, it may help to know the degree to which other land-improving investments are economically feasible and socially desirable

The parameters for age, education, and sex are statistically significant Therefore, these results support the hypothesis that the characteristics of individuals do affect investment behavior Of particular importance for policy design is that individuals with more years of formal education are more likely to invest in conservation structures

The positive relationship between years of formal schooling and the likelihood of investment may indicate that individuals with greater technical and allocative abilities perceive greater gains from soil conservation investments As a result of their formal education, these individuals may be better able to interpret information presented by organizations such as the Extension Service and the Soil Conservation Service Exploring this hypothesis thoroughly would, however, require far more detailed information than is available as length of formal education is an exceedingly rough proxy This result does suggest, however, that information programs positively influence the adoption of conservation structures

The coefficients for farm income are positive but insignificant This result is puzzling because Young and Daugherty, in their analysis of the follow-on survey, found that personal funds were the primary source of funding for conservation investments Further examination of this issue revealed multicollinearity between farm income and the other investment variables (*16*)

Acreage owned is a positive and significant influence on investment The positive relationship may reflect cost- and risk-spreading economies—for example, a greater access to capital markets due to greater wealth and a greater probability of holding land requiring erosion-control structures However, the value per acre of landholdings is not significant in explaining observed variation in investment behavior Further analysis showed no evidence of multicollinearity between land value and other investments (*16*)

One could expect that special property tax assessments which encourage farmland preservation would increase the likelihood of investments Nonetheless, the results do not support this expectation

The soil conservation literature has emphasized the importance of forms of landownership and tenure arrangements as factors affecting conservation investments Our analysis supports these findings The share lease parameters are positive and significant This finding regarding share leases has implications for public policy The greater probability of investment under share leases may be partly attributable to the tax advantages of conservation investments that Federal tax law provides under share leases relative to those it provides under cash leases (*3*) Erosion control is thereby encouraged Our results show that the probability of investment in conservation structures is significantly and negatively affected by the amount of land an owner rents to others This finding conforms to commonly held opinion The amount of land rented in and operated does not appear to significantly influence the likelihood of investment in conservation structures

The likelihood of investment in soil conservation structures also varies by region The productivity of conservation structures depends on climatic, topographic, and soil variations among regions Regional economic conditions and institutional and social factors may also influence the likelihood of conservation investment The regression coefficients for farm production regions are all positive and, with one exception, significant The positive sign simply means that investment in conservation structures is more likely elsewhere than in the Lake States A ranking of the regression coefficients by magnitude generally indicates that the Southern Plains is the region most likely to have a conservative structure installed, the Northern Plains comes next The least likely regions to have conservation investment are the Lake States and the Northeast farm production regions

The parameter for the USLE has the expected sign, but is insignificant This finding is not surprising as the available USLE data may not accurately measure the erosion hazard on the improved parcels

Implications

The results of this study support three hypotheses First, personal characteristics of individual landowners influence adoption of conservation structures Age, education, and sex are significant factors for conservation investments Second, tenure arrangements affect the likelihood of investment in conservation structures There is an inverse relationship between land rented to others and conservation investments This relationship is partially offset when share leases are used Furthermore, the likelihood of investment is greater on larger landholdings Third, conservation structures are more likely to be installed in a package including other land improving measures This finding suggests a complementarity between land improvements and conservation structures

The fundamental implication for policymakers is that attention should be given to the characteristics of landowners, ownership patterns, and the general potential for land improvement when voluntary programs are designed However, although our analysis indicates the importance of these characteristics, those evaluating programs need models capable of providing fairly accurate predictions of participation under alternative program designs to exploit such information Developing these models will require a better data base than is now available Analysts need detailed data on the types, magnitudes, and timing of investments They also need more complete data on farm decisionmakers, soil characteristics, farm location, and other factors affecting the economics of soil conservation

References

(1) Banks, T M, S Bhide, C A Pope, III, and E O Heady *Effects of Tenure Arrangements, Capital Constraints, and Farm Size on the Economics of Soil and Water Conservation Practices in Iowa* Card Report 111 SWCP IV Iowa State University, Center for Agricultural and Rural Development, Apr 1983

(2) Baron, D *Landownership Characteristics and Investment in Soil Conservation* Staff Report No AGES810911 U S Dept of Agr, Econ Res Serv, 1981

(3) Boxley, R F, and W D Anderson "An Evaluation of Subsidy Forms for Soil and Water Conservation," *The Economics of Federal Subsidy Programs*, Part 7 *Agricultural Subsidies* Report of the Joint Economic Committee, Congress of the United States U S Government Printing Office, 1973

(4) Daugherty, A B, and R C Otte *Characteristics of Farmland Owners and Their Farmland* Staff Report No AGES830311 U S Dept of Agr, Econ Res Serv, 1983

(5) Dickason, C, and D Piper *Economics of Agricultural Erosion and Sedimentation—A Selected Review* Staff Report No AGES830328 U S Dept of Agr, Econ Res Serv, Apr 1983

(6) Ervin, C A, and D E Ervin "Factors Affecting the Use of Soil Conservation Practices Hypotheses, Evidence and Policy Implications," *Land Economics*, Vol 58, No 3, Aug 1982, pp 277 92

(7) Feder, G, R J Just, and D Silberman *Adoption of Agricultural Innovations in Developing Countries A Survey* World Bank Staff Working Paper No 444 Feb 1981

(8) Hoover, H, and W Wiitala *Operator and Landlord Participation in Soil Erosion Control in the Maple Creek Watershed in Northeast Nebraska* ESCS Staff Report NRED 80-4 U S Dept of Agr, Econ Stat Coop Serv, 1980

(9) Lee, L K "The Impact of Landownership Factors on Soil Conservation," *American Journal of Agricultural Economics*, Vol 62, No 5, Dec 1980, pp 1070-76

(10) ________, and W H Steward "Landownership and the Adoption of Minimum Tillage," *American Journal of Agricultural Economics*, Vol 65, No 2, May 1983, pp 256-64

(11) Lewis, J A *Landownership in the United States, 1978* AIB-435 U S Dept of Agr, Econ Stat Coop Serv, 1978

(12) Miranowski, J A "Overlooked Variables in BMP Implementation Risk Attitudes, Perceptions and Human Capital Characteristics," *Perceptions, Attitudes and Risk Overlooked Variables in Formulating Public Policy on Soil Conservation and Water Quality* (ed L A Christensen and J A Miranowski) Staff Report No AGES-820129 U S Dept of Agr, Econ Res Serv, 1982

(13) Nowak, V, and P Korsching *Sociological Factors in the Adoption of Best Management Practices* Annual Report to the U S Environmental Protection Agency Ames, Iowa Iowa State University, 1979

(14) U S Department of Agriculture *Soil and Water Resources Conservation Act, 1981 Program Report and Environmental Impact Statement* 1981

(15) Young, C E, and A B Daugherty *Investment in Conservation Structures, 1975-1977* Staff Report No AGESS810709 U S Dept of Agr, Econ Stat Serv, 1981

(16) Young, C E, and J S Shortle "Factors Influencing Investments in Soil Conservation Structures," *Agricultural Economics and Rural Sociology*, No 171 University Park The Pennsylvania State University, 1984

(17) Wischmeier, W H, and D D Smith *Predicting Rainfall-Erosion Losses from Cropland East of the Rocky Mountains* AH-282 U S Dept of Agr, Agr Res Serv, May 1968