VIRGINIA FARMERS' SOIL CONSERVATION DECISIONS: AN APPLICATION OF TOBIT ANALYSIS

Patricia E. Norris and Sandra S. Batie

Abstract

Using data from a survey of farm operators in two Virginia counties, the authors analyze farmers' soil conservation decisions. Results indicate that financial factors, including income and debt, are the most important influences on the sample farmers' use of conservation practices. Additional factors such as perception of erosion, education level, off-farm employment, and tenancy also influence conservation expenditures. Factors influencing conservation tillage acreage differ from those influencing expenditures for other conservation practices. In particular, age and race of the operator and on-farm erosion potential are significantly related to the use of conservation tillage but not other practices. These results are discussed in terms of their implications for conservation programs.

Key words: soil conservation, adoption, Virginia, conservation policy, Tobit models.

Traditional soil conservation programs have sought voluntary conservation practice adoption by farmers. To enhance acceptability, the programs have used education, technical assistance, and financial assistance. Recently, the effectiveness of financial and technical assistance programs of the Agricultural Stabilization and Conservation Service (ASCS) and the Soil Conservation Service (SCS) have been criticized (USGAO). These criticisms are made more important in the context of budgetary constraints.

The design of cost-effective voluntary conservation programs requires knowledge of what influences farmers to adopt soil conservation practices. Previous research has suggested that the influencing factors include the availability of technical and financial assistance, tenure relationships, risk attitudes, intergenerational considerations, and income (Ervin and Ervin; Nowak and Korsching; Lee and Stewart; Forster and Stem).

Several issues have not been adequately treated in previous studies. The first is the appropriate model of farmers' conservation behavior. In their conceptual model of the conservation decision-making process, Ervin and Ervin recognize three components: the perception of an erosion problem, the decision to adopt conservation practices, and the amount of soil conservation effort. Previous researchers have analyzed only one of the three components or have analyzed the components separately.

A second issue is the consideration of conservation tillage versus other conservation practices. Previous studies have combined conservation tillage with other practices or have considered only the use of conservation tillage. If farmers view conservation tillage differently from other conservation practices, conclusions or policy implications from such studies may not apply for the adoption of soil conservation practices in general.

Finally, only a few of the previous studies have included "actual erosion potential" as a decision factor in soil conservation decision models. Ervin and Ervin, Lee and Stewart, and Nowak and Korsching used some measure of erodibility in their analyses. The physical need for erosion control is an important factor in both the decision to adopt and the amount of conservation effort.

The authors examined farmers' use of soil conservation practices in two counties in Virginia's Piedmont Bright Leaf Erosion Control Area (PBLECA), incorporating consideration of the previously neglected issues. The PBLECA, which includes 14 Virginia counties and 13 North Carolina counties, is a United States Department of Agriculture (USDA) targeted area. The targeting pro-

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gram is intended to concentrate technical and financial assistance in those areas where erosion is the most severe. Data from a random sample survey are used in two Tobit models of farmers' conservation practices: (1) conservation tillage and (2) other conservation practices. The results of the analysis have implications for improving the effectiveness of conservation programs.

MEASURING ADOPTION

A major difficulty in modeling conservation decisions is the determination of the appropriate measure of adoption. Earlier studies have measured the willingness to adopt, the actual adoption decision, and the conservation effort. In studies by Dubman and Smathers, and Earle et al., the researchers measured willingness to adopt by farmers' intentions of adoption. However, such a model does not provide information as to farmers' actual conservation decisions, since behavior on any given occasion may be determined more by situational than personal attitudinal factors (McGuire). Thus, it is difficult to draw accurate policy implications from such models.

A more direct approach is to measure adoption or effort by farmers' actual use of conservation practices. Lee and Stewart, Rahm and Huffman, and Baron used dichotomous choice models to measure the probability of adoption. Another approach has been to quantify the adoption decision by the number of conservation practices used on the farm (Ervin and Ervin; Hoover and Wiitala; Forster and Stem). However, modeling only the adoption decision does not provide information as to how extensive are farmers' soil conservation efforts. A farmer using two practices on 50 acres is not necessarily more likely to adopt than a neighbor using one practice on 200 acres, nor does he necessarily exhibit greater conservation effort.[1]

Researchers have modeled conservation effort using the actual erosion rate present on the farm (Lee) and the difference between erosion rates without practices and with recommended practices (Ervin and Ervin). It is important in such a model to consider the magnitude of the initial erosion problem and to account for the differing erosion potential across farms.

This study used Tobit models of soil conservation decisions, which consider both the decision to adopt and conservation effort. Farmers' use of conservation practices is measured by the amount of farmer investment in the practices (i.e., an investment function approach). Farmers' investments in conservation practices, excluding conservation tillage, are represented by the farmers' 1983 total capital expenditures and operation and maintenance expenses for conservation practices.[2] This measure of effort does not consider the amount of achieved erosion control. Rather, expenditures are viewed as a measure of farmers' willingness and ability to actually use conservation practices.

Conservation expenditures were calculated as the sum of annual investment costs, maintenance costs, and opportunity costs. Investments for permanent practices (e.g., terraces, waterways, and critical area cover) were amortized over a seven-year period. A seven-year period was chosen because most "improvement loans" have a seven-year payback period. Practices were assigned maintenance costs where farmers indicated that maintenance occurred. Opportunity costs included foregone income from crops. For those operators receiving cost sharing in 1983, the amount of cost sharing received was subtracted from their 1983 expenditures.

Investment in conservation tillage was measured by the total acres planted using a minimum tillage or no-till practice[3] and was examined separately from other practices for several reasons. First, research has suggested that a different group of factors influences the adoption of conservation tillage and other erosion control practices (Lee and Stewart; Bultena and Hoiberg), in part because many farmers are using conservation tillage as a production practice rather than for erosion control *per se*. Second, annual expenditure was not an appropriate measure of investment in conservation tillage since, for many farmers, the use of conservation tillage presents the potential for increased returns (negative

[1] The standard practice of using the masculine form of third person pronouns is followed here to avoid the awkwardness of he/she and his/her. However, it is recognized that many farm operators are women, and the sample for this study included several women.

[2] Conservation practices considered include terraces, sod waterways, stripcropping, critical area planting, pasture or hayland establishment and/or management, cover crops, and tree planting. No expenditures were included for crop residue use or contour farming, as any costs associated with those practices were considered to be negligible.

[3] Minimum tillage is the minimum soil manipulation necessary for crop production or meeting tillage requirements under the existing soil and climate conditions. No-tillage is a method of planting crops that involves no seedbed preparation other than opening the soil for the purpose of placing the seed at the proper depth.

expenditures) over what would be expected with a conventional tillage practice.

FACTORS INFLUENCING ADOPTION

Economic theory does not provide a strong basis to determine soil conservation decision variables. While the level of a farmer's investment in conservation practices can be derived from the maximization of his utility function (Meyer and Kuh), the arguments of that utility function are unknown. However, research exists which relates farmers' adoption of new practices, in particular conservation practices, to various socioeconomic factors (Pampel and van Es; Feder et al.; Nowak and Korsching); these include farm operator characteristics, farm business aspects, farm agency contacts, and erosion potential.

The farm operator characteristics considered in this study include age, education, perception of erosion, off-farm employment, intergenerational expectations, and race.[4] Several researchers have found that older farmers are less likely to use conservation practices (Baron; Ervin; Forster and Stem). The shorter planning horizons of older farmers and the less than perfect capitalization of yield changes in land prices are hypothesized to result in less effort to maintain soil productivity. Also, younger farm operators may be more educated and more involved with current, innovative farming practices and, as a result, more aware of erosion problems and available solutions. For this study, age is measured by a dummy variable (AGE) equal to one for farmers age 55 or older.[5] A negative impact on both conservation expenditures and conservation tillage is hypothesized.

Higher education levels are hypothesized to be associated with access to improved information on conservation measures and the productivity consequences of erosion, as well as higher management expertise. Education has been found to positively impact conservation adoption in several studies (Ervin and Ervin; Forster and Stem; Baron). Education is included in this study using dummy variables to account for two of three levels of education. The first dummy variable (EDUCATION1) is equal to one for those farmers who graduated from high school but not from college. The second dummy (EDUCATION2) is equal to one for those farmers who did not graduate from high school. Farmers in both groups are expected to have lower probabilities of adoption and lower levels of conservation effort than those farmers who graduated from college.

As suggested by Ervin and Ervin, awareness or perception of an erosion problem is the first step in the adoption process and, as such, is a logical prerequisite for adoption. Recognition of erosion has been found to positively influence conservation behavior in a number of studies (Earle et al.; Lasley and Nolan; Ervin and Ervin). For this analysis, perception of an erosion problem is hypothesized to positively influence farmers' soil conservation decisions and is included as a dummy variable (PERCEPTION) equal to one where the farmer perceived erosion to be a problem on his farm.

The impact of off-farm employment on conservation decisions has not been established by previous research (Ervin and Ervin; Taylor and Miller). In this study, off-farm employment is hypothesized to have a negative impact on conservation adoption and effort and is represented by a dummy variable (OFF-FARM JOB) equal to one if the farmer holds an off-farm job.

Farmers who plan for a relative to take over their farm operation upon their retirement are expected to spend more on conservation practices, since they should be interested in maintaining the productivity of the farm for future generations. This expectation is included in the analysis by a dummy variable (KIN-TRANSFER) equal to one for those farmers expecting a child or other relative to eventually assume management of their farm.

Minority farmers in the study area are expected to practice less conservation because of limited financial resources, smaller farms, and fewer contacts with USDA agencies. In their work with limited resource farmers, Virginia Extension Specialists found that a large proportion of these farmers were minority farmers who had few contacts with local USDA agencies (Moore). Again, a dummy variable (RACE) is used to account for the farmer's

[4] A complete model of soil conservation decisions should include some measure of the farmer's attitude toward risk. For this analysis, an attempt was made to obtain a measure of risk aversion using a survey question, but the results were not usable because farmers chose not to participate in the hypothesized situations which were part of the question.

[5] Age and education are included as discrete rather than continuous variables because of the survey questions used to obtain this information. The professional enumerators who conducted the survey advised that categorical questions would be more acceptable to farmers than questions asking directly for age and education level. A larger number of categories were available for each factor, but the researchers felt that no significant information was lost by using a smaller number of categories in the model.

race and is set equal to one for non-white farmers.

The farm business aspects included in this study are farm size, income, debt, tenancy, and tobacco acreage. Previous studies have found a positive relationship between farm size and conservation (Lasley and Nolan; Baron; Carlson et al.). Operators of larger farms are likely to spend more on conservation because, in many cases, larger farm size is associated with greater wealth and increased availability of capital, which makes investment in conservation more feasible. For this analysis, farm size (SIZE) is included as the total cropland acreage, both owned and rented, operated by the farmer. A positive relationship is hypothesized with both conservation expenditures and conservation tillage acreage.

A positive relationship has been found between gross income and the adoption of conservation practices (Carlson et al.). This relationship is expected, in part, because higher incomes could reduce financial constraints to adoption. Also, higher income farmers usually have higher marginal tax rates and thus benefit more from tax incentives than low income operators for deductible conservation expenditures. In this study, income (INCOME) is included as a combination of both on-farm and off-farm annual after-tax income to account for the total financial resources available to the farmer as he considers investing in conservation. Farmers with higher net incomes are expected to practice more conservation.

Debt level is hypothesized to negatively affect conservation adoption. An anticipated reaction of operators to high debt levels is to plant mostly high-return row crops, with fewer investments in conservation practices, especially structures. There has been no conclusive evidence as to the impact of debt levels in other studies (Ervin and Ervin). For this study, debt (DEBT) is measured as total dollars spent annually toward payment of debt.

A number of studies have considered the influence of tenure and tenancy on conservation behavior (Ervin; Hoover and Wiitala; Lee and Stewart). It is generally held that renters of farmland are less likely to invest in conservation practices because short term leases reduce their incentive to maintain the productivity of the rented land. However, Lee and Stewart found that renters were more likely to use conservation tillage practices than full owners, perhaps because conservation tillage need not involve the large investments of time and capital required by other practices, because conservation tillage was viewed as a production enhancing practice, or because full owners often operate smaller farms than farmers who rent land.

Tenure (TENURE) is measured in this study as the ratio of total rented cropland to total operated cropland acreage. Based on previous research results, a negative relationship is hypothesized between tenure and conservation expenditures, while a positive relationship is hypothesized between tenure and conservation tillage acreage.

An additional farm business aspect, acreage of tobacco planted (TOBACCO ACRES), is considered for this study. Farmers who grow larger acreages of tobacco are expected to practice less conservation for several reasons. The current lease and transfer system allows the tobacco farmer to lease additional tobacco allotment acreages and transfer that additional production to his own farm. As a result, a farmer may have up to fifty percent (the program limit) of total acreage planted in tobacco, a highly erosive crop. Secondly, many farmers depend upon their tobacco crop as their primary source of income and will not rotate any land out of tobacco from year to year. Finally, some conservation practices may be perceived as incompatible with the cultivation of tobacco. Tobacco acreage in 1983 is used in this analysis.

Contacts with farm agencies such as SCS, ASCS, Cooperative Extension Service (CES), Farmers' Home Administration (FmHA), and Virginia Division of Forestry (VDF) are hypothesized to positively impact conservation expenditures. Nowak and Korsching found such contacts to be positively and significantly related to the number of conservation practices used by farmers. The number of contacts made with these agencies in 1983 (CONTACTS) is included in the analysis of conservation expenditures. Only contacts with SCS and CES are considered in the conservation tillage analysis, as these are the two agencies most likely to influence farmers' conservation tillage decisions. In addition to the contacts variable, a dummy variable (PROJECT) is included to reflect whether the farmer was aware of the special PBLECA project. This variable is equal to one for those farmers who were aware of the project; a positive relationship is hypothesized since the project objective was to positively influence farmers' conservation activities.

Two final variables are included with respect to farm agency contacts. Farmers who are cooperators with the local conservation district and have established a conservation plan are more likely to practice conservation. Existence of a conservation plan represents the amount of time that the farmer has spent with a soil conservationist, during which time the farmer may be influenced to implement the plan and adopt conservation practices. A dummy variable (PLAN) is included equal to one for those farmers with a conservation plan. The receipt of cost sharing is also hypothesized to positively affect farmers' use of conservation practices. Researchers have found the level of cost sharing received to be positively related to adoption (Ervin and Ervin; Nowak and Korsching). However, this study considers only whether the farmer received cost sharing. A dummy variable (COST SHARING) equal to one for those farmers who received cost sharing is included in the conservation expenditures model. Cost sharing is not included in the conservation tillage analysis because only two farmers received cost sharing for that practice.

It is expected that farmers who face the most severe potential erosion problems are more likely to practice conservation. The natural potential of soil to erode is influenced by variables such as the type of soil, the weather conditions experienced, and the steepness of the land. Previous research has found that farmers with the potentially more erodible land had greater levels of conservation effort (Ervin and Ervin). Natural erosion potential is represented by the rainfall, soil erodibility, slope length, and slope steepness (RKLS) factors of the Universal Soil Loss Equation (USLE) (Wischmeier and Smith).[6] The RKLS variable is calculated as a weighted average for all cropland operated.

Because conservation tillage is viewed as a production practice, a final variable is included exclusively in the conservation tillage model. In order to consider the impact of the potential profitability of conservation tillage on farmers' decisions, a returns to conservation tillage variable is included. This variable (RETURNS) is measured as the difference between net returns to conservation tillage practices used in 1983 and potential net returns to "typical" conventional tillage practices. A positive relationship is hypothesized between the returns variable and conservation tillage acreage.

TOBIT MODEL SPECIFICATION

Models of conservation practice expenditures and conservation tillage acreage are specified using the variables discussed above. In the absence of a theoretical recommendation for using an alternative specification, a linear specification is used for the two models, as is the case in most previous research.

Tobit analysis is used to estimate the two models (Tobin). This method estimates the likelihood of adoption and the amount of effort (investment or acreage). Tobit is preferable to Ordinary Least Squares (OLS) estimation because it allows for the inclusion of observations which have zero conservation expenditures or conservation tillage acreage. Ordinary Least Squares estimation based on a censored sample with a limited dependent variable would yield inconsistent estimates.[7] An alternative would be to include in the analysis only those observations for which expenditures or acreage are greater than zero. However, this alternative would result in sample selection bias in the estimated coefficients of the OLS model. Tobit coefficients are estimated by the method of maximum likelihood.

Unlike the OLS case, the value of a Tobit coefficient does not represent the expected change in the dependent variable given a one unit change in an explanatory variable. Rather, the Tobit model estimates a vector of normalized coefficients which can be transformed into the vector of first derivatives. The Tobit model and these transformations are summarized in Table 1. In addition, McDonald and Moffitt have shown that elasticities calculated at the means of the variables can be decomposed into two parts. The elasticity of the probability of being above the limit (elasticity of adoption) and the elasticity of the conditional expected value (elasticity of effort given adoption occurs) sum to equal the total elasticity or the percent change in the dependent variable given a one percent change in the independent variable.

Specification of the Tobit model makes the

[6] Erosion potential as measured by the RKLS factors of the USLE does not take into consideration the impact of previous or current erosion control practices. If RKLS is large but conservation practices have been used consistently over time, then the variable may not be an adequate representation of conservation needs.

[7] In statistical literature, the term censored applies to a sample in which some observations are recorded only as above (or below) some threshold. For a detailed discussion of censored response models and limited dependent variables, see Maddala.

TABLE 1. COMPONENTS OF THE TOBIT MODEL.

(1) $Y = X\beta + e$ if $X\beta + e > 0$
$Y = 0$ if $X\beta + e \leq 0$
(2) $E(Y) = X\beta F(z) + \sigma f(z)$
(3) $E(Y^*) = X\beta + \sigma f(z)/F(z)$
(4) $\partial E(Y)/\partial X = F(z)[\partial E(Y^*)/\partial X] + E(Y^*)[\partial F(z)/\partial X] = F(z)\beta$
(5) $\partial E(Y^*)/\partial X = \beta[1 - zf(z)/F(z) - f(z)^2/F(z)^2]$
(6) $\partial F(z)/\partial X = f(z)\beta/\sigma$

where:

X = a vector of regressor variables,
β = a vector of unknown coefficients (Tobit coefficients),
e = a vector of independent and identically distributed normal random variables assumed to have mean zero, and constant variance, σ^2,
$E(Y^*) = E(Y|Y>0)$,
$z = X\beta/\sigma$, normalized index,
$f(z)$ = the standard normal density function, and
$F(z)$ = the cumulative standard normal distribution function.

Source: McDonald and Moffitt

underlying assumption that the same set of factors has the same influence on the adoption decision and effort. This may not be the case (Ervin and Ervin). Heckman offers an alternative procedure to deal with censored samples which would allow for different factors influencing adoption and effort. The two equation procedure would involve estimation of a probit model of the adoption decision, calculation of the sample selection bias, and incorporation of that bias into a model of effort estimated with OLS. While Heckman's procedure allows for different model specifications for adoption and effort, it does not allow for the decomposition of elasticities afforded by the Tobit procedure. Since the results of this study are of interest in terms of policy implications, the elasticity decomposition is a valuable result of using Tobit.

DATA

A random sample of 50 farm operators, stratified by race, was drawn from each of two Virginia counties, Pittsylvania and Lunenburg. Records maintained by ASCS were used to obtain the sample as well as information about the land owned and rented. Each of 100 farmers was asked, via a personal interview, questions about his farm operation, use of conservation practices, perceptions of erosion, and a number of personal characteristics. Seventy-four of the 100 operators were actively farming; they were the final sample for the analysis. Twenty-nine of the sample farmers were black and 45 were white. Average age of the farmers was approximately 55. The average number of cropland acres operated per farmer was 109 acres, and average net income for the sample farmers was just over \$20,500. Sixty of the 74 farmers had conservation expenditures in 1983; average expenditure per farmer was approximately \$1,900. Seventeen farmers were using some form of conservation tillage. The proportions here are not entirely typical of the study area since the sample was stratified by race. A larger proportion of black farmers was included in the sample because, in the study area, the black farmers are limited resource farmers and the constraints to adoption for limited resource farmers are of particular interest.

RESULTS

Results of the conservation expenditures analysis are presented in Table 2. The Tobit coefficients and their standard errors are given in the first column. Perception of erosion, farm size, income, and existence of a conservation plan significantly and positively impact conservation expenditures. Off-farm employment, debt level, tenure, and tobacco acreage significantly and negatively influence conservation expenditures. Also, farmers who have graduated from high school but not college invest significantly less in conservation practices than farmers who are college graduates. A high value of Efron's R^2 suggests a good fit of the conservation expenditures model.[8]

The calculated derivatives for the conservation expenditures model are in the last three columns of Table 2. Interpretation is as follows for the continuous variables. With size as an example, a one acre increase in operated

[8] Efron's $R^2 = [1 - \Sigma(y_i - F)^2/\Sigma(y_i - y)^2]$, and corresponds to the R^2 in standard regression analysis (Amemiya). Collinearity diagnostics and tests for heteroscedasticity were examined for both models and revealed that the classical assumptions of linear regression are satisfied. Because there is no formal procedure to evaluate these assumptions in a Tobit framework, OLS regressions were used to perform the tests.

cropland would result in a .21 percent increase in the probability of adoption ($\partial F(z)/\partial X$), a $6.46 increase in expenditures by those farmers using practices in 1983 ($\partial E(Y^*)/\partial X$), and a $9.19 increase in total expenditures ($\partial E(Y)/\partial X$). All of the discrete variables are intercept shifters.

Results of the conservation tillage analysis are presented in Table 3. Again, the Tobit coefficients and their standard errors are in the first column, and the derivatives are in the last three columns. The derivatives are interpreted as described previously. Intergenerational expectations and operated cropland acreage significantly and positively influence conservation tillage acreage. Age, income, off-farm employment, and erosion potential significantly and negatively affect conservation tillage acreage. Also, non-white farmers have significantly lower conservation tillage acreage than white farmers. The value of Efron's R^2 suggests a good fit of the model.

Expenditure elasticities calculated at the means of the significant variables for both models are presented in Table 4. The elasticities are calculated for those farmers with zero conservation expenditures or conservation tillage acreage ($\eta_{F(z)}$), for those farmers who had some level of conservation expenditures or conservation tillage acreage in 1983 ($\eta_{E(Y^*)}$), and for the total sample ($\eta_{E(Y)}$). As an example of interpretation, a one percent increase in income at the mean would increase the probability of new farmers adopting practices by .53 percent. Farmers who already have some amount of conservation expenditures would be expected to increase their expenditures by .49 percent, and total expenditures would increase by 1.03 percent.[9]

Only three variables, income, size, and off-farm employment, impact both conservation expenditures and conservation tillage acreage. In addition, the sign on the income coefficient is different for the two models. This suggests that the factors influencing the adoption of conservation tillage are different from those which influence the decision to use other conservation practices.

TABLE 2. ESTIMATED TOBIT COEFFICIENTS AND CALCULATED DERIVATIVES, CONSERVATION EXPENDITURES MODEL, PITTSYLVANIA AND LUNENBURG COUNTIES, VIRGINIA, 1983

EXPLANATORY VARIABLES	NORMALIZED COEFFICIENTS (standard error)	CALCULATED DERIVATIVES		
		$\frac{\partial F(z)}{\partial X}$	$\frac{\partial E(Y^*)}{\partial X}$	$\frac{\partial E(Y)}{\partial X}$
INTERCEPT	−.83199 (.7829)			
AGE	.07359 (.3911)	.0262	80.97	115.28
EDUCATION1	−.21628 (.3490)	−.0771	−237.97	−338.81
EDUCATION2	−1.3847[a] (.7407)	−.4938	−1523.6	−2169.3
PERCEPTION	.83881[b] (.3655)	.2991	922.93	1314.1
OFF-FARM JOB	−.8474[b] (.4067)	−.3022	−932.42	−1327.5
KIN-TRANSFER	.10614 (.2929)	.0378	116.79	166.28
RACE	−.26397 (.3126)	−.0941	−290.45	−413.54
SIZE	.00596[b] (.00099)	.0021	6.46	9.19
INCOME	.00005[b] (.00001)	.000018	.0554	.0789
DEBT	−.00004[b] (.00001)	−.000016	−.0486	−.0692
TENURE	−.76014[a] (.4365)	−.2711	−836.4	−1190.8
TOBACCO ACRES	−.02386[a] (.0125)	−.0085	−26.26	−37.38
CONTACTS	.01212 (.0099)	.0043	13.34	18.99
PROJECT	−.17596 (.3426)	−.0627	−193.61	−275.66
PLAN	.84764[b] (.3708)	.3023	932.66	1327.9
COST SHARING	.53664 (.4159)	.1914	590.45	840.68
RKLS	.0018 (.0051)	.0006	1.98	2.82

Efron's R^2 = .7878

[a] Significant at 10 percent level
[b] Significant at 5 percent level

[9] Interpretation of the elasticities for a binary variable (e.g., off-farm employment) differs from that of a continuous variable. For example, the expenditure elasticities associated with the off-farm variable reveal that if the proportion of sample farmers who held an off-farm job was increased by, say, ten percent, then conservation expenditures for the sample would be expected to decrease by approximately 6.2 percent. Of that 6.2 percent decrease, almost 3 percent would be attributable to decreases in expenditures by practicing conservation farmers. The remaining 3.2 percent would come from newly-investing conservation farmers.

TABLE 3. ESTIMATED TOBIT COEFFICIENTS AND CALCULATED DERIVATIVES, CONSERVATION TILLAGE ACREAGE MODEL, PITTSYLVANIA AND LUNENBURG COUNTIES, VIRGINIA, 1983

EXPLANATORY VARIABLES	NORMALIZED COEFFICIENTS (standard error)	CALCULATED DERIVATIVES		
		$\frac{\partial F(z)}{\partial X}$	$\frac{\partial E(Y^*)}{\partial X}$	$\frac{\partial E(Y)}{\partial X}$
INTERCEPT	2.1151 (1.5788)			
AGE	−2.1571[a] (.7679)	−.1278	−23.37	−5.18
EDUCATION1	−.6329 (.6582)	−.0375	−6.86	−1.52
EDUCATION2	−.44723 (1.0676)	−.0265	−4.85	−1.07
PERCEPTION	.31807 (.7896)	.0188	3.45	.7634
OFF-FARM JOB	−1.13[b] (.6647)	−.0669	−12.24	−2.71
KIN-TRANSFER	2.427[a] (.7981)	.1438	26.30	5.82
RACE	−1.319[b] (.7126)	−.0781	−14.29	−3.17
SIZE	.00962[a] (.0019)	.00057	.1043	.0231
INCOME	−.000032[a] (.000013)	−.000002	−.0004	−.00008
DEBT	.000022 (.000024)	.0000013	.0002	.00005
TENURE	−1.1662 (.9447)	−.0691	−12.64	−2.80
TOBACCO ACRES	.02032 (.0188)	.0012	.2202	.0488
CONTACTS	.02885 (.0304)	.0017	.3126	.0692
PROJECT	.28565 (.6103)	.0169	3.10	.6856
PLAN	−.70682 (.6116)	−.0419	−7.66	−1.70
RKLS	−.04493[a] (.0180)	−.0027	−.4868	−.1078
RETURNS	−.00722 (.0254)	−.0004	−.0782	−.0173
Efron's R^2 = .8891				

[a] Significant at 5 percent level
[b] Significant at 10 percent level

TABLE 4. ELASTICITIES CALCULATED AT MEANS OF SIGNIFICANT VARIABLES, CONSERVATION EXPENDITURES MODEL AND CONSERVATION TILLAGE ACREAGE MODEL, PITTSYLVANIA AND LUNENBURG COUNTIES, VIRGINIA, 1983

EXPLANATORY VARIABLES	ELASTICITY COMPONENTS		
	$\eta F(z)$	$\eta E(Y^*)$	$\eta E(Y)$
Conservation Expenditures Model			
EDUCATION2	−.0587	−.0540	−.1127
PERCEPTION	.3377	.3107	.6484
SIZE	.3353	.3085	.6438
INCOME	.5339	.4911	1.0249
OFF-FARM JOB	−.3232	−.2974	−.6206
DEBT	−.1256	−.1156	−.2412
TENURE	−.1396	−.1284	−.2680
TOBACCO ACRES	−.1029	−.0946	−.1975
PLAN	.0898	.0826	.1724
Conservation Tillage Acreage Model			
AGE	−3.88	−.5020	−4.39
KIN-TRANSFER	2.91	.3765	3.29
RACE	−1.21	−.1562	−1.36
SIZE	2.45	.3179	2.78
INCOME	−1.53	−.1983	−1.73
OFF-FARM JOB	−1.92	−.2491	−2.18
RKLS	−6.23	−.8065	−7.05

IMPLICATIONS FOR CONSERVATION PROGRAMS

This study did not consider the benefits of erosion control or the specific impact of adoption on erosion in the study area. Rather the assumption is that the emphasis on erosion control efforts and on conservation programs in current agricultural policy is evidence of a perceived need for increased adoption of erosion control measures and an underlying perception of benefits of controlling erosion. A number of different factors were found to significantly influence farmers' conservation decisions. These results have several implications for increasing the adoption of conservation practices and conservation tillage by farmers in the PBLECA and, perhaps, in other regions where farmer characteristics and farm operations are similar.

Higher incomes, larger farm size, and lower debt levels are associated with higher conservation expenditures in the study area. This suggests that there are significant financial constraints to conservation adoption, particularly for limited resource farmers. Thus, programs designed to encourage the voluntary adoption of conservation practices may need to take into consideration the special needs of limited resource farmers.[10] While many of the limited resource farmers in the sample are black, farmers' race does not appear to impact the use of conservation practices, all else held constant.

The results reveal that, with all other factors held constant, a one percent increase in average annual net income for the sample farmers would result in a 1.03 percent increase in total conservation expenditures and a .53 percent increase in the probability of adoption by new farmers. A combined effort of SCS and CES to promote income-enhancing practices is one way to encourage conservation behavior. For example, the agencies

[10] Research has suggested that federal crop programs have benefited disproportionately operators of larger farms and with higher incomes (Gardner et al.). If this has also been true of federal conservation programs, then that might explain, in part, the lower adoption rates of limited resource farmers.

might coordinate the promotion of management techniques designed to lower production costs and increase efficiency.[11]

Traditional conservation programs have relied on the cost sharing of farmers' conservation expenditures as the main form of financial assistance. However, the results of this study indicated that the receipt of cost sharing was not important in sample farmers' conservation decisions. It is possible that limits on cost sharing are too low to affect the affordability of conservation. Currently, with rare exception, ASCS limits the total amount of money an individual can receive in cost sharing payments to $3,500. In the study, 1983 expenditures for conservation ranged as high as $31,000 and the average was $1,900; the average cost sharing assistance received was $150.25. Such a small amount of cost sharing assistance may not significantly increase some farmers' abilities to invest in certain conservation practices.

The analysis suggests that a one percent decrease in annual expenditures for debt repayment would increase conservation expenditures by the sample farmers by .24 percent. One possibility for easing debt, while encouraging adoption of conservation practices, would be low-interest operating loans to conservation farmers. That is, farmers using conservation practices in a manner consistent with erosion control objectives would be eligible for lower interest rates on borrowed money. For example, eligibility requirements for FmHA loans could include the implementation of needed conservation practices and encouragement of the use of funds for such practices.

Results of this study also reveal that a positive perception of erosion problems significantly influences adoption of conservation practices in the study area. Thus, increasing farmers' ability to invest in conservation will not assure that the investments will be made, especially if farmers do not perceive that they have erosion problems. According to these results, a one percent increase in the proportion of farm operators who perceive erosion problems on their farms would result in a .65 percent increase in conservation expenditures and a .34 percent increase in the probability of adoption. Therefore, education will continue to be an important component of a successful conservation program.

Because erosion rates, types of erosion, and the consequences of erosion will vary with soil types and depths, climatic factors, and cropping practices, an objective of conservation education should be to inform individual farmers of their erosion problems. Also, the effectiveness of different practices and their compatibility with farming operations will vary for each farm. This suggests that a broad program of education and information designed to reach all farmers will be less effective than a program tailored for individual farmers. Existing information delivery systems could be coupled with active "outreach" programs targeted to reach those farmers who have not recognized an existing erosion problem.

An education program also needs to take into account the limitations placed on part-time farmers by their off-farm jobs (where other factors, such as income, are held constant). Off-farm employment is a deterrent to the use of conservation practices in the sample area. If part-time farmers practice less conservation because they have less time to devote to farm management, then SCS may be able to reach such farmers through an "outreach" program and work with them to design a conservation plan which requires less time.

Farmers in the sample who operate larger proportions of rented land and have lower conservation expenditures are less likely to adopt conservation practices. This suggests a role for SCS in encouraging landowners to include conservation requirements in leasing agreements. Cost sharing agreements between landowner and tenant might also be encouraged, based on the perceived distribution of benefits of adoption.

The study also reveals that farmers with larger acreages of tobacco have lower conservation expenditures and are less likely to adopt. Current research into no-till production of tobacco and replacement of tobacco with alternative cash crops (e.g., broccoli) may reduce the negative impact of tobacco production on conservation effort.

As discussed previously, conservation tillage adoption was considered separately from other conservation practices because farmers may view the practices differently. The analysis reveals that only two factors, farm size

[11] Higher incomes as a result of higher commodity prices will not necessarily achieve the desired increases in conservation effort. Farmers reacted to the increase in farm prices of the early 1970's by removing conservation practices and expanding production onto more erodible land (Batie). For most farmers, higher prices resulted in a reduction of conservation effort.

and off-farm employment, impact the adoption of conservation tillage and other practices in the same way. The income variable is related to adoption of both types of practices, but higher incomes are associated with higher conservation expenditures and lower conservation tillage acreage. In terms of conservation policy, these differences suggest that it is inappropriate to generalize results from studies which combine the adoption of conservation tillage and other practices.

Furthermore, an analysis of conservation tillage adoption alone is likely inapplicable to soil conservation adoption in general. That is, programs to encourage the adoption of terraces or waterways should not be designed based on an analysis of farmers' conservation tillage decisions. An effective program should consider the acceptability of each different type of practice, as well as farmers' motives for adopting each practice. For example, perception of an erosion problem or high potential erodibility does not appear important in the adoption of conservation tillage. Therefore, promoting the potential profitability of conservation tillage may be a more effective means of influencing farmers to adopt such a technique. Such an erosion control program should be designed to reach those farmers with the more erodible land.[12]

There was not a significant relationship between the use of conservation tillage and returns to the practice. It is likely that this result is due to the use of 1983 returns rather than a long-run returns variable in the model, especially if farmers base their decisions to use conservation tillage, and in particular no-till, on expectations of higher returns over the long run. For example, no-till may result in higher yields in drought years and lower yields in wet years as compared to conventional tillage practices. Also, the timeliness of conservation tillage, such as the ability to plant crops earlier, may influence farmers' decisions to use the practice. These considerations were not captured by the returns variable used.

Encouraging the adoption of conservation tillage presents a particular challenge for conservation programs. Since neither contacts with SCS and CES in 1983 nor the existence of a conservation plan had a significant impact on farmers' decisions to use conservation tillage, it may be that conservation tillage adopters are receiving their information about the technique from other sources, for example, equipment and pesticide dealers and/or other farmers. If so, then SCS and CES might work with these groups to assure that their information programs include the erosion control benefits of conservation tillage.

As with the conservation expenditures model, larger farm size is associated with larger conservation tillage acreage. However, it appears that the adoption of conservation tillage is not constrained by lower income and higher debt levels, as is the adoption of other conservation practices. In fact, this study found that lower income was associated with larger acreage of conservation tillage. This suggests that conservation tillage might be one alternative to other more capital intensive practices, especially for limited resource farmers. Minimum tillage practices may require little or no changes in equipment inventory. The opportunity to lease no-till equipment from equipment dealers, other farmers, and, in the PBLECA, from conservation districts may reduce the need for large investments and the accompanying need for loans.

Race of the operator was not important in terms of conservation expenditures, but results indicate that minority farmers in the sample are less likely to plant with a conservation tillage method.

CONCLUSIONS

Three main points arise from this analysis of farmers' conservation decisions which have important implications for the success of soil conservation programs in the PBLECA in meeting erosion control goals. First, perception of an erosion problem is necessary before farmers will adopt most conservation practices. However, a negative relationship was found between erosion potential and the use of conservation tillage. This suggests that program objectives should include actively approaching those farmers with the more severe erosion.

Second, there appear to be significant financial constraints to the adoption of soil conservation practices. Given the limitations of the

[12] The erosion control achieved with conservation tillage may be at the expense of water quality problems. Concern has been voiced over the increased use of chemicals required with no-till and some minimum tillage practices, in particular because of the associated increase in runoff of these chemicals (Hinkle). To control the increased runoff of chemicals and nutrients, conservation tillage may have to be used as part of a system of conservation practices, for example, combined with grass waterways and filter strips.

current cost sharing program, alternative programs to increase the affordability of conservation practices should increase adoption. These could include education programs on management and marketing strategies or research into reducing the costs of implementation. The financial constraints do not appear to exist for conservation tillage adoption. Also, if farmers view conservation tillage differently from other conservation practices, as this study suggests, programs to encourage the use of conservation tillage may need to concentrate on characteristics unique to conservation tillage.

Finally, according to the results of this study and other research, the factors which significantly impact farmers' conservation decisions differ widely among farmers. Program effectiveness will depend largely on the extent to which such differences are recognized. To be successful, a soil conservation program must be flexible enough to accommodate the diversity of both farmers and their soil conservation needs.

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