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University of Tennessee Agricultural Experiment Station

William M. Park

Kevin W. Ferguson

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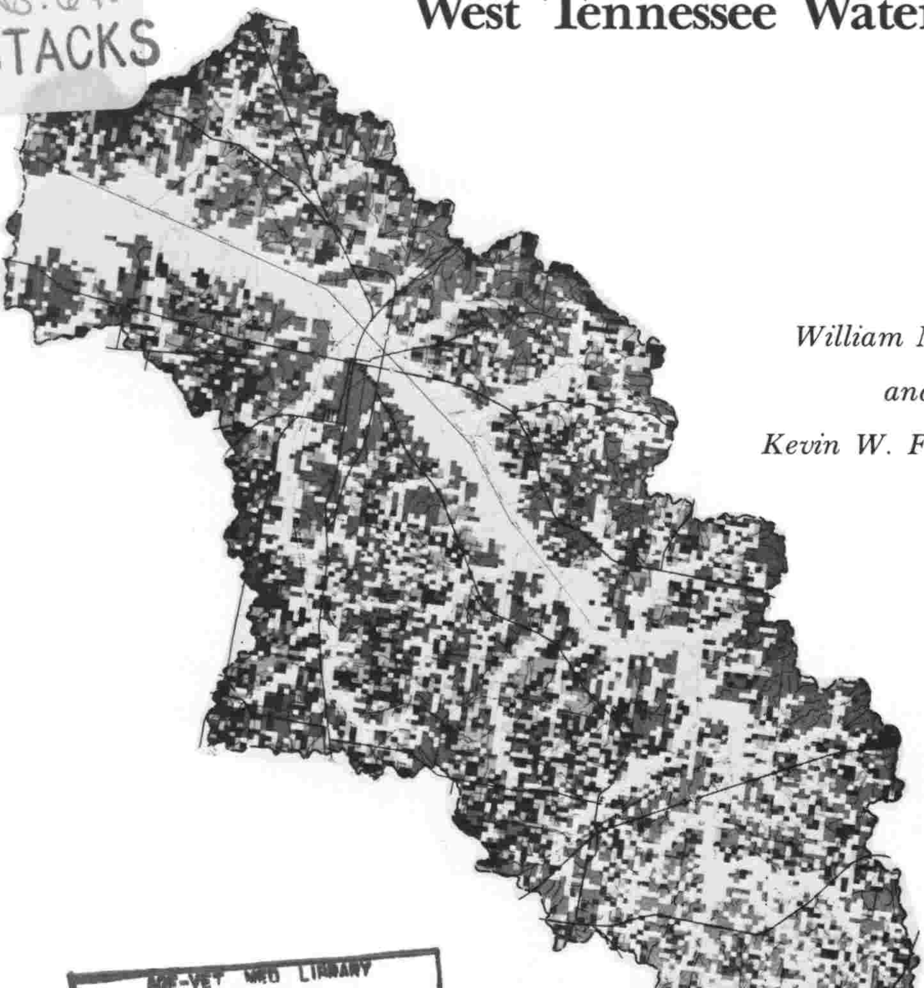

The University of Tennessee
Agricultural Experiment Station
Knoxville, Tennessee
D. M. Gossett, Dean

cover: derived from the USDA Soil Conservation Service map of the North Fork of the Forked Deer River Watershed within Gibson County, Tennessee—Map 4, Gross Erosion Upland.

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William M. Park
Associate Professor

Kevin W. Ferguson
Graduate Research Assistant

Department of Agricultural Economics and Rural Sociology
The University of Tennessee
Institute of Agriculture

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INTRODUCTION

The problem of soil erosion from our nation's cropland has been receiving increasing attention over the last decade. Concern has been expressed about the possible long-term impact on soil productivity and food costs [U.S.G.A.O., 1977a; Crosson and Scott], as well as the off-site impacts of sedimentation and water quality degradation [U.S.G.A.O., 1977b; Clark et al.]. Concern has also been expressed about the cost effectiveness of federal programs that provide technical and financial assistance to induce farmers to implement soil erosion control practices [U.S.G.A.O., 1983; American Farmland Trust].

The erosion problem is concentrated in particular areas of the country, one of which is West Tennessee. A 20-county, 6.8-million-acre area of West Tennessee was estimated to have almost 1.7 million acres of cropland eroding at greater than 5 tons per acre per year in 1982. These 1.7 million acres were estimated to have an average erosion rate of 19.0 tons per acre per year [USDA, 1984]. The 80,000-acre North Fork of the Forked Deer (NFFD) Watershed in Gibson County is fairly typical of much of the West Tennessee area. Analysis of yields for the major soil type in the watershed suggests that at the erosion rate noted above, soybean yields may decline by more than a bushel per acre over a 10-year period [Hunter and Keller]. Water quality data indicate the NFFD River experiences high levels of suspended solids and turbidity. Aquatic life and recreation criteria set by the EPA and the state of Tennessee have been exceeded for mercury, dieldrin, DDT, and phosphate. Land damage from sediment deposition has been estimated at $175,383 annually [USDA, 1980].

In recent years, a number of research studies have used primary survey data in attempting to identify personal, economic, and institutional factors that influence erosion rates, adoption of particular practices, or attitudes toward soil erosion. These studies have varied substantially in survey location, statistical approach, and specific variables employed, and as such, only a limited degree of consensus on the above relationships has developed. Additional studies of this type are needed if their findings are to be useful in providing guidance in the design and implementation of more cost effective programs for soil erosion control.

This report describes such a study on the NFFD Watershed. Following a discussion of the survey procedure and a description of the sample, findings from two types of statistical models are presented and discussed. The first type seeks to identify factors related to soil erosion control effort, while the second seeks to identify factors related to the expression of need for conservation practices.

SURVEY PROCEDURE AND SAMPLE CHARACTERISTICS

The population for the survey was chosen from a list obtained from the Agricultural Stabilization and Conservation Service (ASCS) of the approximately 850 farms units in the NFFD Watershed. From this list, every tenth unit was drawn, providing a random sample of 85 farm units. Of that sample, nine of the operators could not be interviewed for various reasons. Therefore, the final sample consisted of 76 farm units. Personal interviews of the operators of the 76 farm units were conducted in September 1982. Information was obtained on various characteristics of the operator, the unit selected, and their farm operation, particularly field basis information including soil type, slope, and crops grown, as well as tillage, planting, and conservation practices.

The total acreage of the 76 farm units was 4,648.6 acres. The average size of the units, as they were defined for purposes of the ASCS office, was 61.2 acres, though on the average these farmers operated an additional 448.0 acres as an owner or renter. A total of 1,870.4 acres were operated under rental arrangements on 36 of the farm units. The remaining 2,778.2 acres of the survey farms were operated by owners. It is interesting to note that the 1982 Census of Agriculture indicates that the average farm size in Gibson County is 226.0 acres. However, the census also reports that farms operated under the part-owner tenure (both owned and rented land) had an average size of 446.8 acres. This figure is comparable to the average total acreage operated by the farmers in the survey of 509.2 acres. Of the farmers in the survey, 60.5% operated both owned and rented land.

Operators were asked to provide information on a field basis indicating bottomland or upland, main soil type, slope class, use of the field, tillage and planting practices, and conservation practices on the farm unit selected. Bottomland comprised 19.7% of the land in the 76 farm units and was assumed to generate zero erosion in subsequent estimates of erosion rates. Five major soil types—Loring, Grenada, Memphis, Lexington-Rustin, and Calloway—were found to predominate in the watershed. The most common soil types indicated by the farmers were Loring and Grenada.

Operators were asked to estimate the slope of each upland field with reference to the slope classes generally used for West Tennessee, which are as follows:

1. Less than 2%
2. 2-5%
3. 5-8%
4. 8-12%
5. Greater than 12%.

One might expect farmers to underestimate the slopes of their fields, as at least one study has indicated that farmers underestimate the seriousness of their erosion problems relative to Soil Conservation Service assessments (Hoover and Wiitala). However, when the survey data for each slope class were compared to data for the entire NFFD Watershed (Table 1), it was found that operators apparently had a tendency to overestimate the slope on gently

Table 1. Comparison of Slope Class Estimates for the NFFD Watershed

	Survey Data		NFFD Watershed[a]
Slope Class	Number of Acres	Percentage of Upland	Percentage of Upland
Less than 2%	299.0	8.4	11.6
2-5%	1,953.1	54.7	51.2
5-8%	1,141.7	32.0	17.1
8-12%	159.5	4.5	11.5
Greater than 12%	17.0	0.5	8.6
Totals	3,570.3[b]	100.0	100.0

[a]USDA, 1980.

[b]This figure does not include 163.0 acres of upland for which farmers failed to indicate the slope of the field. The majority of this acreage was idle land not devoted to crops.

sloping land and underestimate the slope on steeply sloping land. The vast majority of upland in the 76 farm units (86.7%) was reported to be in slope classes 2 and 3, compared to 66.0% for the watershed.

A complete summary of the uses of the land on the selected farm units is included in Table 2. Cropland (soybeans, wheat, corn, cotton, and milo) accounted for 63.9% of the total acreage; pasture, hay, and idle land for 30.0%; and trees, buildings, and other uses, the remaining 7.1%. Single-crop soybeans were grown on 34.7% of the total acreage, double-cropped wheat and soybeans on 13.5%, and corn on 11.0%.

Operators were asked to describe the tillage and planting practices that were implemented on each of their cropland fields on the selected farm units. The major tillage practices used were the moldboard plow, the chisel plow, the offset disk, and no-till planting. Planting practices included conventional wide rows, narrow rows, grain drill, and no-till. The number of acres farmed under each combination of tillage and planting practices was determined for each major crop (Table 3).

Chisel plow/conventional rows was the most commonly used combination for single-crop soybeans; 46.6% of that crop was planted in that manner. Chisel/narrow rows was used on 17.0% of the soybean acreage, chisel/grain drill on 10.9%, and moldboard plow/conventional rows on 10.2%. On the selected farm units no single-crop soybean acreage was planted with a no-till planter. For double-cropped wheat and soybeans, the tillage and planting practice was disk/grain drill on 24.9% of the acreage, no-till on 17.2% of the acreage, chisel/conventional rows on 15.5% of the acreage, and moldboard/conventional rows on 14.1% of the acreage.

Findings with regard to soybean planting practices in the NFFD Watershed in 1982 can be compared to those from a 1981 study by Morris et al. of West Tennessee soybean producers. The proportion of double-cropped soybeans was nearly the same in the two surveys, between 25 and 30%. Morris

Table 2. Use Distributions of Survey Acreage in the NFFD Watershed for 76 Operators in 1982

Use	Number of Acres	Percentage
Cropland	2,972.1	63.9
Pasture, hay, and idle	1,347.0	29.0
Trees, buildings, and other	329.5	7.1
Total	4,648.6	100.0
Soybeans	1,610.7	34.7
Pasture	826.3	17.8
Wheat/soybeans	625.6	13.5
Corn	511.1	11.0
Trees	299.5	6.4
Hay	266.7	5.7
Idle	254.0	5.5
Cotton	120.0	2.6
Vegetables	40.4	0.9
Wheat	34.3	0.7
Milo	30.0	0.7
Buildings and other uses	30.0	0.7
Total	4,648.6	100.0

categorized soybean acreage (single-crop and double-crop) according to planting practices, including row crop, grain drill, no-till, and broadcast. Morris reported that 76.8% of the soybeans in the West Tennessee study were planted as row crops, 11.0% were planted by grain drill, 11.7% were planted by no-till, and 0.4% were broadcast. Information from the NFFD Watershed survey indicated that 69.4% of the total soybean acreage was planted in row crops, 23.6% was planted by grain drills, 4.8% was planted by no-till and 2.2% was broadcast. Though confidence intervals on the estimates in both studies are relatively wide, it does appear that a higher proportion of soybeans was planted with grain drills, and a lower proportion was row cropped or no-tilled in the NFFD Watershed in 1982 as compared to West Tennessee as a whole in 1981. Though data on primary tillage are not strictly comparable, practices in the NFFD Watershed and West Tennessee as a whole appear to be relatively consistent.

The NFFD Watershed survey also provided information about characteristics of the operators and their farming operations. Approximately 36.8% of the operators were 60 years of age or older; the average age of the farm operators was 52.5 years. The 1982 Census of Agriculture reports that the average age of farmers in Gibson County, Tennessee (where the NFFD Watershed is located), was 51.6 years. The 76 operators in the study had been farming an average of 28 years; the minimum amount of farming experience was 3 years and the maximum was 52 years. Farming provided more than 75% of family income for 57.9% of these farmers; on the average, 62% of the operators' family incomes came from farming. About 26% of the

Table 3. Tillage and Planting Practices for Survey Cropland Acreage in the NFFD Watershed for 76 Operators in 1982

Crop	Practice	Number of Acres	Percentage
Soybeans (single-crop)	Moldboard plow/conventional rows	164.3	10.2
	Moldboard plow/grain drill	68.0	4.2
	Chisel/conventional rows	750.5	46.6
	Chisel/narrow rows	273.9	17.0
	Chisel/grain drill	175.0	10.9
	Disk/conventional rows	55.0	3.4
	Disk/narrow rows	62.0	3.8
	Disk/grain drill	62.0	3.8
	No-till	0.0	0.0
	Totals	1,610.7	100.0
Wheat/soybeans[a] (double-crop)	Moldboard plow/conventional rows	88.2	14.1
	Chisel/conventional rows	97.0	15.5
	chisel/grain drill	67.0	10.7
	Disk/conventional rows	60.0	9.6
	Disk/grain drill	156.0	24.9
	Disk/broadcast	50.0	8.0
	No-till	107.4	17.2
	Totals	625.6	100.0
Corn	Moldboard plow/conventional rows	138.4	27.1
	Chisel/conventional rows	237.7	46.5
	Disk/conventional rows	135.0	26.4
	No-till	0.0	0.0
	Totals	511.1	100.0
Cotton	Moldboard plow/conventional rows	53.0	44.2
	Chisel/conventional rows	55.0	45.8
	Disk/conventional rows	12.0	10.0
	Totals	120.0	100.0

[a]Tillage and planting practices are for soybeans.

operators indicated that less than 25% of their family income came from farming. Some form of formal education beyond high school had been obtained by 21.1% of the farmers.

Based on the survey, 49.3% of the operators owned beef or dairy cattle. The 1982 Census reports that 48.6% of the farmers in Gibson County owned beef or dairy cattle. No-till planters were owned by 24.0% of the operators, grain drills by 38.7%, and haying equipment by 34.7%. Anticipation of selling their land or changing current lease arrangements within the next 5 years was expressed by 18.7% of the operators.

The operators were asked to identify conservation practices used on the selected farm unit, the need for new or additional practices on the selected farm unit, their knowledge of conservation programs, and their source of information on conservation measures.

Some form of conservation practice was in use on 47.4% of the survey farms. The most commonly used conservation practices indicated by the operators were "crop residue left on the surface" and "winter cover crop" followed by "debris basins" and "terraces." However, 61.8% of the operators expressed a need for one or more new or additional conservation measures on their farms, choosing from a list of 13. "Terraces" were indicated as needed by 44.7% of the farmers, "debris basins" by 39.5%, "diversions" by 15.8%, "permanent vegetative cover" by 11.8% and "no-till planting" by 9.2%. The most common important obstacles to implementing these needed conservation measures were reported to be "too expensive" and "ownership problems." Additional options in the question were "lack of livestock enterprises," or operators could specify other obstacles.

"Quite a bit" or "some" knowledge about the regular Agricultural Conservation Program administered by the Gibson County ASCS office was expressed by 56.6% of the operators. However, only 30.3% of the operators indicated "quite a bit" or "some" knowledge about the special project of the Agricultural Conservation Program on the NFFD Watershed. SCS soil conservation plans were established on 11.8% of the farm units. Of the operators, 64.5% had talked with SCS personnel in the past five years about conservation techniques. During that same time span, 32.4% of the operators had talked with cooperative Extension personnel about conservation practices. To gain a better understanding of farmers' attitudes toward certain conservation policy options, operators were asked their opinion of the statement "a farmer should be required to follow recommended soil conservation practices on his farm to qualify for price and income support programs." This statement was "strongly agreed" to or "agreed" to by 46.1% of the operators.

The primary purpose of the information on the physical features of the operators' fields as well as their crop, tillage, planting, and erosion control practices was to estimate both the average erosiveness and the average erosion rate for each farm unit by means of the Universal Soil Loss Equation [Wischmeier and Smith]. The equation, which predicts the average erosion rate in tons of soil per acre per year, takes the form $A = RKSLCP$.

The erosiveness measure was calculated as the product of the physical factors R, K, L, and S. The rainfall and runoff factor (R) for the NFFD Watershed is 250. Soil erodability factors (K) were obtained for the following major soil types indicated by the operators: Loring = .37, Grenada = .43, Memphis = .40, Lexington-Rustin = .40, and Calloway = .43. Data on the slope length (L) for each field were unavailable, so the typical slope length for the NFFD Watershed of 100 feet was used, based on communication with SCS personnel in Gibson County. Slope classes (S) generally used for West Tennessee are as follows:

1. Less than 2% (midpoint = 1.0)
2. 2-5% (midpoint = 3.5)
3. 5-8% (midpoint = 6.5)
4. 8-12% (midpoint = 10.0)
5. Greater than 12% (midpoint = 14.0).

This measure provided a basis for addressing the question: "Who operates the more highly erosive land?" Contrary to some hypotheses, and perhaps conventional wisdom, there was no statistical evidence (.10 level) that the more highly erosive land was associated with any particular type of operator or farm—for example, smaller farms, younger operators, or rented acreage.

The cover and management factor (C) and the conservation support practice factor (P) reflect the effect of operator decisions on the erosion rate. The C-factor is the ratio of soil loss from a field in a particular crop rotation and tillage practice to that from a field in clean-tilled continuous fallow. The C-factor ranges from around .010 for a good grass cover to around .300 to .400 for conventional tillage soybeans, cotton, or corn. Thus, for a given field, the USLE predicts 30 to 40 times as much soil loss from conventional tillage row crops as from a hay field or pasture. The average C-factor for the farm units surveyed was .155, with a range from .019 to .373. The P-factor is the ratio of soil loss from a field with a specific support practice (contouring, terracing, or strip cropping) to that lost from a field plowed up and down the hill. Terraces have a P-factor value of 0.5 for most slopes, implying soil loss would be half as much with terraces compared to plowing up and down the hill. The average P-factor for the farm units surveyed was .981, with a range from .662 to 1.000.

Based on use of the full USLE and assuming the erosion rate for bottomland and forestland to be zero, the average erosion rate for the 72 farm units for which estimates could be made was 5.9 tons per acre per year, with a range of 0.0 to 38.9. However, for the 59 farms with upland cropland, the average erosion rate for upland cropland was estimated to be 10.0 tons per acre per year, with a range of 1.5 to 53.7. This can be compared to an average erosion rate of 13.6 tons per acre per year for cropland eroding at greater than 5 tons per acre per year in Gibson County as a whole, based on the 1982 Natural Resources Inventory. If upland cropland eroding at less than 5 tons per acre per year were included, this Gibson County figure would be somewhat lower, probably around 12 tons per acre per year.

Much of the survey information presented above was transformed into explanatory variables used in one or both of the statistical models to be discussed later. Definitions and statistical characteristics of these variables are presented in Table 4 to avoid redundancy for those used in both models.

Before turning to the first of the two statistical models, a comment about findings is in order. Where possible in the preceding discussion, comparison has been made between findings from the NFFD Watershed survey and data from the 1982 Census of Agriculture or the 1981 survey of soybean producers in West Tennessee by Morris. Generally, findings from the NFFD Watershed survey are reasonably consistent with data from these other sources. However, conclusions drawn from the information presented above and the results of the statistical analyses to follow can be generalized to Gibson County and to West Tennessee as a whole with only a limited degree of confidence.

MODELING SOIL EROSION CONTROL BEHAVIOR OF OPERATORS

A number of recent empirical studies have sought to identify factors associated with soil conservation behavior on the part of farmers. Some studies have focused on adoption of conservation practices in general [Hoover and Wiitala; Bultena and Hoiberg; Nowak and Korsching] or the number of practices adopted [Carlson et al.; Ervin and Ervin]. Other studies have focused on adoption of particular practices such as structural measures [Young and Shortle] and conservation tillage or no-tillage methods [Lee and Stewart; Korsching et al.; Jamnick and Klindt]. Ervin and Ervin [1982] estimated models for several specific practices. Another set of studies have investigated the influence of tenure on erosion rates [Lee, 1980; Ervin; Bills] and adoption of conservation tillage [Ervin; Lee, 1983]. Finally, two studies have used the C and P factors of the USLE to represent soil conservation effort in a more general way [Ervin and Ervin; Saliba and Bromley].

The models of soil erosion control effort estimated in this study are highly comparable with these last two studies, by virtue of the use of essentially the same dependent variables. Following discussion of these two recent studies, the statistical models are specified, results are presented and conclusions and policy implications are drawn.

Review of Comparable Studies

Ervin and Ervin used information from a 1978 survey of Missouri farmers (owner-operators only) to estimate statistical models developed to explain variation in three alternative dependent variables: perception of degree of erosion problem, number of soil conservation practices, and soil con-

Table 4. Definitions and Statistical Characteristics of Variables Used in Statistical Models

Variable	Definition[a]	Mean	Standard Deviation	Minimum	Maximum
Postsecondary education	0 if none; 1 if any	.21	.41	0	1
Years farmed	—	27.9	13.5	3	52
Use of conservation practices	0 if used; 1 if at least one used	.49	.50	0	1
Need of conservation practices	0 if none expressed; 1 if need for at least one expressed	.62	.49	0	1
Feeling toward cross-compliance	0 if disagreed; 1 if no opinion[b] or agreed	.62	.49	0	1
Owner-operator	0 if rented; 1 if owned	.53	.50	0	1
Soil conservation plan	0 if no for farm unit; 1 if yes	.12	.33	0	1
Knowledge of NFFD special project	0 if none or little; 1 if some or a lot	.30	.46	0	1
Total acres farmed	In total, not just on selected farm unit	509	600	6	3,553
Net income percentage from farming	12, 37, 62, and 87, representing quartile ranges in survey question	62	33	12	87
Plans to sell or change rental arrrangements within five years	0 if no; 1 if yes	.18	.39	0	1
Existence of a livestock enterprise	Anywhere, not just on selected farm unit; 0 if none; 1 if any	.49	.50	0	1
Ownership of a no-till planter	0 if no; 1 if yes	.24	.43	0	1
Ownership of a grain drill	0 if no; 1 if yes	.39	.49	0	1
Erosiveness	R × K × S × L from USLE; weighted average for whole-farm unit	41.3	30.9	0	147.3
Erosion rate	C × P × R × K × S × L from USLE; weighted average for whole-farm unit	5.6	6.1	0	39.2

[a]Unless otherwise noted, responses apply to the farm unit selected for the survey only.
[b]The no opinion category had 16% of the response.

servation effort. The latter variable, abbreviated as EFFORT, is of most interest here. EFFORT was defined as "the difference between the estimated farm erosion rate without conservation practices and that rate reflecting sample information on practices used" [Ervin and Ervin, p. 282]. The erosion rates were based on the USLE. Four categories of factors were hypothesized to influence EFFORT: physical, personal, economic, and institutional. Of the 15 explanatory variables included in the multiple regression analyses, 5 were significant at the .10 level or lower. EFFORT was found to be positively related to erosion potential (based on SCS ratings on a scale of one to three), education, preception of degree of erosion problem, and the percentage of owned cropland that received cost sharing. EFFORT was found to be lower for cash grain farms.

Saliba and Bromley used information from a 1983 study of Wisconsin farmers (owner-operators only) to estimate three models with the dependent variables based on the USLE: the C-factor, the P-factor, and the C-factor times the P-factor. The dependent variable CxP is essentially the same as Ervin and Ervin's EFFORT variable. Though it is difficult to tell from their description, EFFORT appears to be $(R \times K \times L \times S \times C_{max} \times P_{max})-(R \times K \times L \times S \times C_{actual} \times P_{actual})$, where R, K, L and S represent the influence of rainfall, soil type, length of slope, and slope on the erosion rate. Since C_{max} and P_{max} are equal to one, this reduces to $R \times K \times L \times S(1-C_{actual} \times P_{actual})$. Thus, the only difference between EFFORT and Saliba and Bromley's CxP variable is in EFFORT the product of the C-factor and P-factor is weighted by the inherent erosiveness of the land so that erosion control is measured in absolute rather than relative terms.

Saliba and Bromley employed a logit transformation of the dependent variables to force predicted values to fall between zero and one. Five categories of explanatory variables (financial, farm type, land, owner, and location) are included in their generalized least square regressions. Dairy farms had a lower CxP value (meaning a lower erosion rate). A higher degree of erosion hazard was also associated with lower CxP values. These same variables were also highly associated with lower P-factor values alone. However, greater total income and a stronger opinion that erosion reduces crop yields were also associated with lower P-factor values. On the other hand, the land variables were much less significant in explaining variation in C-factor values. Opinions regarding erosion and yields were not significant at all. Dairy and other livestock farms had lower C-factor values, while a higher debt-asset ratio was associated with higher C-factor values.

Specification of Statistical Models

In this study, as in Saliba and Bromley [1984], three alternative dependent variables were employed: the C-factor, the P-factor, and CxP. Use of the CxP variable focused on the total influence that operators have over erosion rates. Use of the C-factor and P-factor separately allowed consideration of whether different factors appear to influence crop and tillage decisions as distinct from decisions to employ practices such as terracing, which are the most common practice affecting the P-factor value in the study area.

For more meaningful interpretation of the coefficients of various explanatory variables, it would have been preferable to have a dependent variable in terms of average erosion rates rather than CxP. However, as Ervin and Ervin pointed out, statistical estimation problems arise if USLE factors are used as both an explanatory variable to reflect erosiveness and as the dependent variable. Ervin and Ervin opted to use a less precise variable to reflect erosiveness in order to keep the dependent variable in terms of erosion rates. In this study the other option was taken, i.e., to use a more precise variable to reflect erosiveness and leave the dependent variable as CxP. Interpretation of coefficients in terms of erosion rates is then provided as an additional step in the analysis.

Following Ervin and Ervin, explanatory variables representing four categories of factors were included. Personal variables included education, years farmed, expression of need for additional conservation practices, and feeling toward cross-compliance. Economic factors used as variables included total acres farmed, net income percentage from farming, plans to sell or change rental arrangements, existence of a livestock enterprise, ownership of a no-till planter, and ownership of a grain drill. Institutional factors included tenancy (owner-operator or not) and cooperation with SCS to the extent of having a soil conservation plan. Physical factors were represented by the erosiveness variable defined earlier.

Results from the Models

Multiple regression analyses by ordinary least squares were performed for the three models. The results are presented in Table 5, along with the hypothesized sign for each variable based on the literature cited earlier and the authors' logic. The R^2 statistics for the models are comparable with those from both Ervin and Ervin and Saliba and Bromley.

For the C-factor model, years farmed, existence of a livestock enterprise, and ownership of a no-till planter were significant with the expected signs. However, percentage of net income from farming was significant with the opposite sign from what was expected. As the percentage of income from farming increases, the C-factor increases. A reasonable explanation for this would be that operators with off-farm income sources have a higher opportunity cost of time and thus may find reduced tillage or no-tillage methods advantageous. Of interest too is the fact that having a soil conservation plan and particularly erosiveness are not significant at all in explaining variation in the C-factor. This is consistent with what is becoming a widely held hypothesis, that reduced tillage decisions are being made by operators on the basis of short-term economic considerations (i.e., fuel and labor costs) as opposed to long-term soil conservation considerations

Table 5. Results of Regression Analysis of Factors Associated with Erosion Control Behavior in the NFFD Watershed for 76 Operators in 1982

		Dependent Variables[a]					
		C[b]		P[c]		C×P[d]	
Explanatory Variables	Hypothesized Signs	Coefficient (× 10^{-3})	T-ratio	Coefficient (× 10^{-3})	T-ratio	Coefficient (× 10^{-3})	T-ratio
Personal							
Postsecondary education	−	15.854	.56	−2.621	−.12	14.733	.55
Years farmed	−	−1.292	−1.57*	−.600	−.94	−1.501	−1.92**
Need for conservation practices	+	13.027	.62	11.867	.73	17.650	.89
Feeling toward cross-compliance	−	.222	.01	6.425	.35	1.167	.05
Economic							
Total acres farmed	−	.015	.69	−.007	−.41	.014	.69
Net income percentage from farming	−	.856	1.95*	.558	1.63*	.995	2.39**
Plans to sell or change rental arrangements	+	−23.586	−.92	16.495	.83	−17.923	−.74
Existence of a livestock enterprise	−	−83.211	−4.00**	3.798	.23	−82.680	−4.19**
Ownership of a no-till planter	−	−44.053	−1.36*	27.990	1.11	−38.429	−1.25
Ownership of a grain drill	−	5.440	.24	−40.841	−2.28**	−4.815	−.22
Institutional							
Owner-operator	−	3.011	.12	27.748	1.26	8.304	.35
Soil conservation plan	−	21.541	.67	−48.950	−1.95**	12.740	.42
Physical							
Erosiveness	−	.097	−.31	−.874	−3.60**	.337	1.14
R^2		.27		.33		.31	

*Significant at .10 level.
**Significant at .05 level.
[a]Levels of C, P, and C×P are directly related to erosion rates. Thus, if a coefficient is negative, an increase in the variable is associated with a decrease in the erosion rate.
[b]Cover and management factor in Universal Soil Loss Equation: mean, .155; range, .019 to .373.
[c]Conservation support practice factor in Universal Soil Loss Equation: mean, .981; range, .662 to 1.000.
[d]Cover and management factor and conservation support practice factor in Universal Soil Loss Equation: mean, .152; range, .019 to .373.

[Crosson; Cook]. Interpretation of the coefficients of these variables can be converted into terms of average erosion rate for a farm (tons per acre per year, or TAY) by assuming all other USLE factors at their means for the sample (RKLS = 43.96 and P = .98). While the average erosion rate for all farms was 5.97 TAY, having a livestock enterprise was associated with a 3.58 TAY lower erosion rate; having a no-till planter, a 1.90 TAY lower erosion rate; having farmed 10 more years, a .56 TAY lower erosion rate; and having 25% more of net income from farming, a .92 TAY higher erosion rate.

For the P-factor model, having a soil conservation plan and erosiveness were significant with the expected signs. Net income percentage from farming was again significant, but with a positive sign. A reasonable explanation in this case may be that income from an off-farm source is available for investment in terraces. Having a grain drill was negatively associated with the P-factor, though it is unclear why this might be expected. Of most interest with regard to the P-factor model is the significance of having a soil conservation plan and erosiveness, in contrast to the cases of the C-factor model. It would appear decisions regarding the use of terraces and similar practices are based on long-term soil conservation considerations and the influence of technical assistance efforts on the part of SCS personnel. Interpretation of the coefficients in terms of farm erosion rates (assuming RKL S = 43.96 and C = .14) indicates that having an SCS farm plan is associated with a .30 TAY lower erosion rate; having 25% or more of total income from farming, a .09 TAY higher erosion rate; and having a 10 TAY greater potential erosion rate, a .36 TAY lower erosion rate.

For the CxP model, years farmed and existence of a livestock enterprise were significant with the expected signs, while net income percentage from farming was again significant with a positive sign. Significance of other variables was apparently obscured by using a combination of the C and P factors. Interpretation of the coefficients of these three variables is similar to that for the C-factor model.

Conclusions and Policy Implications

To increase cost effectiveness, various modifications in soil erosion control policy are being experimented with or seriously considered. Among them are targeting, variable cost sharing, rental payments, increased technical assistance, and regulatory measures. Increased understanding of factors influencing farmers' decisions concerning crop, tillage, and erosion control practice is needed as a basis for policy decisions. The findings from the above models, together with those of recent studies, can help to provide such an increased understanding.

Though Ervin and Ervin's EFFORT variable reflected the combined effect of the C and P factors, their results were consistent with those of this study. The significance of erosion potential, cash grain farm, and cost sharing in their model corresponds with that of erosiveness, existence of a livestock enterprise, and having a soil conservation plan in this study.

Comparison with Saliba and Bromley's findings reflects consistency as well. The significance of income and erosiveness variables in their P-factor model corresponds with that of net income percentage from farming and erosiveness in this study. The significance of livestock variables and the much weaker significance of erosiveness variables in their C-factor model corresponds with the significance of existence of a livestock enterprise and lack of significance of erosiveness in this study.

Of most interest among the findings of this study is the difference in factors associated with the C-factor versus the P-factor. The findings as to factors related or unrelated to farmers' tillage decisions have important policy implications for 1) the use of information/education as opposed to financial assistance and 2) what advantages are emphasized in information/education efforts. The relationship between having a livestock enterprise and the C-factor is consistent with the observed difficulty of inducing conversion of highly erosive, marginal cropland to permanent cover on cash grain farms with no livestock enterprise. The significance of having a soil conservation plan and of erosiveness for the P-factor does provide evidence of the influence of erosion potential and technical and financial assistance on the use of terraces and similar practices. In addition, the indication that operators with greater off-farm income percentages have lower C and P values has implications for targeting efforts toward full-time versus part-time operators. Noteworthy too is the absence of any identifiable association between personal variables such as post-secondary education, expression of need for additional conservation practices, and feeling toward cross-compliance, as well as total acres farmed, tenancy status, and erosion control behavior.

MODELING OPERATORS' EXPRESSION OF NEED FOR CONSERVATION PRACTICES

The preceding section of this report presented a model of how farm and farmer characteristics are associated with soil erosion control effort. However, Ervin and Ervin [1982] noted that prior to adoption of specific conservation practices or a generalized effort to reduce soil erosion, the producer must recognize the problem and the need to do something about it. Only a few studies have attempted to address the question of factors influencing farmers' perceptions regarding soil erosion as a problem needing attention. Seitz and Swanson [1980] mention four studies that provide very limited evidence regarding important factors. One of those four, Hoover and Wiitala [1980], found that farmers' perceptions of the degree of their erosion problem were much lower than that of local SCS personnel. However, younger farmers and those who had resided on their farms for a shorter period of time were more likely to perceive a soil erosion problem where SCS personnel said one existed. In addition, operators already using conservation practices were more likely to express a need for additional practices. Ervin and Ervin [1982] found only erosion potential and education to be strongly related to farmers' perception of degree of erosion problem.

If technical and financial assistance are to be effective in inducing farmers to reduce soil erosion, we must develop a better understanding of what influences farmers' perception that they have a problem that needs attention. Unless farmers are predisposed in this way, they will be unreceptive to such assistance. With a better understanding of important factors, information and education programs could conceivably be better designed in terms of content and better targeted to specific groups.

Specification of Statistical Model

Farmers' expression of need for conservation practices was represented in this study as a binary (0,1) variable equal to one if the operator expressed a need for conservation practices on the farm unit (beyond practices currently being used) and equal to zero if such a need was not expressed. Several recent studies have demonstrated the usefulness of the logit model where the dependent variable is a binary variable. Young and Shortle [1984] employed the logit model in their investigation of factors influencing investment in conservation structures. Jamnick and Klindt [1985] represented the adoption of no-tillage practices by means of the logit model. Capps and Kramer [1985] analyzed food stamp participation with the logit model and provided a comparison of the logit model with other binary or qualitative choice models.

The logit model is based on the cumulative logistic probability function. This model allows for transformation of the linear probability model in a manner that predictions will lie in the (0,1) interval. "One important appeal of the logit model is that it transforms the problem of predicting probabilities within a (0,1) interval to the problem of predicting the odds of an event occurring within the range of the entire real line" [Pindyck and Rubinfeld]. The transformation of the logit model allows the dependent variable to become the natural logarithm of the odds that a choice will be made. The form of the logit model is as follows:

$$\ln \frac{P_i}{1-P_i} = a + BX_i$$

where:

P_i = the probability that an event will occur
a = intercept
B = slope
X_i = explanatory variable.

The logit model parameters in this study were estimated by means of maximum likelihood estimation. Maximum likelihood estimation of the logit model produces asymptotically best linear unbiased estimates of the coefficients [Judge et al.].

Following Ervin and Ervin [1982], the independent variables hypothesized to be related to expression of need can be categorized as personal, institutional, economic, and physical. Personal variables included those representing postsecondary education, years farmed, feeling toward cross-compliance and current use of conservation practices. Economic variables included total acres farmed, net income percentage from farming, plans to sell or change rental arrangements, and existence of a livestock enterprise. Institutional variables represented tenancy (owner-operator or not), existence of a soil conservation plan, and knowledge of the special project on the NFFD Watershed. Physical factors were represented by the estimated erosion rate for the farm unit.

Results from the Model

The findings from the logit model used in this analysis are presented in Table 6, along with hypothesized signs based on the literature cited earlier and the authors' logic. The usual F test for testing the significance of coefficients is replaced by the likelihood ratio test, which follows a chi-square distribution in logit analysis using maximum likelihood estimates [Pindyck and Rubinfeld]. The likelihood ratio test indicates whether the amount of variation explained by the model is significantly different from zero. The test statistic for the model was 34.76, which is significant at the 0.01 level. Of the 12 independent variables in the logit model, 8 were significant at the 0.10 level or lower. However, three of these significant variables (feeling toward cross-compliance, existence of a livestock enterprise, and net income percentage from farming) exhibited opposite signs from those hypothesized.

With regard to feeling toward cross-compliance, it was hypothesized that farmers who agreed with the statement "a farmer should be required to follow recommended conservation practices on his farm to qualify for price and income support programs" would be more likely to express a need for soil conservation practices. The actual relationship was found to be negative, indicating that those operators who agreed with the statement were less likely to express a need for conservative practice. Perhaps those operators who agreed with the statement had already recognized a problem and applied soil conservation practices, or perhaps they do not recognize any erosion problem of their own and feel free to take a hard line on cross-compliance. With regard to existence of a livestock enterprise, it was hypothesized that an operator who owned beef or dairy cattle would be less likely to express a need for soil conservation practices. An explanation for the actual relationship being positive may be that livestock farmers who likely have some land in pasture or hay have pursued animal enterprises because they were initially more sensitive to erosion problems. With regard to net income percentage from farming, it was also hypothesized

Table 6. Results of Logit Analysis of Expression of Need for Conservation Practices in the NFFD Watershed by 76 Operators in 1982

Explanatory Variables[a]	Hypothesized Signs	Coefficient	T-statistic
Intercept		−0.340	−0.215
Personal			
Postsecondary education	+	−0.046	−0.049
Years farmed	+	0.044	1.507*
Feeling toward cross-compliance	+	−3.245	−3.085**
Use of conservation practices	+	0.339	0.461
Economic			
Total acres farmed	+	0.003	2.704**
Net income percentage from farming	+	−0.031	−1.739*
Plans to sell or change rental			−0.397
arrangements	−	−0.316	2.393**
Existence of a livestock enterprise	−	1.920	
Institutional			
Owner-operator	+	1.030	1.027
Soil conservation plan	−	−2.049	−1.392*
Knowledge of NFFD special project	+	2.621	2.389**
Physical			
Erosion rate	+	0.107	1.596*

*Significant at the 0.10 level.
**Significant at the 0.05 level.
[a]Dependent variable is zero if operator expressed no need for additional conservation practices and one if need for at least one was expressed.

that operators with a larger percentage of family income coming from farming would be more likely to express a need for conservation practices. Perhaps those who rely on farming for most of their family income have already implemented needed practices to protect that income.

Of those variables that were not significant, the use of conservation practices and tenancy status are of most interest. The lack of a significant, positive association between current use of conservation practices and expression of need for conservation practices suggests that some operators may not express a need for more conservation practices because they already have implemented some. There is weak support for the hypothesis that owner-operators would be more likely to express a need for conservation practices, but the lack of strong support suggests that owner-operators may have already implemented practices they believe they need.

Another factor to consider in assessing significance levels and attempting to make sense of the model's results is the possible interaction among some of the independent variables. One would expect feeling toward cross-compliance and use of conservation practices to be related to one another and to other variables like soil conservation plan and erosion rate. In addition, existence of a livestock enterprise may be related to erosion rate, while net income percentage from farming may be related to total acres farmed. However, since several of these variables are (0,1) in nature, assessing problems of multicollinearity is difficult.

Interpretation of the coefficients of significant variables in Table 6 is somewhat difficult, given the transformation noted earlier that must be made. Thus, impacts of changes in the significant variables on the predicted probability of a farmer expressing a need for conservation practices are presented in Table 7. Binary variables are assumed to change from zero to one, continuous variables from one-half standard deviation below their mean to one-half standard deviation above. All other variables are assumed to be at their mean (if continuous) or at whichever of zero or one is closest to their mean (if binary). With this information a better sense of the relative importance of the variables can be gained.

Several measures of goodness-of-fit to sample data are appropriate for

Table 7. Interpretation of Coefficients of Significant Variables from Logit Analysis

Variable Groups and Name	Mean[a]	Change in Value of Variable[b]	Change in Probabilities of Expression of Need for Conservation Practices[c]
Personal			
Years farmed	27.9	21.1 to 34.7	.19 to .30
Feeling toward cross-compliance	1	1 to 0	.25 to .89
Economic			
Total acres farmed	509.2	209.1 to 809.3	.12 to .44
Net income percentage from farming	62.0%	45.7% to 78.3%	.35 to .16
Existence of a livestock enterprise	0	0 to 1	.25 to .69
Institutional			
Soil conservation plan	0	0 to 1	.25 to .04
Knowledge of NFFD special project	0	0 to 1	.25 to .80
Physical			
Erosion estimate	5.59	2.55 to 8.63	.19 to .31

[a]Closest of zero or one to the mean for binary variables.
[b]Change is from zero to one for all binary variables and from one-half standard deviation below the mean to one-half standard deviation above the mean for continuous variables.
[c]Assuming all other variables at their mean (if continuous) or at whichever of zero or one is closest to their mean (if binary).

the logit analysis including Efron's R^2 and McFadden's R^2. "The former is the squared correlation coefficient between the binary dependent variable and the predicted probabilities. The latter is expressed as 1-(1(BML)/10), where 10 is the value of the log likelihood function subject to the constraint that all regression coefficients except the constant term are zero, and 1(BML) is the maximum value of the log likelihood function without constraints" [Capps and Kramer].

Efron's R^2, which measures the overall fit of the model, had a value of 0.415. This indicates that 41.5% of the total variation in the dependent variable is explained by the model explanatory variables. The value for McFadden's R^2 was found to be 0.344, which indicates that 34.4% of the variation was explained by the model. In a study using logit analysis, Capps and Kramer [1985] found that the value for McFadden's R^2 is generally less than Efron's R^2. These R^2 values are comparable to similar studies of this nature using logit analysis. Capps and Kramer [1985] note that "dichotomous dependent variable models are not likely to yield R^2's too close to 1 . . . [their] upper limit is likely to be substantially less than 1."

Another measure of the goodness-of-fit of the logit model involves the correct classification of the farmers in the sample regarding their expressed need for conservation practices. This classification procedure uses the explanatory variables of each operator in the estimated model to predict the probability that the operator will express a need for conservation practices. If the probability obtained is greater than 0.5, the operator is predicted to express a need for conservation practices. If the probability is less than 0.5, the operator is predicted not to express a need for conservation practices. If the operator's predicted choice matches the actual choice, then it is correctly classified. The model used in this study correctly classified 85.5% of the operators. This particular model was more efficient in classifying those that expressed a need for conservation practices (91.5% were correctly classified) than those not expressing such a need (only 75.9% were correctly classified).

Conclusions and Policy Implications

Definitive conclusions are difficult to derive from a single study such as this. However, together with findings from other similar studies, those reported here should be helpful in making progress toward a better understanding of what factors influence farmers' perception regarding erosion problems and expression of a need for conservation practices. Effectiveness of information/education approaches may be improved and bases for targeting technical or financial assistance may be identified. The findings of this study suggest publicity regarding special erosion control projects can increase farmers' recognition of their need for conservation practices and that having a soil conservation plan generally leads to implementation of practices sufficient to eliminate the need for further practices. As far as targeting goes, the findings suggest that larger farmers, those with livestock enterprises, those who have been farming a long time, and those with higher erosion rates were more likely to express a need for conservation practices. Thus, farmers with these characteristics may be more responsive to efforts to provide technical and financial assistance.

SUMMARY OF CONCLUSIONS

The general survey information was consistent with more aggregate data in confirming several significant trends having to do with farm size, leasing, off-farm income, and tillage/planting practices. Operators of the selected farm units operated a total of 509 acres on average. Tenure arrangements involved leasing or renting on 47.4% of the farm units and 40.2% of the land. Over 26% of the operators received less than 25% of their income from farming. Many operators employed reduced or conservation tillage and less erosive planting practices as compared to what was conventional just a few years before, though the C-factor model results suggest this trend is related as much or more to short-term budget considerations than to long-term soil erosion considerations.

The general survey information also indicated that conservation practices were in use on 47.4% of the farm units, though need for additional practices was expressed by 61.0% of the operators. The most important obstacles to implementing additional soil conservation practices were identified as expense and ownership problems. The concept of cross-compliance, that "operators should be required to follow strict conservation practices in order to qualify for price and income supports," was agreed with by 46.1% of the operators. Finally, there was no strong evidence to support hypotheses that the most erosive land is associated with particular types of operators or farms—for example, smaller farms, younger operators, or rented acreage.

In summarizing the conclusions from the statistical models that were estimated, attention is given first to variables that were significant in at least one of the USLE factor models and the expression of need model. Having an animal enterprise and having farmed more years were associated with a lower C-factor and a higher probability of need. Having a greater percentage of income from farming was associated with higher C and P factors and a lower probability of need, which were unexpected results. Having an SCS conservation plan was associated with a lower P-factor and a lower probability of need.

Several variables were significant only in the expression of need model. Agreeing with the concept of cross-compliance was associated with a lower probability of need. Operating a greater number of acres, having knowledge about the special water quality project in the NFFD Watershed, and having a higher average erosion rate were associated with a higher probability of need.

In the USLE factor models, the inherent erosiveness of the land was associated with a lower P-factor but had no significant association with the C-factor. These findings are consistent with those of similar studies in recent years and provide the basis for the earlier statement about the motivation for reduced or conservation tillage/planting practices. Of particular interest, too, with regard to the USLE factor models, is the lack of any significant association between tenure arrangements and these factors.

These findings have important implications for soil erosion control policy, particularly the use of information/education, technical assistance, and financial incentives. They suggest that each of these have their place in the process of stimulating awareness of an erosion problem and motivating action to deal with it. They suggest that reduced or conservation tillage recommendations should be made with reference to short-term budget considerations as well as long-term soil erosion considerations and may not require financial incentives in general. Also, they suggest that some types of operators or farms may be targeted, based on a predisposition toward recognition of a problem or a tendency toward having higher C and/or P factors, other things being equal. Finally, though tenure arrangements did not prove significant in the statistical models, the response of operators regarding obstacles to soil conservation and the prevalence of renting suggests that special efforts may be needed to encourage soil erosion control on rented land.

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THE UNIVERSITY OF TENNESSEE
AGRICULTURAL EXPERIMENT STATION
KNOXVILLE, TENNESSEE 37916
E11-0415-00-006-87