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Targeting Soil Erosion Control Efforts in a Critical Watershed

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ABSTRACT

The public cost of reducing erosion in a west Tennessee watershed pilot program was 34 percent lower than the national average. The difference was attributed to the pilot program's emphasis on targeting specific erosion problems and to the establishment of permanent vegetative cover on highly eroding land. Even greater use of permanent vegetative cover, no-till cropping practices, and less reliance on cover improvement and terraces could reduce erosion in the area by an additional 32 percent with the same level of funds. A variable cost-sharing approach to erosion control may yield even bigger dividends in a targeting program.

Keywords: Erosion control, soil conservation, economics of conservation, conservation targeting, conservation practices, cost-sharing, conservation policy, cost-effectiveness.

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SUMMARY

The research reported here evaluated the cost-effectiveness of a special Agricultural Conservation Program (ACP) water quality project in which $1.65 million was targeted to the North Fork Forked Deer (NFFD) Watershed in west Tennessee. The research also considerd to what extent the use of variable cost-sharing rates could have potentially increased the cost-effectiveness of the project.

To assess the cost-effectiveness of targeting funds to critical watersheds, we compared the data from the NFFD project with data from ongoing ACP projects elsewhere in the country. We compared the NFFD project's costs incurred both for the reduction per ton of soil erosion and for the reduction achieved by different conservation practices.

In the NFFD project, 49 percent of all conservation practices were applied to fields eroding at a rate of more than 15 tons per acre per year (TAY); in the ACP national sample, only 19 percent. However, less treatment of the most highly erodible land was accomplished than what might have been expected given the generally more highly erodible land in the NFFD Watershed. The higher percentage of practices applied to more highly erodible land (> 15 TAY) in the NFFD Watershed seems to be related exclusively to the difference in percentage distributions of land by prepractice erosion rates. Targeting to the most highly erodible land in the NFFD Watershed was limited.

The average public cost per ton of erosion reduction was estimated to be 34 percent lower for the NFFD project compared with the ACP. The difference can be attributed primarily to the lower average cost of permanent vegetative cover establishment, which resulted from relatively greater application to more highly erodible land in the NFFD project. Application of terraces involved somewhat higher cost per ton of erosion reduction in the NFFD project than in the ACP, while cost per ton of erosion reduction was slightly lower for no-till in the NFFD project.

Variation in average cost per ton of erosion reduction by erosion rate class shows how targeting more highly erodible land can increase cost-effectiveness. Based on the variance in average cost across erosion rate classes, if 36 percent treatment had been accomplished on each subclass, approximately four times the actual erosion reduction would have been secured with the same budget.

Based on the variance in average cost per acre for different conservation practices, 60 percent accomplishment could have been obtained for each of these practices with the same budget, resulting in approximately 32 percent more erosion reduction.

Thus, the potential improvements in cost efficiency from targeting within a critical watershed to more highly erodible land and more cost efficient practices appear great.

A variable cost-sharing pilot program could improve cost-effectiveness even more by shifting the distribution of practices or acreage by erosion rate

class toward the higher classes. Pilot programs in selected counties base cost-sharing rates on the initial erosion rate and the percentage reduction achieved in the erosion rate. The maximum rate is 75 percent and no cost-sharing is available where soil loss tolerance is already met.

Under the assumption of no changes in participation, variable cost-sharing would have reduced overall commitment of cost-sharing funds in the 59 participating farms by approximately 40 percent. Under variable cost-sharing, approximately 37 percent of the cost-sharing funds would have gone to land eroding at greater than 20 TAY, in contrast to only 23 percent under uniform cost-sharing.

Based on these findings then, serious consideration of the use of variable cost-sharing in ACP special water quality projects appears warranted. However, further questions, both philosophical and practical, must be raised in connection with variable cost-sharing. These relate to the "fairness" of differential treatment, consistency with the whole-farm requirement, and estimation of the initial erosion rate.

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INTRODUCTION

The notion of "targeting" in a broad sense refers to efforts to increase the cost-effectiveness of Federal soil erosion control programs. This perceived need to increase cost-effectiveness developed over a long period of time but was stimulated in particular by Government reports on soil conservation (12) and nonpoint pollution (13) and a USDA report (10). These reports documented that most Federal technical assistance and cost-sharing funds were directed at erosion problems that were only slight to moderate, with relatively little serving to induce long-term conservation treatment of highly erodible land.

Three major policy initiatives have been undertaken to focus conservation efforts. Those initiatives represent three levels of targeting that can be distinguished--to specific practices, to general areas, and to highly erodible land within general areas. First, policy changes shifted the emphasis from short-term, single-field, production-oriented practices to long-term, whole-farm, conservation-oriented plans. Second, some Agricultural Conservation Program (ACP) funds were diverted from regular county allocations to critical watersheds or regions, the type of policy change most commonly associated with the term targeting. Third, a pilot program began under which participating counties can offer variable rates of cost-sharing depending upon the expected level of erosion reduction associated with conservation efforts on a particular field.

A major recipient of much of the targeting attention and funds has been a 21-county, 6.8-million-acre area in west Tennessee. (See Figure 1.) Data for the largest river basin in the area, the Obion-Forked Deer, indicate why. The 1.7 million acres of upland soils in the basin are predominantly wind-deposited loess and very susceptible to erosion. At the same time, these soils are highly productive, even in the higher land capability subclasses with their relatively steep slopes. The acreage in continuous soybean production has expanded markedly since 1970, replacing cotton in some areas but also drawing from land historically in pasture. The 780,000 acres of upland used for crop production were estimated to have an average erosion rate of 38.4 tons per acre per year in 1977, representing a threat to long-term agricultural prosperity in the area. In terms of offsite

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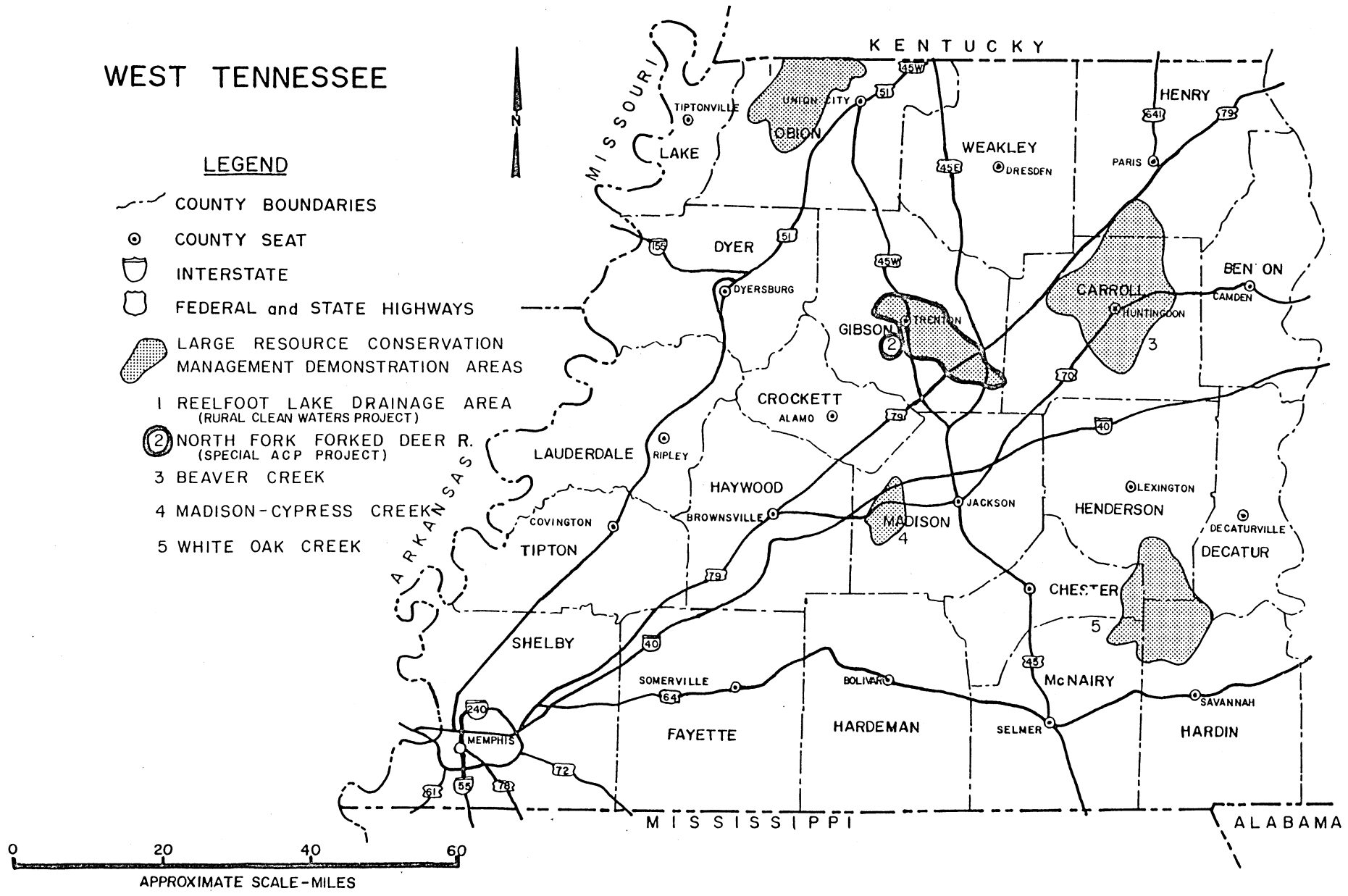

effects, sedimentation is estimated to have reduced downstream carrying capacities by two-thirds, to have increased expected annual flooding damages by $105 million, and to have made 47,000 acres too wet for crop, grass, or timber production. Though water quality data are limited, suspended concentrations of sediment, nutrients, and pesticides in the basin are believed to be a serious problem (9).

Funds have been targeted to west Tennessee through three different channels. Beginning in 1979, funds from the Agricultural Conservation Program (ACP) were made available for a special water quality project on the North Fork Forked Deer (NFFD) Watershed. In total, $1.65 million has been committed for cost-sharing and technical assistance in the NFFD Watershed. Second, the Rural Clean Water Program has provided $4.54 million for a similar project in the Reelfoot Lake drainage area (which includes some land in southwest Kentucky). Third, $2.19 million was allocated in the 1982-83 period to the 21 counties in west Tennessee as part of the targeting effort within the basic component of the ACP (8).

The primary purpose of the research reported here was to evaluate the cost-effectiveness of an aspect of the second level of targeting--to general areas--by analyzing the impact of the special ACP water quality project on the NFFD Watershed. 1/ Because of the nature of the requirements for participation in this project, it was also possible to address aspects of the first level of targeting--specific practices. Participants were required to enter into long-term agreements to implement practices designed to reduce erosion rates on all fields farmed in the watershed to soil loss tolerance for 3-10 years. The whole-farm requirement is a method for targeting at the third level--to highly erodible land--as cost-sharing was not made available for slightly erodible land without a commitment to erosion control on highly erodible land as well. A secondary purpose was to consider whether variable cost-sharing could have increased the cost-effectiveness of the project.

The remainder of the report is divided into five parts. In the first section a general description of the NFFD Watershed and the project is

1/ Cost-effectiveness in this research was defined in terms of public cost per unit of reduction in erosion from any type of land. In its recent report on soil conservation programs the General Accounting Office emphasized the need to consider onsite productivity losses in the implementation of a targeting strategy (13). Otherwise, "such a strategy . . . could, in some cases, favor highly eroding but relatively less productive land at the expense of fragile land that may be more productive but less erodible. Additionally, targeted money could be spent on deep, highly erodible lands that can tolerate erosion losses with little or no short- or mid-term impact on productivity at the expense of shallower soils that may erode at lower rates but suffer larger or more immediate productivity losses" [p. 39]. However, until more is known about the relationship between erosion and productivity and until the capability exists to compare off-site and onsite benefits, public cost per unit of reduction in erosion appears to be the most reasonable criterion for cost-effectiveness.

provided, based on the more general information derived from analysis of the long-term agreements and an independent survey of farmers in the watershed. In the second section, an attempt is made to evaluate the extent to which ACP funds for the project increased the cost-effectiveness of soil erosion control efforts compared with the effect of ACP funds nationwide. In the third section, the potential for improvements in cost-effectiveness from targeting to more highly erodible land in the NFFD Watershed is examined. In the fourth section, the potential impact of variable cost-sharing is compared with the actual impact of the project. In the final section, conclusions and policy implications are outlined.

OVERVIEW OF THE WATERSHED AND SPECIAL WATER QUALITY PROJECT

The NFFD Watershed comprises 80,190 acres in the central portion of the Obion-Forked Deer River Basin. The project application, developed in early 1979, estimated 570 farms to be in the area, with an average size of 126 acres. Of the 45,119 acres of cropland in the watershed, 20,150 acres had a critical erosion problem, that is, an average erosion rate of 47.5 tons per acre per year. Analyses of yields for the major soil type in the watershed suggest that at such an erosion rate, soybean yields may decline as much as 3 bushels per acre over a 10-year period (5). Nearly 800 acres of gullies, degrading ditches, and roadbanks were also identified as critical erosion problems.

In total, 1.2 million tons of soil movement could be expected to take place each year, with approximately a quarter of this transported out of the watershed and another quarter deposited in streams, waterways, and floodplains. Water quality data indicate that the NFFD River has high levels of suspended solids and turbidity. In addition, aquatic life and recreation criteria set by the Environmental Protection Agency and the State of Tennessee have been exceeded for mercury, dieldrin, DDT, and phosphate (2). Land damage from sediment deposition was estimated to amount to $175,383 annually.

A random survey of the operators of 76 farms units encompassing 4,649 acres in the watershed, conducted in September of 1982, provided additional information on the farms and farmers there. The average size of the farm units, as defined for the Agricultural Stabilization and Conservation Service office, was 61 acres, though on average the operators of these farms operated another 438 acres as an owner or renter. Of these farm units, 47.4 percent (covering 40.2 percent of the acreage) were farmed under rental arrangements. The farm operators averaged 53 years in age and had been farming an average of 28 years. Farming provided more than 75 percent of family income for 57.9 percent of these farmers. Soybeans were grown on 25.4 percent of the acreage on the survey farms, wheat double-cropped with soybeans on 12.4 percent, corn on 10.5 percent and cotton on 2.7 percent. Dairy or beef cattle enterprises were operated by 49.3 percent of these farmers. Use of some conservation practice was indicated by 48.7 percent of these farmers, most commonly "crop residue left on surface" and "winter cover crop." Need for conservation practices was indicated by 61.8 percent, most commonly "terraces" and "debris basins." "Quite a bit" or "some" knowledge of the Agricultural Conservation Program was indicated by 56.6 percent of these farmers, but only 30.3 percent indicated "quite a bit"

or "some" knowledge of the special water quality project on the NFFD Watershed.

The plan for dealing with erosion in the watershed involved cost-sharing for practices covering approximately 20,000 acres on approximately 450 farms. In actuality, the initial $1.2 million in funding was allocated during the 1979-81 period to about 70 farms. Additional funding allowed another 94 farms to sign up by July 1983, with cost-sharing of $1.4 million for 12,602 acres (8). At the time this research was conducted, data from 59 farms were available, covering 9,372 acres. However, cost-sharing was directly applicable to only 6,930 acres, as some fields required only reduced tillage, for which cost-sharing was not available. Reduction of sheet and rill erosion over the period of the long-term agreements was projected to be 589,812 tons, with cost-sharing commitments of $611,909. Cost-sharing commitments for control of gully erosion totaled $365,859.

IMPACT OF TARGETING TO THE WATERSHED

A reasonable assessment of the extent of increased cost-effectiveness gained from targeting to critical watersheds can be made on the basis of comparisons of two related sets of information from the NFFD project with similar sets of information from the National Summary Evaluation of the Agricultural Conservation Program, Phase I. The first comparison involves information on the distribution of practices across erosion rate classes; the second, information on cost per ton of erosion reduction.

Distribution of Practices

The impact of the NFFD project can perhaps most simply be presented by information on the distribution by erosion rate class of acreage to which cost-shared practices were applied (table 1). While 38.4 percent of the cost-shared acreage were eroding at more than 15 tons per acre per year (TAY), 34 percent of the cost-shared acreage were eroding at less than 5 TAY. At the same time, 46.6 percent of cost-sharing funds were applied to land eroding at greater than 15 TAY, while 27 percent of cost-sharing funds were applied to land eroding at less than 5 TAY. The skewed distribution of cost-sharing funds toward the higher erosion rate classes indicates that treatment of more highly erodible land is generally more costly per acre.

Of even more relevance, however, is the comparison for the seven practices that were common to both the ACP and the NFFD project (table 2). These practices included permanent vegetative cover establishment (which will be referred to as cover establishment), permanent vegetative cover improvement (which will be referred to as cover improvement), terraces, diversions, cropland protective cover (which will be referred to as winter cover), critical area treatment, and no-tillage. This comparison could be done only on the basis of the number of incidences of each practice, because data on acreage were not available from the ACP. The first column of table 1 and the "Total" rows of table 2 show that the distribution of incidences is skewed toward the higher erosion rate classes relative to the distribution of acreage, indicating that the more highly erodible fields tended to be smaller. As can be seen from comparing the "Total" rows in table 2, relatively more practices in the NFFD project were applied to more highly

Table 1--Percentage distribution of cost-shared acreage and cost-sharing funds across erosion rate classes in the NFFD project

Prepractice erosion rate class	Cost-shared acreage	Cost-sharing funds
Tons/acre/year	Percent	
0-5	34.0	27.0
5-10	13.5	14.0
10-15	13.9	13.4
15-30	24.6	28.9
30	13.8	17.7
Total	99.8	100.0

erodible fields than in the ACP. In the NFFD project, 49 percent of all practices were applied to fields eroding at a rate of more than 15 TAY; in the ACP, only 19 percent.

How much of the increased application of practices to more highly erodible fields is due to differences in the distribution of land across erosion rate classes in the NFFD Watershed versus the Nation as a whole? And how much is due to the requirements of the LTA approach embodied in the NFFD project as opposed to the general ACP approach?

Some insight regarding these questions can be gained by comparing the distribution of acreage by erosion rate class for the Nation for the period covered by the ACP with that for the NFFD Watershed prior to the project period. In 1977 only 4 percent of the land in the United States was estimated to be eroding at a rate of more than 15 TAY (table 3). Nationally then, 17.5 percent of all practices were applied to the 4 percent of the land that was most erodible, while for the NFFD Watershed, 46 percent of all practices were applied to the 23.7 percent of the land that was most erodible. This comparison, however, provides only a limited basis for addressing the questions raised above. More revealing would be a comparison of what percentage of all practices were applied to the 10 percent of the most highly erodible land (or other percentages such as 20 or 30 percent).

Alternatively, the percentage allocation of practices to erosion rate classes in the NFFD Watershed could be predicted on the basis of the percentage of practices applied to the X percent most highly erodible land nationally. That is, if 20 percent of the practices were applied to the 10 percent of the land that was most highly erodible land nationally, we might expect the same in the NFFD Watershed apart from any impact from the requirements of the LTA approach. The distribution of practices predicted on this basis and the actual distribution of practices presented in table 4 are quite revealing. The cumulative distributions (last two rows) indicate that a smaller percentage of practices were applied to the 0-5 TAY class

Table 2--Percentage distribution of practices across erosion rate classes for the national ACP and the NFFD project

Type of practice	Erosion rate class (Tons/acre/year)						Total practices applied 1/
	0-5	5-10	10-15	15-30	30	Total	
National ACP	Percent						Units
Vegetative cover establishment	53	18	9	11	9	100	10,315
Vegetative cover improvement	69	13	7	7	4	100	6,978
Terrace	15	27	22	26	10	100	1,754
Diversions	37	23	10	15	15	100	429
Cropland protective cover (winter)	28	38	22	6	6	100	2,916
Critical area treatment	38	26	19	14	3	100	119
No-tillage	9	5	17	52	17	100	217
Total	51	20	11	11	8	100	22,728
	0-5	5-10	10-15	15-30	30	Total	Total practices applied 1/
NFFD Special Water Quality Project	Percent						Units
Vegetative cover establishment	7	7	11	23	53	101	178
Vegetative cover improvement	78	2	2	4	13	99	139
Terrace	9	21	17	43	10	100	132
Diversions	35	15	8	28	15	101	52
Cropland protective cover (winter)	14	25	14	34	4	101	36
Critical area treatment	21	19	24	32	4	100	72
No-tillage	18	0	6	12	66	102	17
Total	28	12	12	24	25	101	626

1/ Number of incidences of each practice, whether alone or in combination with one or more practices on a single field.

Table 3--Percentage distribution of acreage and practices across erosion rate classes

	Erosion rate class (Tons/acre/year)					
	0-5	5-10	10-15	15-30	30	Total
National ACP 1/			Percent			
Percent of acreage	86.7	7.0	2.3	2.2	1.8	100.0
Percent of ACP practice	52.4	19.5	10.6	10.9	6.6	100.0
Cumulative percent of acreage	86.7	93.7	96.0	98.2	100.0	100.0
Cumulative percent of practices	52.4	71.9	82.5	93.4	100.0	100.0
	0-5	5-10	10-15	15-30	30	Total
NFFD Special Water Quality Project			Percent			
Percent of practices	63.2	6.3	6.9	14.0	9.7	100.1
Percent of ACP practice	29.2	12.6	12.2	24.3	21.7	100.0
Cumulative percent of acreage	63.2	69.5	76.4	90.4	100.1	100.1
Cumulative percent of practices	29.2	41.8	54.0	78.3	100.0	100.0

1/ Source: (10).

Table 4--Predicted and actual distributions of practices by erosion rate for the NFFD project

	Erosion rate class (Tons/acre/year)					
	0-5	5-10	10-15	15-30	30	Total
	Percent					
Percent of acreage	63.2	6.3	6.9	14.0	9.7	100.1
Actual percent of practices	29.2	12.6	12.2	24.3	21.7	100.0
Predicted percent of practices 1/	38.2	3.8	4.2	16.5	37.3	100.0
Cumulative percent of acreage	63.2	69.5	76.4	90.4	100.1	100.1
Actual cumulative percent of practices	29.0	41.8	54.0	78.3	100.0	100.0
Predicted cumulative percent of practices 1/	38.2	42.0	46.2	62.7	100.0	100.0

1/ Predicted on the basis of the percentage allocation of practices nationally to the X percent most highly erodible land, as reported in the national ACP.

than might have been expected, but about the same percentage were applied to the 0-10 TAY classes as might have been expected. Beyond this point a larger percentage of practices were applied to the less erodible land in the NFFD Watershed than might have been expected, 78.3 percent versus 62.7 percent to the 0-30 TAY classes, for example. However, looking at the erosion rate classes individually provides further insights. The special ACP project in the NFFD Watershed allocated a smaller percentage of practices than might have been expected to the 0-5 TAY classes, but also a much smaller percentage to the 30+ class. Significantly higher percentages were allocated to the 5-10, 10-15, and 15-30 TAY classes. Thus, the use of long-term agreements apparently resulted in less treatment, relative to the national average, of the most highly erodible land. The higher percentage of practices applied to moderate to highly erodible land in the NFFD Watershed appears to be related to the erosion rates.

Cost-Effectiveness

Analysis of the cost of practices planned in the NFFD project provides a further basis for assessing the impact of targeting to a critical watershed. Information on the distribution of cost-shared acreage and cost-sharing funds by type of practice is presented in table 5. Terraces and debris basins each accounted for about a quarter of the total cost-sharing funds. Those practices are significantly more expensive per acre than most other practices. About the same amount was spent on cover improvement as on cover establishment.

We estimated the public cost per ton of erosion reduction for the five practices in the NFFD project for which reductions in erosion could be predicted with the Universal Soil Loss Equation (USLE) (table 6). For all these practices together (excluding winter cover) the average public cost per ton of erosion reduction, weighted by percentage of total erosion reduction, was estimated to be 34.5 percent lower for the NFFD project compared with the ACP.

Two important points should be highlighted with regard to this comparison of cost figures. First, the cost figures published for the ACP were for the full cost of the practices. To compare those costs with the NFFD project cost estimates (which were based on the 75 percent ASCS cost share alone) we had to adjust the ACP figures. ASCS cost-sharing for the practices in the ACP survey was typically 50 percent, but varied by a few percentage points, depending upon the particular practice. In the interest of presenting a comparison of public cost efficiency, the ACP figures were reduced by half. Second, this comparison ignores the use of funds in the NFFD project (approximately half) for practices directed at gully erosion, for which we could not make confident estimates of erosion reduction.

The overall difference in average cost can be explained by reference to the distribution information from table 2, together with the cost information by practices in table 7, and can be attributed primarily to the lower average cost for cover establishment. This resulted from relatively greater application of cover establishment to more highly erodible land in the NFFD project. The costs of establishing permanent vegetative cover, which vary little if any with slope, were spread over larger reductions in erosion.

Table 5--Distribution of cost-shared acreage cost-sharing funds across practices for the NFFD project

Type of practice	Cost-shared acreage		Cost-sharing funds	
	Acres	Percent	Dollars	Percent
Permanent vegetative cover establishment	1,620	14.3	137,523	14.1
Permanent vegetative cover improvement	1,725	15.2	139,678	14.3
Terrace	2,070	18.3	267,812	27.4
Diversions	779	6.9	52,875	5.4
Cropland protective cover (winter)	480	4.2	16,202	1.7
Critical area treatment	316	2.8	10,289	1.1
No-tillage	1,207	10.6	50,694	5.2
Debris basin	2,256	19.9	254,456	26.0
Grassed waterway	517	4.6	13,965	1.4
Pond	372	3.3	44,274	4.5
Total	1/ 11,342	100.1	2/ 977,768	100.1

1/ This figure double-counts acres to which more than one practice was applied.

2/ This figure excludes $6,588 in cost-sharing funds for minor practices like tree planting, wildlife habitat, etc.

As for permanent vegetative cover improvement, the higher cost for the NFFD project resulted from the fact that in virtually every case the prepractice erosion rate was estimated to be in the 0-5 TAY class. An estimated 31 percent of the applications of permanent vegetative cover improvement in the ACP were on fields with erosion rates in excess of 5 TAY. 2/

2/ We have some difficulty understanding this finding since even poor sod has a very low C-factor in the USLE, resulting in very low predicted erosion rates for even highly erodible soils on steeply sloping fields.

Table 6--Comparison of average cost per ton of erosion reduction from the NFFD project and the national ACP

Type of practice	National Agricultural Conservation Program		North Fork Forked Deer Special Water Quality Project	
	Incidence	Average cost per ton of erosion reduction 1/	Incidence 2/	Average cost per ton of erosion reduction 3/
	Number	1981 dollars	Number	1981 dollars
Permanent vegetative cover establishment	10,315	4/ 2.77	136	.81
Permanent vegetative cover improvement	6,978	4/ 4.20	109	11.21
Terrace	1,754	5/ 1.56	69	2.05
Cropland protective cover (winter)	2,916	8.39	8	.70
No-tillage	119	1.02	39	6/ .84
Total or average for all practices 7/	19,166	1.97	353	8/ 1.29

1/ An adjustment factor of 1.39 was used for all practices to account for inflation as measured by the producer price index for the period 1978 to 1981. An adjustment factor of 0.50 to reflect the typical cost-sharing rate was also used for all practices, since figures from the ACP were for total cost, while those from the NFFD project were for the 75 percent ASCS cost-share.

2/ The number of incidences or fields for each practice represent cases where only one cost-shared practice was applied. The numbers in table 2 include cases where two or more cost-shared practices were applied in combination.

3/ These cost figures are for the 75 percent ASCS cost-share only.

4/ An adjustment factor of 1.39 was used for permanent vegetative cover establishment and permanent vegetative cover improvement to account for differences in assumed length of practice life. In amortizing cost at 8 percent, the ACP used 8 years while the analysis of the NFFD project used the minimum required maintenance period of 5 years.

5/ An adjustment factor 1.28 was used for terrace to account for the difference in assumed length of practice life. In amortizing at 8 percent, the ACP used 15 years while the analysis of the NFFD project used the minimum required maintenance period of 10 years.

6/ Cost-sharing for no-tillage in the NFFD project was strictly for no-tillage.

7/ Weighting is by percentage of total erosion reduction. Since acreage data were not available, it was assumed that average field size was the same for each practice in the ACP. Cropland protective cover (winter) is not included because of noncomparability.

8/ This figure includes cases where more than one cost-shared practice was applied to a field and erosion reductions on noncost-shared fields. However, it should be noted that this figure does not represent the overall cost-effectiveness of the NFFD project for one reason in addition to the exclusion of cropland protective cover (winter), a minor factor in itself. Approximately 50 percent of the nearly $1 million of cost-sharing funds was committed for practices which control gully erosion, diversions, critical area planting, debris basins, grassed waterways, and ponds. Cost per ton of erosion reduction could not be estimated for these practices to which the USLE, which predicts sheet and rill erosion, cannot be applied.

Table 7--Average cost per ton of erosion reduction by erosion rate for the NFFD project

Erosion rate class 1/	Type of practice: Permanent vegetative cover establishment	Permanent vegetative cover improvement	Terrace	Cropland protective cover (winter)	No-tillage	Average for all practices
	1981 dollars					
0-5	9.66	27.48	9.07	3.91	3.74	19.55
5-10	3.00	3.99	3.02	1.13	.94	2.99
10-15	1.38	3.07	1.56	NA	.62	1.42
15-20	1.42	2/ NA	1.84	.24	.98	1.64
20-30	.85	1.23	2.05	NA	.57	.90
30-40	.66	.55	NA	.07	.49	.64
40-50	.57	NA	.79	NA	NA	.59
50-70	.44	NA	NA	NA	NA	.44
70-90	.27	NA	NA	NA	NA	.27
90+	.21	NA	NA	NA	NA	.21
All classes	.81	11.21	2.05	.70	.84	1.66

1/ Tons per acre per year based on application of the Universal Soil Loss Equation.

2/ Not applicable. No practices were applied to land in these erosion rate classes.

Terraces were less cost-efficient in the NFFD project than the ACP, even though terraces were applied to slightly more highly erodible land in the watershed. The primary explanation for this lies in the variation in average cost by erosion rate class for terraces in the NFFD project. As indicated in table 7, average cost declines over the first three classes but turns back up for the 15-20 and 20-30 TAY classes. Terrace costs apparently rise more quickly than erosion reduction as slope increases over the range associated with the 10-15 through 20-30 TAY classes. Terraces in the NFFD project were more concentrated in the 15-20 TAY class than they were nationally (table 2).

The cost figures for cropland protective cover (winter) are difficult to compare for the following reason. Acceptance of cost-sharing for winter cover in the NFFD project required a conservation cropping system, where necessary, to insure that soil loss tolerance was met. Such a conservation cropping system generally involved reduced or minimum tillage of some kind, residue management, and contour planting, practices for which cost-sharing was not available. Thus, the much lower cost per ton for the NFFD project is a function more of the conservation cropping system than the impact of winter cover, which has only a small effect on the C-factor in the USLE. In addition, winter cover was not often cost-shared because double-cropping

of wheat with soybeans is becoming more common in the NFFD Watershed and harvesting a cost-shared crop is prohibited.

The cost per ton was slightly lower for no-tillage in the NFFD project for two reasons. First, in the NFFD project, cost-sharing was available only for no-till that reduced erosion rates somewhat more than various reduced or minimum tillage practices. Second, no-tillage, with a constant cost across slopes, at least in terms of costs-shared, was applied to more highly erodible land in the NFFD project (table 2).

POTENTIAL FOR TARGETING WITHIN THE WATERSHED

The relatively greater application of practices to more highly erodible land and increased cost-effectiveness of the NFFD project, as compared to the ACP, were a function primarily, if not exclusively, of the more highly erodible land in the NFFD project. This finding was not totally unexpected. Though the long-term agreements in the NFFD project involved whole-farm, soil loss tolerance, and long-term requirements, there was little change in the traditional voluntary, first-come, first-served approach. Later discussion will suggest how these requirements may actually limit potential cost-effectiveness. The potential for increasing cost-effectiveness by targeting within critical watersheds to highly erodible land and particular practices can be glimpsed by viewing the variation in average cost per ton of erosion reduction across erosion rate classes (table 7) together with the extent to which land capability class treatment goals (table 8) and practice treatment goals (table 9) of the NFFD project were met.

Table 8--Percentage accomplishment of land capability class treatment goals for the NFFD watershed

Land capability subclass	Erosion rate ranges 1/	Acreage goals 2/	Actual acreage	Percentage accomplishment goals
	Tons/acre/year	------- Acres -------		Percent
Mixed 3/	0-5	1,096	2,370	216.2
IIe	5-20	5,488	3,260	59.4
IIIe	20-40	5,835	933	16.0
IVe	40-70	3,130	442	14.1
VIe and VIIe	70+	4,408	107	2.4
Total		19,957	7,102	35.6

1/ Tons per acre per year based on the USLE.
2/ See (6).
3/ This 2,370 acres included 1,725 acres of improvement of vegetative cover, which was applied to fields in various land capability subclasses with prepractice erosion rates of 0-5 tons per acre per year. The remainder was accounted for by various practices applied to cropland in subclasses such as I and IIw or IIIw (wet soils). The 1,096-acre goal was for permanent vegetative cover improvement only.

Table 9--Accomplishment of conservation practice application goals for the NFFD watershed

Conservation practice	Acreage goals	Actual acreage	Percentage accomplishment of goals
	--- Acres ---		Percent
Permanent vegatative cover establishment	4,408	1,683	38.2
Permanent vegatative cover improvement	1,096	1,725	157.4
Terraces	2,890	2,070	71.6
No-tillage (reduced tillage) 1/	10,644	3,075	28.9
Total	2/ 19,038	2/ 8,553	44.9

1/ A conservation cropping system, generally involving reduced tillage (i.e., disk or chisel plow), drilled soybeans in narrow rows, planting on the contour, and residue management, was not a cost-shared practice, but was required where necessary to meet soil loss tolerance.

2/ These figures differ from those in table 8 for two reasons. First, they exclude residue management and rotations, which were not cost-shared practices. In general, residue management was required on all cropland receiving cost-sharing. The acreage goal for grass-based rotations was 4,170, but only 132 acres were planned. Second, some acres were double-counted in this table as multiple practices were planned and applied in some cases.

The far right column of table 7 shows vividly how targeting to more highly erodible land can increase cost-effectiveness. Note also that the cost-effectiveness of the four basic practices generally followed the order no-tillage, cover establishment, terrace, and cover improvement. Cover establishment was the only option for highly erodible land; no-tillage and cover establishment were comparable for moderately erodible land. Cover establishment and terrace were comparable behind no-tillage for slightly erodible land. The question remains, however: To what extent could treatment have been targeted to more highly erodible land and more cost-effective practices?

Treatment goals for the NFFD project were outlined in terms of land capability subclasses (table 8). The treatment goal (the land estimated to need treatment) was 19,957 acres. Analysis of 59 of the farms under the NFFD project indicated treatment was scheduled for 7,102 acres, representing 35.6 percent accomplishment overall. Land capability subclass treatment goals, however, were met to a different degree. The 1,096-acre

goal for the "mixed" class was for improvement of existing vegetative cover. However, 1,725 acres of permanent vegetative cover improvement were scheduled. In addition, 637 acres of various practices on subclasses such as I, IIw, and IIIw were scheduled as well, for a total of 2,370 acres treated in this mixed class corresponding to the 0-5 TAY class. The rest of table 8 can be summarized by noting that the percentage accomplishment falls sharply in moving from subclass IIe (59.4 percent) to the more highly erodible subclasses. Based on the variance in average cost across erosion rate classes in table 7, we conclude that if 35.6 percent of the acreage in each subclass had been treated, the average cost would have been about 75 percent lower. In other words, approximately four times the actual erosion reduction conceivably could have been secured with the same budget.

Treatment goals for the NFFD project were also outlined in terms of practices, as indicated for the four basic cost-shared practices in table 9. The overall percentage accomplishment was 44.9 percent. However, the percentage accomplishment was less than that for the more cost-effective practices, vegetative cover establishment and no-tillage, and greater than that for the less cost-effective practices, vegetative cover improvement and terrace. Based on the variance in average cost per acre for different practices, 59.7 percent of the acres could have been treated for each practice with the same budget. With less vegetative cover improvement and terrace and more vegetative cover establishment and no-tillage, approximately 32 percent more erosion reduction could have been secured with the same budget. A goal of 4,170 acres of grass-based rotations was also set, but only 132 acres were included in the 59 farms studied. No cost-sharing was available for establishment of grass or hay for less than 5 years, the practice life required under vegetative cover establishment.

Thus, the potential improvements in cost-effectiveness from targeting more highly erodible land and more cost-effective practices appear great, though limitations imposed by administrative feasibility and administrative cost must be recognized.

VARIABLE COST-SHARING AS A TARGETING STRATEGY

The variable cost-sharing (VCS) pilot program has been offered since 1981 as an option in the regular component of the ACP. Initially, it could take one of two forms. In one, cost-sharing rates are based on the initial erosion rate and the percentage reduction achieved in the erosion rate (PER). Percentage reduction, as estimated by application of the Universal Soil Loss Equation (USLE), prepractice and postpractice, is multiplied by a "severity" factor (table 10) to arrive at the appropriate cost-sharing

Table 10--Severity factors for percentage erosion reduction form of variable cost-sharing program

Erosion rate class	Severity factor
Tons/acre/year	
0-T[1]/	0
T-10	.7
10-15	.8
15-20	1.0
20+	1.3

1/ Soil loss tolerance, which varies by soil between 2 and 5 TAY.

rate, with a maximum of 75 percent. 3/ For example, terraces that reduce the erosion rate on a field from 14 TAY to 7 TAY (a 50-percent reduction) would qualify for 40-percent cost-sharing (50% x 0.8 = 40%). Similarly, establishing a permanent vegetative cover that reduces the erosion rate on a field from 30 TAY to 3 TAY (a 90-percent reduction) would qualify for the maximum 75-percent cost-sharing (90% x 1.3 = 117%). No cost-sharing is available where soil loss tolerance is already being met.

3/ Subsequent to completion of this research, we learned that the "severity" or weighting factors for the PER form of variable cost-sharing had been modified in 1983 to take into account differing T-values across soils. Weighting factors were specified for pretreatment erosion rate intervals of 2 TAY for T-values of 2, 3, 4, and 5. Generally, the specification of the factors is based on the following table:

Weighting factor	<----->	Erosion rate (TAY)
0		$E \leq T$
.7		$T < E \leq 2T$
.8		$2T < E \leq 3T$
1.0		$3T < E \leq 4T$
1.3		$E > 4T$

Thus, a soil with T = 3 eroding at 13 TAY would have a higher weighting factor than a soil with T = 5 eroding at 13 TAY. Note that the original factors apply when T = 5. Since most soils in the NFFD Watershed have a T-value of 3, the costs under variable cost-sharing reported later for erosion rate classes between 5 and 20 TAY and for practices applied to land eroding at these rates would be somewhat higher under the modified weighting factors. Data were not collected in a manner that would allow a revised analysis to be undertaken.

The other form of variable cost-sharing based cost-share rates on the land capability class of the field to be treated (LCC). 4/ The variation in cost-sharing is indicated in table 11. Because land capability class and erosion rates are positively correlated (at least in the case of land use for row crop production), these two forms of variable cost-sharing work in the same direction to adjust incentives relative to uniform cost-sharing. In particular, under the LCC form of variable cost-sharing, proposed practices are screened initially and rejected if the initial erosion rate is less than soil loss tolerance, just as under the PER form.

A variable cost-sharing program could, therefore, be expected to improve cost-effectiveness by encouraging some conservation practices (if the cost per ton is relatively low) that would not have been implemented with 50-percent cost-sharing, and by discouraging some conservation practices (where cost per ton is relatively high) that would have been implemented with 50 percent cost-sharing. In addition, cost-effectiveness would be increased (decreased) to the extent that less (more) cost-sharing is provided where conservation would have been undertaken at either the uniform or variable rate. Thus, the distribution of practices or acreage by erosion rate class (as in table 1) would be shifted toward the higher classes, resulting in an improvement in overall cost-effectiveness. In addition, the range of cost per ton of erosion reduction across erosion rate classes (as in table 7) would be reduced.

This reduction in the range of cost per ton reflects movement in the direction of a strategy that would offer an equal dollar subsidy per ton of erosion reduction, regardless of the practice or field to which it was applied. A list of alternatives developed in the recent Resources Conservation Act review and assessment of soil erosion control policy included this type of strategy, referred to as the bonus contract approach (3). Such a strategy would be similar to the effluent tax and subsidy schemes

4/ This form of VCS was dropped in 1983, apparently due to the limited number of counties selecting it and concern about its potential effectiveness.

Table 11--Land capability class form of variable cost-sharing program

Land capability class	Cost-sharing rate
	Percent
I, II	45
III	55
IV	65
VI, VII	75

that have long been recommended for pollution control policy on the basis of their economic efficiency. Applying such a strategy would assure that a given budget for financial assistance to farmers would go toward only the most cost-effective practice and field combinations, those for which farmers perceived their cost per ton of erosion reduction to be less than or equal to the subsidy rate.

Potential Impact of Variable Cost-Sharing in the Project

If either type of variable cost-sharing program had been used to set cost-share rates in the NFFD Watershed, some farmers probably would not have signed long-term agreements due to lower cost-share rate offers on some fields. Or some fields might have been treated with different practices. However, in the analysis that follows, we assumed that under VCS all 59 agreements would have been signed with the same practices applied to the same fields, except that no practices would have been applied to fields with initial erosion rates of less than 5 TAY. Ideally, one would need to estimate the minimum average cost-share rate across fields or total cost-share amount that would induce participation in the case of each farmer, in order to predict changes in participation under variable cost-sharing relative to uniform cost-sharing. Cost-effectiveness is thus likely to have been increased even more with a VCS program than suggested by the findings below, because funds that went to some farmers who would not have participated would instead have gone to more highly erodible farms that would have participated under VCS. We analyzed the impact of VCS on cost-effectiveness from several perspectives, looking first at the distribution of cost-sharing funds by erosion rate class and by practice, and second at cost per ton across classes and practices.

Information is presented in table 12 on the actual commitment of cost-sharing funds by prepractice erosion rate class in the NFFD project under uniform 75 percent cost-sharing versus projected commitment with the two forms of VCS. As can be seen from the bottom row, either form of VCS would have reduced overall commitment of cost-sharing funds to the 59 farms by approximately 40 percent. The reduction comes primarily from the 100-percent reduction for the 0-5 TAY class, for which cost-sharing would not have been offered. There were also substantial reductions in the next two or three erosion rate classes, where cost-sharing would have been offered, but at rates well below 75 percent. For the highest three classes (50 TAY and greater) VCS does not reduce cost, since these involved very high initial erosion rates and percentage erosion reductions needed to meet soil loss tolerance on class VIe and VIIe land. Under either form of VCS, approximately 37 percent of the cost-sharing funds would have gone to land eroding at greater than 20 TAY, in contrast to only 23 percent under uniform cost-sharing.

A difference in the two VCS forms shows up in table 12 by focusing on the 5-10 TAY and 15-20 TAY classes. In the 5-10 TAY class, the percentage reduction in cost for the PER VCS program is much greater than for the LCC VCS program compared with uniform cost-sharing. This occurs because the low "severity" factor in the PER form and the relatively small percentage reduction needed to meet tolerance (with terraces, for example) lead to a variable cost-sharing rate less than the minimum 45 percent for class I and IIe land under the LCC form. However, under the PER form, once the

Table 12--Distribution of cost-sharing funds by erosion rate class under uniform versus variable cost-sharing

Erosion rate (TAY)	Uniform cost-sharing		Variable cost-sharing					
			PER form			LCC form		
	Cost	Percent of total	Cost	Percent of total	Percent reduction from uniform	Cost	Percent of total	Percent reduction from uniform
	Dollars	Percent	Dollars	----- Percent -----		Dollars	---- Percent ----	
0-5	268,379	27.2	0	0	100	0	0	100
5-10	138,446	14.0	74,889	12.5	45.9	94,439	17.0	31.8
10-15	131,484	13.3	99,260	16.6	24.5	95,832	17.3	27.1
15-20	219,792	22.3	202,265	33.8	8.0	159,772	28.8	27.3
20-30	63,283	6.4	61,107	10.2	3.4	53,975	9.7	14.7
30-40	61,307	6.2	59,782	10.0	2.5	52,827	9.5	13.8
40-50	36,915	3.7	35,536	5.9	3.7	33,858	6.1	8.3
50-70	51,674	5.2	51,674	8.6	0	51,674	9.3	0
70-90	3,189	.3	3,189	.5	0	3,189	.6	0
90+	10,332	1.0	10,332	1.7	0	10,332	1.9	0
Totals	986,801	100.0	598,827	100.0	39.3	554,859	100.0	43.8

erosion rate reaches the 15-20 TAY class, the variable cost-sharing rate is generally near or equal to the 75 percent maximum, and thus greater than the 55 percent rate that applies to the class of land with such an initial erosion rate, class IIIe, under the LCC form.

Table 13 shows the actual commitment of cost-sharing funds by practice in the NFFD project under uniform cost-sharing versus the projected commitment with both forms of VCS. For practices directed at sheet and rill erosion, both VCS forms shifted emphasis from vegetative cover improvement to vegetative cover establishment, terrace, cropland protective cover (winter), and no-tillage. For practices generally directed at gully erosion, both VCS forms shifted emphasis from diversions, debris basin, grassed waterway, and pond to critical area treatment. The two VCS forms display a rather consistent difference in percentage cost reduction except for the case of vegetative cover establishment. The contrast here results from the fact that vegetative cover establishment generally reduces erosion by more than 95 percent and thus receives close to 75 percent cost-sharing under the PER form regardless of the initial erosion rate, whereas application of vegetative cover establishment to class IIIe or IVe land receives only 55 or 65 percent cost-sharing, respectively.

Table 14 shows the cost per ton of erosion reduction across prepractice erosion rate classes for uniform cost-sharing, as actually employed in the NFFD project, and for both forms of VCS. VCS would have reduced cost per ton overall by approximately 35-40 percent. In addition, the range of cost per ton across erosion rate classes would have been reduced substantially, moving in the direction of a subsidy per ton of erosion reduction strategy. Not counting the two highest erosion rate classes to which relatively few funds were committed, the range of cost per ton declined from a multiple of about 45 ($18.05 + $0.39) under uniform cost-sharing to a multiple of about 4 ($1.36 or $1.75 + $0.39) under either form of VCS. Again, the impact of the two forms of VCS differed on the 5-10 TAY class versus the 10-40 TAY classes for reasons outlined earlier.

Table 15 shows cost per ton of erosion reduction by practice. Cost per ton for vegetative cover establishment declined least because it was generally applied to more highly erodible land in higher capability classes. Cost per ton for vegetative cover improvement declined dramatically with elimination of practice application to the 0-5 TAY class. Only the steepest land with poor vegetative cover and erosion rates greater than 5 TAY are treated. Cost-effectiveness estimates for terraces and conservation tillage declined comparably, within the 20-35 percent range.

Summary and Discussion

As expected, a VCS program would have significantly reduced the amount of funds needed and the cost per ton or erosion reduction for the lower erosion classes and reduced the range of cost per ton across erosion classes and practices. The LCC form would have resulted in somewhat greater reductions in overall costs and for all erosion classes and practices, except the 5-10 TAY class. The greatest single factor involved in improving cost-effectiveness was the virtual elimination of cost-sharing for permanent vegetative cover improvement. This alone accounted for about 40-45 percent

Table 13--Distribution of cost-sharing funds by practice under uniform versus variable cost-sharing

Practice	Uniform cost-sharing		Variable cost-sharing					
			PER form			LCC form		
	Cost	Percent of total	Cost	Percent of total	Percent reduction from uniform	Cost	Percent of total	Percent reduction from uniform
	Dollars	Percent	Dollars	----- Percent -----		Dollars	---- Percent -----	
Permanent vegetative cover establishment	137,523	13.9	125,599	21.0	8.7	108,445	19.5	21.1
Permanent vegetative cover improvement	140,563	14.2	32,483	5.4	76.9	28,750	5.2	79.5
Terrace	267,812	27.1	191,421	32.0	28.6	178,211	32.1	33.5
Diversions	52,875	5.4	1/ 26,587	4.4	49.7	24,400	4.4	53.9
Cropland protective cover (winter)	16,202	1.6	10,223	1.7	36.9	10,765	1.9	33.6
Critical area treatment	10,199	1.0	1/ 9,363	1.6	8.2	9,017	1.6	11.6
No-tillage	50,694	5.1	36,538	6.1	27.9	32,365	5.8	36.2
Debris basin	254,456	25.8	1/ 144,713	24.2	43.1	141,554	25.5	44.4
Grassed waterway	13,965	1.4	1/ 6,423	1.1	54.0	5,730	1.0	59.0
Pond	45,924	4.7	1/ 16,227	2.7	64.7	15,487	2.8	66.3
Totals	986,801	100.0	598,827	100.0	39.3	554,859	100.0	43.8

1/ The costs for these practices (which are generally used to treat gully erosion) under the PER form of VCS are based on variable cost-share rates associated with the percentage reduction in erosion rate achieved by one or more of the five practices (SL-1, SL-2, SL-4, SL-8, SL-15) for which the USLE (which estimates sheet and rill erosion) is applicable.

Table 14--Cost per ton of erosion reduction by erosion rate class under uniform versus variable cost-sharing

Erosion rate (TAY)	Uniform cost-sharing	Variable cost-sharing			
		PER form		LCC form	
		Cost	Percent reduction from uniform	Cost	Percent reduction from uniform
	-- Dollars/ton --		Percent	Dol./ton	Percent
0-5	18.05	0	0	0	0
5-10	2.65	1.36	48.7	1.75	34.0
10-15	1.43	1.10	23.1	1.03	28.0
15-20	1.70	1.55	8.8	1.23	27.7
20-30	.88	.82	6.8	.72	18.2
30-40	.61	.61	0	.54	11.5
40-50	.43	.43	0	.40	7.0
50-70	.39	.39	0	.39	0
70-90	.23	.23	0	.23	0
90+	.08	.08	0	.08	0
Totals	1.29	.85	34.1	.77	40.3

Table 15--Cost per ton of erosion reduction by practice under uniform versus variable cost-sharing

Practice	Uniform cost-sharing	Variable cost-sharing			
		PER form		LCC form	
		Cost	Percent reduction from uniform	Cost	Percent reduction from uniform
	--- Dollars/ton ---		Percent	Dol./ton	Percent
Permanent vegetative cover establishment	.81	.73	9.9	.62	23.5
Permanent vegetative cover improvement	11.24	1.71	84.8	1.24	89.0
Terrace	2.04	1.50	26.8	1.36	33.7
No-tillage	.84	.66	21.4	.55	34.5

of the reduction in cost per ton of erosion reduction achieved by VCS. Based on these findings then, serious consideration of the use of VCS in ACP special water quality projects appears warranted. The modification in the PER form of VCS to take into account T-values does not appear to weaken the basis for these general conclusions significantly.

However, uncertainty remains as to how such a different cost-sharing scale might affect participation in the projects. Farmers whose cost-sharing rates would be significantly lower, i.e., on farms with less severe erosion problems, would probably not participate. If additional farms with more severe erosion problems could therefore participate, the "problem" of nonparticipation would cease to exist. However, a few further questions, some of a philosophical nature, some more practical or pragmatic, must be raised in connection with VCS.

Uniform percentage cost-sharing was the unquestioned norm until recently, due primarily to its sense of "fairness" or "equal treatment." Thus, variable cost-share rates must have a "reasonable" basis in terms of these values to maintain acceptability. Some have questioned whether the PER and LCC forms have such a basis. The PER form appears to reward farmers who have been practicing little or no soil erosion control and penalize those who have been practicing at least some control. On the other hand, the LCC form gives preferential treatment to farmers with poorer land relative to those with better land. The "reasonableness" of these VCS forms in terms of the overall objectives of the ACP does not necessarily correlate with "reasonableness" in terms of equity.

A second philosophical question arises in consideration of the potential inconsistency of VCS and the long-term agreement. The whole-farm and soil loss tolerance aspects of the long-term agreements are basic components of the conservationist philosophy. It is well documented that requiring soil loss tolerance to be met if a field is to be treated at all can push marginal costs well up along the steeper portion of the curve. The whole-farm requirement was apparently incorporated to assure that cost-sharing was not provided for slightly erodible fields on a farm without also treating highly erodible fields. However, this requirement works in the other direction as well. Costs are shared for treatment of slightly erodible fields, though the primary interest of a farmer may be in his highly erodible fields. Variable cost-sharing seems consistent with reducing the cost-sharing rate for slightly erodible fields. But to the extent that requiring treatment of such fields at a reduced cost-sharing rate may discourage participation and thus treatment of highly erodible fields, VCS and the whole-farm requirement may work somewhat against one another.

In terms of administering such a program, a few points should be made. Since the PER form is based partly on the initial erosion rate, determination of the existing situation is a key, leading to several questions. Can practices directed at gully erosion (which is not estimated by the USLE) be adequately handled? What period of time should be used to establish the initial erosion rate? What incentives might be given for perverse behavior, e.g., plowing up pasture for row crops to get a high rate of cost-sharing for re-establishment or going back to conventional tillage for a couple of years to get a higher rate of cost-sharing on terraces and debris basins? In addition, the discretionary and somewhat subjective judgment of SCS

technicians in estimating the C, P, S and L factors in the USLE becomes extremely important. What pressure may there be for an upward bias on these factors to increase the estimate of the initial erosion rate and thus too the cost-sharing rate? Also, given the additional time needed to estimate erosion rates, where is the balance in the trade-off between cost-effectiveness in the use of cost-sharing funds and administrative cost?

Such concerns suggest that while VCS appears in concept to have great potential for improving cost-effectiveness of Federal soil erosion control efforts, care must be given to assure that it proves acceptable and effective in practice. Thus, research is needed to evaluate the impact of VCS in practice, within the context of the regular county component of the ACP relative to the traditional uniform cost-sharing approach. Only then can a more confident appraisal of its relative merit be made.

POLICY IMPLICATIONS

Kenneth Cook recently concluded that the "ACP will remain voluntary, and so limits on its effectiveness can be expected, even with considerable reform" but also that "there exists considerable room for improvement within the voluntary framework" [4, p. 27]. The findings from this analysis indicate that targeting special ACP water quality project funds to a critical watershed can provide a significant increase in the cost-effectiveness of soil erosion control efforts. Thus, continuance of special ACP and Rural Clean Water Program (RCWP) projects appears advisable. However, perhaps even more potential remains for increasing cost-effectiveness from targeting relatively highly erodible land and cost-effective practices within critical watersheds. Our findings suggest that some characteristics of current Federal soil erosion control programs need to be reappraised, including the whole-farm and soil loss tolerance aspects of the long-term agreements, the first-come, first-served nature, uniform cost-sharing, and out-of-pocket expense basis for cost-sharing of both the traditional approach and the long-term agreements.

Some explanation for why there was no more of an increase in treatment of highly erodible land and cost-effectiveness than occurred in the NFFD project is suggested by the nature of the long-term agreements. That approach embodies some of the basic principles of the conservationist philosophy: first, that conservation be viewed in the context of long-term, whole-farm planning; and, second, that every field be treated to the point where soil loss tolerance is met. This, of course, insures that highly erodible cropland will be taken out of production, though a farmer's primary interest may have been in constructing terraces or experimenting with conservation tillage on land eroding at only slightly above soil loss tolerance. But it also implies that cost-sharing funds will be expended for treatment of slightly erodible land, though a farmer's primary interest may have been in obtaining financial assistance in taking critical land out of crop production. In the NFFD project, 51 to 59 farms received cost-sharing for practices on fields with erosion rates of less than 10 TAY. The severity of erosion problems varied greatly across the average nine fields per farm, with few farms highly or slightly erodible as a whole. Only three farms had erosion rates of less than 10 TAY on all treated

fields. About 70 percent of the farms had acreage-weighted average erosion rates of 10-20 TAY. In such case, targeting to farms within a watershed is limited in its potential impact on cost-effectiveness. Targeting to fields within farms would have much greater potential impact. Thus, constraints on cost-effectiveness must be weighed against the advantages or there may be benefits of the whole-farm requirement, in terms of potential cost economies for administration of cost-sharing and technical assistance. However, cost-effectivensss may be substantially improved by targeting critical fields on a partial-farm basis. In addition, partial-farm contracting would likely increase willingness to participate by some farmers. 5/

The soil loss tolerance requirement of the LTA approach may also limit cost-effectiveness. Numerous studies have indicated that the marginal cost of additional erosion reduction often increases sharply as soil loss tolerance is approached. For example, for a field in the NFFD Watershed with Grenada soil, 5-8 percent slope, and typical slope length, soil loss tolerance could be reached only by establishing permanent vegetative cover or by practicing no-till with terraces or contour planting. Yet a conservation tillage method commonly used in west Tennessee would reduce the erosion rate from about 31 TAY to about 11 TAY. A farmer might be reluctant to participate in this case if neither of the former practices were viable options even with cost-sharing. Public funds for cost-sharing and technical assistance are expected to be severely limited relative to the acreage in the Nation needing treatment (according to the soil loss tolerance criterion). As such, the advisability of treating a small percentage of fields to tolerance versus a higher percentage of fields to some level above tolerance must be considered, even with the onsite soil productivity goal in mind. Pursuance of the offsite water quality goal clearly argues for treating the "worst first" up to the point where the marginal cost begins to increase sharply.

Prospective cooperators in the NFFD project were generally serviced on a first-come, first-served basis. 6/ With limited funds, this characteristic may have significantly limited cost-effectiveness. Over 150 farmers indicated interest in the NFFD project by signing up in the ASCS office before its initiation. However, there were cost-sharing funds for less than 100 farmers which covered only a small fraction of the highly erodible land in the NFFD Watershed. Over 20 percent (12) of the 59 farms analyzed in this study were on farms where the acreage-weighted average erosion rate was approximately 7.5 TAY or less for fields receiving treatment. Put another way, over 25 percent (16) of the 59 farms had a cost per ton of erosion reduction of more than twice the average overall. One way to address this problem would be to develop a criterion, such as acreage-weighted average erosion rate or total erosion, by which farms could be

5/ The local Coordinating Committee for the Reelfoot Lake Rural Clean Water Program in west Tennessee has recommended allowance of partial-farm contracting for this reason (7).

6/ This occurred in spite of the general policy of the Agricultural Stabilization and Conservation Service to service farmers on a priority basis (13). However, in reviewing this manuscript, ASCS personnel pointed out that first-come, first-served servicing was effectively eliminated in September of 1983.

ranked in terms of severity of erosion problem once an initial signup period had been completed. Then, farmers would be serviced according to this priority ordering until a contract had been accepted or rejected. Such a strategy would involve substantial upfront investment of administrative time and resources to allow SCS personnel to assess each farm, but might pay tremendous dividends in terms of more cost-effective use of actual cost-sharing funds. An alternative approach would be to set aside or reserve some percentage of funds for particular land capability or erosion rate classes, which would revert back to the State or Federal level if unused within a reasonable period of time. Program administrators at the local level need both an incentive and a mechanism for targeting funds within a voluntary framework.

One characteristic of Federal erosion control programs is uniform percentage cost-sharing, which generally applies regardless of the particular field or practice involved. Subsidies can be designed to give greater incentives for application of the most cost-effective practices on the most highly erodible land and to reduce rents, i.e., payments in excess of the minimum necessary to induce voluntary adoption, a reservation price concept. In this way, some degree of targeting can be accomplished even within the whole-farm, soil loss tolerance, voluntary, first-come, first-served approach. Ideally, the subsidies would vary, depending on the characteristics of each field, and would be in amounts just sufficient to cover net costs to the farmer, i.e., gross costs less any onsite soil productivity benefits. The subsidies would be offered in order of highest to lowest erosion reduction per subsidy dollar until available funds were exhausted. Though the costs of negotiating individually with each farmer to implement such a strategy are prohibitive, a bidding scheme might reduce rents with relatively low administrative costs. 7/ Other, perhaps more practical, subsidy strategies also appear to have potential as alternatives to uniform cost-sharing.

Offering a uniform subsidy payment per ton of erosion reduction is an attractive targeting strategy. Such a strategy would not eliminate rents but assures that best management practices (BMP's) will be applied only where the cost per ton of erosion reduction, as perceived by the farmer, is less than or equal to the subsidy rate. This type of strategy would discourage use of less cost-effective BMP's and treatment of slightly eroding land and encourage use of more cost-effective BMP's and treatment of highly erosive land. Consideration of such a strategy is perhaps constrained by its pure or straight subsidy nature in contrast to the traditional "cost-sharing" approach.

Variable cost-sharing (VCS), though, has some of the same efficiency attributes. VCS appears likely to generate substantial improvements in cost-effectiveness, if potential weaknesses do not prove serious in practice. Based on conceptual analyses incorporating participation prediction models and experience with VCS in the field, it may be possible to adjust its parameters to make it function even more like a subsidy per ton of erosion reduction strategy.

7/ The proposed Soil Conservation Act of 1984 (H.R. 3457) includes a title which would authorize offering of rental payments based on farmers' bids for putting highly erosive cropland into a conservation reserve for 7-15 years.

A final characteristic of the ACP which limits targeting to highly erodible land considered marginal for row crop production is the out-of-pocket expense basis for cost-sharing. Understandably, concern for maintenance of the "cost-sharing" approach and documentation of expenses has dictated that payments be made only to reimburse part of out-of-pocket expenses. However, this has imparted some bias in the incentive structure facing farmers, favoring practices like terraces over practices like permanent vegetative cover establishment. This is because the costs to the farmer of establishing permanent vegetative cover include the opportunity cost of income foregone from crop production, which may dwarf out-of-pocket expenses, especially if the farmer has no complementary livestock enterprise or strong cash hay market. Thus, an offer of 75-percent cost-sharing of out-of-pocket expenses may represent only 25-50 percent cost-sharing relative to total economic cost, perhaps too little to induce a farmer to take land out of crop production. Though enterprise budgets with average fixed costs included may suggest negative net returns for crop production on marginal, highly erodible land, farmers may rationally view crop production on 10 or 20 acres of such land on a 500-acre farm as a marginal decision and be concerned only with covering average variable costs with revenue from production on that land.

This logic also applies to shorter rotations of row and grass crops. A 5-year rotation with 3 years of hay may be less costly than terraces for a moderately erodible field, but no cost-sharing is available to offset the foregone income from row crop production. It is little wonder there were so few acres of rotations in the NFFD project. The new conservation reserve program being coordinated with commodity programs is an effort to increase the incentives for taking highly erodible land out of row crop production, but still within the framework of cost-sharing for out-of-pocket expenses. Breaking out of this framework would seem to be a necessity to make substantial headway in dealing with highly erodible land. 8/

The policy questions raised in this concluding section deal with strongly held views and traditions of the philosophy of both conservation itself and government involvement therein. Yet, the need for targeting to increase the cost-effectiveness of Federal erosion control policy is rapidly becoming (or perhaps has already become) a strongly held view as well. Some steps toward targeting have already been taken in the form of eliminating cost-sharing for production-oriented practices, designating special funds for critical watersheds or areas, and implementing a pilot variable cost-sharing program. Continuing review of these strategies and consideration of possible modifications in or alternatives to the current approach are needed to insure that progress is made toward more cost-effective use of the limited resources available for soil erosion control.

8/ The proposed Soil Conservation Act of 1984 (H.R. 3457) recognizes this in authorizing rental payments, above and beyond cost-sharing for cover establishment, for holding land out of row crop production.

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