COST SHARING AND COST-EFFECTIVE SOIL EROSION CONTROL POLICY

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ABSTRACT

An integer programming model is employed to simulate BMP adoption by farmers in a case study watershed in order to analyze the 1) limitation imposed on public cost effectiveness of federal soil erosion control policy by uniform cost sharing and 2) impact of a variable cost-sharing program on public cost effectiveness.

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This paper reports on an analysis of the 1) limitation imposed on public cost effectiveness by uniform cost sharing as an institutional constraint within federal soil erosion control policy and 2) impact on cost effectiveness of the pilot variable cost-sharing program. Following a brief conceptual discussion, the empirical procedure and findings are presented. The empirical procedure involved use of an integer programming model to simulate adoption of "best management practices" (BMPs) on a set of representative farms in a case study watershed.

COST SHARING IN THEORY AND PRACTICE

Current economic research suggests that subsidies are a necessary component of policies designed to induce voluntary adoption of BMPs to reduce soil erosion from agricultural land, and thereby limit declines in soil productivity and water quality degradation.

> Subsidies are a reality in nonpoint source abatement programs--emission standards are not--and one of the most pressing issues facing local and state units of government is the allocation of scarce federal, state and local funds in a manner conducive to the attainment of the goals of PL 92-500. In this context, financial incentives assume the pivotal role of inducing the application of pollution abatement technology on an individualistic basis rather than playing the role of dampening the financial burdens associated with meeting tolerable loadings [Sharp and Bromley, p. 592].

Subsidy programs, in principle, seek to compensate farmers by an amount equal to net BMP cost, i.e., gross costs for BMP adoption less the economic return from on-farm productivity benefits of soil erosion control. Because subsidy program funds are limited, cost effectiveness in their use should be a matter of concern [U.S.G.A.O., 1977a; U.S.G.A.O., 1977b].[1]

Currently the Agricultural Conservation Program (ACP), the primary federal effort to encourage soil erosion control, employs a cost-sharing approach to offering subsidies. Until recently, uniform cost sharing, across farmers and practices, has been the rule. However, the minimum cost-share percentage necessary to induce adoption of BMPs may vary significantly across farm situations. Consider terracing as an example. Gross cost differs widely depending on slope [Mitchell, Brach and Swanson], while on-farm productivity benefits from soil erosion control differ depending on slope and soil type [Buntley and Bell]. Net BMP cost for terraces, and thus the minimum cost-share percentage necessary to induce adoption, may also vary depending upon whether a farmer owns earth-moving equipment and builds the terraces himself. Terrace construction may be induced with 40% cost sharing in some cases, while 50% may be necessary in other cases, and 60% in still others. As a result, with a 50% cost-sharing rate some farmers are receiving "rents"; i.e., receiving cost-share payments in excess of their net BMP costs. Moreover, inducing additional BMP adoption within a uniform cost-sharing approach would require increasing the rate to perhaps 60% and result in rents being received by all farmers who would have adopted a BMP at a rate of less than 60%.

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[1]The goal of limiting the decline of soil productivity in view of projected world food needs in the future suggests that in the social utility function, reducing soil erosion by a given amount may be worth more on some types of land than on others. However, "cost effectiveness" in this study refers only to cost per unit reduction in erosion from any type of land, given the increasing emphasis on the water quality goal and the lack of any justifiable basis for establishing relative weights for the two goals.

In a more formal sense, the inability or unwillingness of the ACP administrators to practice perfect price discrimination in their role as a monopsonist buyer of soil erosion control leads to subsidy payment costs in excess of the minimum amount necessary to induce any particular level of soil erosion control. Rents could be reduced to zero if cost-sharing rates could be varied on a field-by-field basis as additional increments of erosion reduction are sought. However, there exist two constraints upon the possible extent to which such price discrimination could be employed. First, costs for information, contracting and policing would increase substantially as more differentiation was attempted. Second, political acceptability would be likely to dictate that the same cost-share rate be offered for adoption of a particular BMP on similar fields regardless of farmer characteristics which might influence net BMP cost.

From a more pragmatic perspective, the ACP has been modified in several ways in an attempt to increase the cost effectiveness of public expenditures. These efforts came in response to documentation of the fact that in recent years the bulk of cost-sharing funds was directed to slight to moderate erosion problems, with only 28% going for practices on fields estimated to be eroding at an annual average rate of greater than 10 tons per acre [U.S.D.A., 1980a]. First, additional funds are being targeted to highly erosive "critical watersheds." Second, a pilot variable cost-sharing program is being implemented.

The VCS pilot program can take one of two forms. One form bases cost-sharing rates on the initial erosion rate and the percentage reduction achieved in the erosion rate (PER). Percentage reduction, as estimated by pre- and postpractice application of the Universal Soil Loss Equation, is multiplied by the appropriate "severity" factor, as indicated in Table 1, to arrive at the cost-sharing rate, with a maximum of 75%. For example, terraces which reduce the erosion rate on a field from 14 TAY to 7 TAY (a 50% reduction) would qualify for 40% cost sharing (50% x 0.8 = 40%).

Table 1. "Severity" Factors for Percentage Erosion Reduction Form of VCS Program

Initial erosion rate class (tons/acre/year)	"Severity" factor
0-T[a]	0.0
T-10	0.7
10-15	0.8
15-20	1.0
20+	1.3

[a]Soil loss tolerance, which varies by soil between two and five tons/acre/year.

The other form of VCS bases cost-sharing rates on the land capability class of the field to be treated (LCC). The cost-sharing rate is set at 45% for class I and II land, 55% for class III, 65% for class IV and 75% for class VI and VII. As under the PER form, no cost sharing is available where soil loss tolerance is already being met.

Variable cost sharing, thus, could be expected to improve cost effectiveness in three ways: 1) by eliminating cost sharing where soil loss tolerance is already being met, 2) by encouraging some application of practices to fields (where cost per ton is relatively low) which would not have taken place with 50% cost sharing and discouraging some applications (where cost per ton is relatively high) which would have taken place with 50% cost sharing and 3) by providing less cost sharing in some cases where application would be undertaken at either the uniform or variable rate. Variable cost sharing of the PER or LCC form will not necessarily reduce rents as a percentage of total cost-sharing expenditures. However, variable cost sharing can conceivably improve public cost effectiveness by influencing the practices adopted and the fields in which they are implemented.

EMPIRICAL PROCEDURE

The North Fork Forked Deer Watershed in West Tennessee, where an ACP water quality project was initiated in 1979, served as the case study area for the analysis. Fifteen representative farms were developed on the basis of a random survey of 80 farms in the watershed and a Soil Conservation Service study of the watershed [U.S.D.A., 1980b]. These representative farms accounted for the approximately 32,000 acres of cropland in the 80,000-acre watershed. The farms were differentiated on the basis of soil type (Grenada/Loring, Lexington-Ruston, Memphis), tenure status (owner-operator or renter), crops (soybeans, wheat, corn), livestock (beef cattle or not), tillage practices (conventional, reduced or no) and ownership of earth-moving equipment (yes or no). Farms characterized by Grenada/Loring soils had four fields with slopes of 0-2%, 2-5%, 5-8% and 8-12%; Lexington-Ruston soils, two fields with slopes of 5-8% and 8-12%; Memphis soils, one field with a slope of 2-5%.

To remain relatively consistent with the characteristics of the ACP water quality project, which involved Long Term Agreements (LTAs) requiring reduction of erosion rates for all fields on a farm to approximately soil loss tolerance, only BMP options which reduced erosion rates to less than eight tons per acre per year were considered. Erosion rate reductions were estimated with the Universal Soil Loss Equation and information for West Tennessee from Jent, Bell and Springer. Fields with 0-2% slope required no BMPs. Fields with 2-5% slope had two BMP options, terraces with reduced tillage or no-till without winter cover. Fields with 5-8% slope had three BMP options, terraces with reduced tillage, no-till with winter cover or establishment of permanent vegetative cover. Fields with 8-12% slope had one BMP option, establishment of permanent vegetative cover.

To arrive at an estimate of net cost to the farmer for each BMP on each field, a gross cost estimate was developed. Then, on-farm productivity benefits from reductions in erosion estimated by Hunter and Keller were subtracted. However, to maintain consistency with the ACP, a gross cost basis for calculating the cost-share payment was developed differently. For terraces, construction costs estimated by Blisard were used. For no-till, a fixed cost of $18 per acre as established for the water quality project was used. This figure was somewhat above the gross cost estimate from which net cost was derived, which reflected reduced costs for labor but increased costs for chemicals and no-till equipment, as estimated by Ray and Walch. For cover establishment, costs for establishment of pasture were used, as estimated by Ray and Walch. However, in arriving at net cost, returns from pasture and crop income foregone were taken into account. In some cases then net cost for cover establishment was greater than the gross cost basis for cost sharing, implying that even 100% cost sharing would not induce voluntary adoption. The gross cost bases for cost sharing and net costs for all BMPs were converted to a present value basis, given a 10-year planning horizon and 8% discount rate.

The information developed on erosion reduction, gross cost basis for cost sharing, net cost and minimum cost-share percentage to induce adoption were incorporated into an integer programming (IP) model with a fairly simple structure. This structure essentially allowed for maximization of total erosion reduction subject to constraints on acreage per field and total net cost (to estimate the perfect price discrimination baseline) or minimum cost-sharing percentage (to simulate uniform cost sharing at various rates and the two forms of variable cost sharing). An IP approach was required to simulate the cost-sharing alternatives, basically because a linear programming approach would allow BMPs to come in on a partial field basis to circumvent the minimum cost-share constraint. In the integer program BMPs are included as zero-one activities with technical coefficients on a whole-field rather than an acre basis. If the technical coefficient representing the minimum cost share for a BMP is greater than the cost-share rate set on the right-hand side, then the BMP comes into solution on a whole-field basis.

EMPIRICAL RESULTS

The model was initially run on a linear programming basis in order to establish a "perfect price discrimination" or "no rents" baseline. That is, the model was employed to simulate application of BMPs in order of increasing net cost per ton of erosion reduction. This was accomplished by parametrically varying the right-hand side of the net cost constraint by $100,000 increments up to $2.6 million, at which point all of the 37 fields on the 15 representative farms were treated. This total cost curve is labeled "BASELINE" in Figure 1. Net cost per ton ranged from $0.10 per ton of erosion reduction up to $1.49. Twenty "different" BMPs were represented, i.e., the three basic BMPs distinguished by soil, slope, prepractice crop and tillage, tenure, livestock and equipment characteristics. Generally speaking, the order of application was permanent vegetative cover on the higher slopes, followed by no-till and then terraces with reduced tillage on the lower slopes.

Next the model was run on an IP basis to simulate various levels of uniform cost sharing. The right-hand sides for the minimum cost-share constraints were varied parametrically by 10% increments from a 10% up to 90%. The total public cost curve for uniform cost sharing is labeled "UNIFORM" in Figure 1 with individual points on the curve identified by the cost-share rate. No BMPs came into solution until the cost-share rate was increased to 30%. Public cost increased from $73,000 with 30% cost sharing to $2,845,000 with 90% cost sharing.

The "UNIFORM" curve lies above the "BASELINE" curve for two distinct reasons. First is the fact that as the uniform cost-share rate is increased, rents are paid in cases where BMPs would have been adopted with a lower cost-share rate. Rents represent 29.7% or $845,000 of public cost for the 90% cost-share level. Second, uniform cost sharing results in two types of social cost inefficiencies as well, which account for the additional amount by which UNIFORM lies above BASELINE, almost $900,000 at the 90% level, for example. The first type of inefficiency stems from the order of

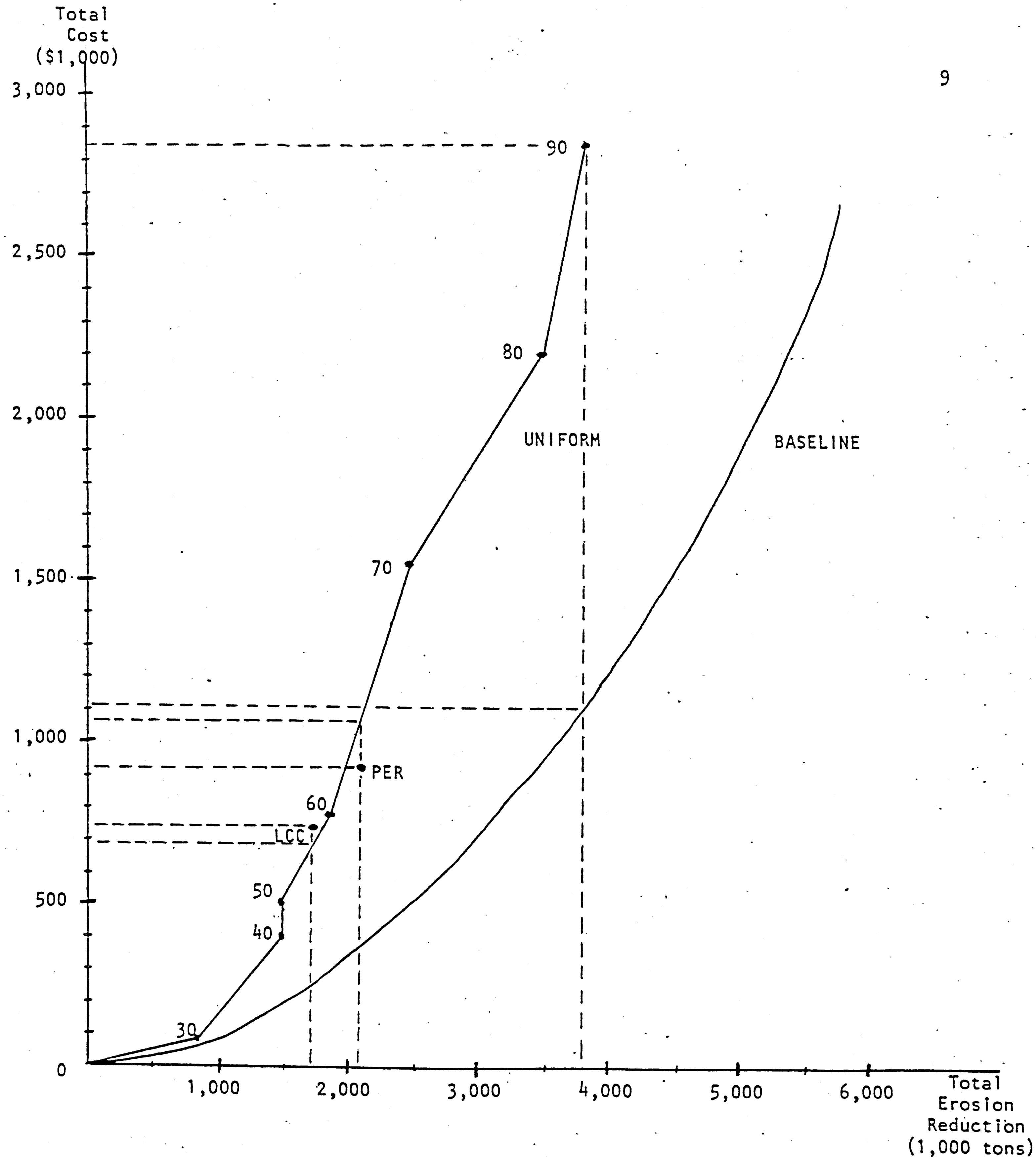

Figure 1. Cost Effectiveness of Alternative Cost-Sharing Strategies

BMP adoption. Net cost per ton for the BMPs is not always correlated with minimum cost-share rate. For example, for an owner-operator no-till (from conventional till) corn on Grenada soil with 2-5% slope ranks fifteenth among the 20 BMPs in the BASELINE solution but is adopted third in the UNIFORM solution because its minimum cost-share rate is 32%.

The second type of inefficiency stems from adoption on some fields of a BMP which is not in the BASELINE set of 20, i.e., it is not the socially cost efficient BMP for the field. Take the case of an owner-operator with livestock and earth-moving equipment growing reduced tillage soybeans on Grenada soil with 5-8% slope. Though net cost per ton for permanent vegetative cover is $0.55 compared to $1.00 for terraces, the minimum cost-share rate for the farmer is 78% for the former compared to 69% for the latter. This is primarily due to the lack of accounting for foregone soybean revenues in the gross cost basis for cost sharing on permanent vegetative cover.

Finally, to simulate the two forms of variable cost sharing, the right-hand sides for the minimum cost-share constraints were set in each case at the appropriate levels. Rather than total public cost curves, these two simulations each gave just one point.

Public cost and erosion reduction for the percentage erosion reduction form are indicated by the point labeled PER in Figure 1. Based on extrapolation between the 60% and 70% cost-share levels on UNIFORM, public cost under this form of variable cost sharing is 14.2% lower than under uniform cost sharing. This increased cost effectiveness was primarily due to cost-share rates under PER of only 41% for no-till (from conventional till) corn on Grenada soil with 2-5% slope, which was still high enough to induce adoption.

Public cost and erosion reduction for the land capability class form are indicated by the point labeled LCC in Figure 1. The result here was somewhat surprising, as public cost under this form of variable cost sharing was 6.6% higher than under uniform cost sharing, based on extrapolation between the 50% and 60% rates along UNIFORM. The reduced cost effectiveness in this case was primarily due to cost-share rates under LCC of 75% for permanent vegetative cover on 8-12% slopes, compared to approximately 57% (based on extrapolation) under uniform cost sharing, when only 26% to 31% cost-share rates were required to induce adoption.

Another basis for evaluating the two forms of variable cost sharing is to compare public cost per ton of erosion reduction for PER and LCC with that of 75% uniform cost sharing, as is generally employed in targeted water quality projects. In this case PER and LCC would be viewed as offering reduced rates of cost sharing for BMP application on less highly erosive land. Though total erosion reduction would be lower under PER and LCC as compared to 75% uniform cost sharing, public cost per ton estimates for PER and LCC were $.44 and $.42, respectively, compared to $.62 for uniform cost sharing. This 29% to 32% reduction is due to cost-share rate offers under variable cost sharing of 38% to 56% being less than the 63% to 67% necessary to induce adoption of no-till (from reduced tillage) soybeans on Grenada soils with 2-5% slopes.

For both forms of variable cost sharing, public cost is well above the BASELINE curve in Figure 1 for the same reasons that UNIFORM lies above BASELINE. Under PER, 28.2% of public cost reflects rents; under LCC, 43.9%. In addition, the socially cost efficient order of BMP application is not followed. Under both forms, the top three ranked BMPs come into solution, but the next most highly ranked BMP under either form is the twelfth one, with net cost per ton jumping from $0.27 to $0.61.

CONCLUSIONS

Uniform cost sharing has been shown to impose a substantial limitation on the potential cost effectiveness of federal soil erosion control policy. At typical rates of cost sharing, the combination of rents and socially inefficient ordering of BMP adoption served to more than double public cost per ton of erosion reduction relative to the theoretical minimum, which abstracts from administrative and political costs. Depending on the basis of comparison, variable cost sharing was shown to increase public cost effectiveness as much as 30%. The percentage erosion reduction form of variable cost sharing demonstrated somewhat greater potential than the land capability class form for increasing cost effectiveness. However, a comprehensive evaluation would necessitate estimation of increased administrative costs for estimation of prepractice erosion rates and erosion reductions versus those for identification of land capability class.

The evident willingness on the part of ACP administrators to consider and even experiment with innovative subsidy strategies portends well for future improvements in the cost effectiveness of federal soil erosion control policy. Further analyses of variable cost sharing are needed, particularly of actual experience in the field and administrative costs. In addition, conceptually appealing strategies such as offering a uniform subsidy per unit reduction in erosion deserve careful analysis in as realistic an empirical context as possible.

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