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INSTITUTIONAL CONSIDERATIONS
IN TARGETING SOIL CONSERVATION EFFORTS

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Preface

A number of term papers prepared for Agricultural and Applied Economics 8-264 have been of high quality. For several of these papers the students were willing to rewrite the papers for a more general audience. These papers are being issued in the Staff Paper Series of the Department of Agricultural and Applied Economics.

This paper by Matt Smith provides a framework for targeting our soil conservation efforts. He argues that physical, economic and institutional parameters must all be included if our targeting efforts are to be effective.

September 1983 K. William Easter Lee R. Martin

INSTITUTIONAL CONSIDERATIONS IN TARGETING SOIL CONSERVATION EFFORTS

Matthew G. Smith [1/]

INTRODUCTION

The concept of targeting soil conservation efforts and funds to areas where they can be most effective has drawn increasing interest in recent years. Revelations such as that over half of the conservation practices partially funded through the federal Agricultural Conservation Program had been applied to land without serious erosion problems raised the need for a more efficient allocation of public resources. A resurgence of public interest in the problem of erosion and closer scrutiny of the effectiveness of virtually all government programs has added emphasis to the search for new approaches to soil conservation policy.

Soil erosion does impose significant agricultural and environmental costs on society. Erosion of the topsoil exceeding the rate at which it is naturally regenerated poses a threat to the long term productive capacity of farmland, although the confounding effects of improved capital inputs and management over the past forty years make the relationship between soil loss and agricultural productivity difficult to quantify (Ogg et al, 1982). Erosion from agricultural land causes extensive environmental damage as well. It has been estimated that 4 billion tons of sediment enter United States waterways annually, 3 billion tons of which originate in agriculture. Waterborne sediment damages, in the form of costs of dredging silt from rivers and harbors, reduced life of reservoirs, downstream flooding, and other damages, were estimated in the 1960's to cost $500 million annually (Pimental et al, 1976). With the increase in erosion that is generally agreed

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to have accompanied the grain export boom of the 1970's (Heady, 1982), and the conversion to 1983 dollars, the cost of sediment damages is undoubtedly much higher today.

Sedimentation also imposes a range of environmental damages that are even more difficult to assess. Siltation and turbidity caused by agricultural runoff can destroy fish and wildlife habitat and otherwise reduce recreational and aesthetic values. Chemical residues entering the water with sediment from agricultural land may cause environmental damages in the future that are not even anticipated at present. Although difficult to measure precisely, the magnitude of benefits that could be realized from more effective control of soil erosion is thus potentially very great.

This paper will outline an approach to targeting soil conservation efforts that rests upon an analysis of physical, economic, and institutional parameters. Within this context, the literature on the relationship between soil erosion and some common arrangements of land ownership and control will be examined to provide insights useful in the formulation of public policy and to suggest further opportunities for research.

A Targeting Strategy in Three Dimensions

Current federal soil conservation policies are based on the principle of voluntary cooperation by farm owners and operators, pursued through education, technical assistance, and cost-sharing for the installation of erosion control devices such as terraces. If future policies are to continue to rely on voluntary participation, an appropriate soil conservation strategy must take into consideration not only physical and economic variables such as average rates of erosion or costs per ton of erosion reduction, but also the social, cultural, economic, and legal context within which the individual farm owner or operator must decide whether or not to undertake a voluntary program of conservation. If the individual's decision to participate is the key to the success of our soil conservation policies, then a knowledge of the circumstances that promote or retard that decision is essential for developing successful policies.

Physical Parameters

The basis for an effective targeting strategy must be a reliable data base detailing the physical magnitude of current soil erosion. While this data base has been greatly improved in recent years due to efforts such as the 1977 National Resources Inventory, there remain many important physical parameters and relationships which have not been adequately defined. Two of the most critical gaps in current knowledge relate to the extent of net soil loss from particular tracts of land, and the proportion of sediment dislodged by erosion that actually finds its way into water bodies.

Net soil loss from a given field is that proportion of the material dislodged by erosion that is actually transported out of the field and not merely from one location to another within the field. The use of the Universal Soil Loss Equation (USLE), designed to estimate the amount of soil moved by water from its original position, to depict the amount of topsoil irretreivably lost to the farmer due to erosion overstates the true extent of those losses. Soil collects in depressions, along fence lines, and at the toes of field slopes, thus effecting a transfer of some topsoil and fertility within the field that must be subtracted from the gross soil movement predicted by the USLE (Wischmeier, 1977). This point has been so frequently misunderstood or ignored that one observor has suggested that "loss" in the USLE be replaced with "displacement" (Cook, 1982).

The divergence between soil movement as predicted by the USLE and actual losses of soil from individual farms holds important implications for individual farmers trying to assess whether or not to invest in soil conservation (Miller, 1982). At the aggregate level, matters are complicated further by the effects of soil transported between farms, as in the case of soil washing from a cornfield onto an adjacent pasture owned by another farmer, or soil deposited on floodplains far downstream. In these cases the net loss of soil resources would appear to be less than that suggested by the USLE, and the cost of such erosion in terms of productivity losses would perhaps be less than anticipated. The available data are thus not entirely adequate for describing the physical phenomena that underlie any potential losses in productivity.

A similar problem exists in determining the contribution of individual tracts of land to stream sedimentation and other water quality problems. Even at the watershed level, sediment delivery ratios, which denote the fraction of displaced soil actually entering waterways, can vary from .06 or less to as high as .50, depending on the size of the watershed, soil types, and topography (Cook, 1982). Sediment loadings from individual tracts can be even more difficult to predict, although efforts are underway to develop sophisticated field-level models of soil movement and delivery (Osteen et al, 1981).

The currently available data base is thus inadequate for measuring precisely the extent of net soil losses from erosion or the amount of sediment entering waterways as a result. As one writer put it, "We just do not know very well where the eroded soil goes." (Cook, 1982, p. 91) When added to the uncertainty over the degree to which soil losses result in agricultural productivity losses, a great deal of ambiguity is introduced into the physical parameters that underly the economic analysis of soil conservation problems. Three researchers recently observed that none of the economic analyses of the effects of soil erosion that they had encountered had been based on a sophisticated model of the physical processes involved (Osteen et al, 1981).

Effective targeting of soil conservation programs requires that scientists achieve a more detailed understanding of the physical relationships between particular practices in a given location and the actual impact on soil depth and structure and on water quality. While such an understanding will be difficult and costly to achieve, and probably will never be accomplished completely, it is important that economists recognize the limitations of the physical parameters on which their analyses rest and that they urge their continued refinement.

Economic Parameters

A second dimension of analysis necessary for effective targeting is the attachment of economic values to physical parameters. At the aggregate level, the economist's aim should be to identify the social costs and benefits of marginal changes in the amount of soil lost from agricultural use or deposited in streams and rivers. Ideally, to allow precision in targeting, this analysis of costs and benefits should be done with as detailed a geographic focus as the physical data base will permit. Marginal costs per ton per acre of erosion reduction vary according to soil types, cropping patterns, topography, and types of conservation practices employed. The marginal benefits to society of erosion and sedimentation reductions are even more elusive, particularly in the case of improved water quality, which confers a range of recreational and aesthetic benefits that for the most part are not traded in private markets and are difficult to value. Differences in sediment yields between fields in a given watershed, as well as differences in the economic value of sediment reductions among watersheds, suggest that if water quality is to be a consideration in targeting soil conservation efforts, the most appropriate focus of evaluation should be areas within critical watersheds which have high delivery rates.

This approach is of course replete with difficulties. As already mentioned, the available physical data appear to be inadequate to the task. Much necessary economic analysis remains undone as well. While it is possible in concept to evaluate the costs and benefits of changes in the quality and character of environmental resources, it is extremely difficult to do so in practice, and this difficulty has been noted frequently in the literature (Krutilla and Fisher, 1975; Freeman, 1979).

A recent proposal for targeting soil conservation expenditures is illustrative (Ogg et al, 1982). Using data from the 1977 National Resources Inventory, a number of counties with at least some land eroding at rates in excess of 50 tons per acre per year were identified. By placing the less than 1 percent of cropland currently eroding at this rate in adequate conservation practices, over 30 percent of the gross soil loss by weight from land currently eroding at rates in excess of 5 tons per acre could be eliminated. This would also allow a considerable reduction in costs per ton of erosion control over current programs. The critical link in their analysis is the assumption "that a ton of soil conserved on a steep field with a shallow topsoil is as valuable in maintaining productivity as conserving a ton of soil on a relatively non-erosive field." It was also assumed, at least implicitly, that each ton of erosion reduction anywhere has an identical value in terms of improved water quality. The proposal later concedes, however, that "erosion's impacts on water quality and crop yields are unknown on most erosive soils," and that "the benefits of conserving soil... seem to depend upon several parameters that have yet to be researched." (Ogg _et al_., 1982, p. 71)

While the constraints imposed by data limitations must be acknowledged, as well as the political difficulties confronting any proposals to alter the present distribution of soil conservation subsidies, it is important to recognize that such approaches are essentially noneconomic ones. A search for lowest-cost per ton opportunities to reduce erosion offers an improvement over current practices, but represents only half the evaluation economists should make to identify areas most in need of conservation practices.

Research focusing on the economics of soil conservation at the farm level is another important component in the development of effective targeting policies. Since analysis at this level is concerned solely with costs and benefits incident on the individual farm enterprise, the problem of estimating off-site damages can be avoided and the analysis made much more tractable. As a result, a number of studies utilizing traditional farm management research techniques have attempted to determine the relative profitability of different degrees of erosion reduction through a variety of conservation practices on a range of different soils and topography. While subject to some of the data problems relating to soil movement and loss mentioned earlier, such farm level approaches to the economics of erosion control hold much promise. One aim of such research should be to gain insight into the extent to which farmers in different areas face different private economic incentives to control soil erosion, and the sensitivity of those private incentives to changes in planning horizons, personal discount rates, input and output prices, and production and conservation technologies.

The analysis of physical and economic data together holds great potential for achieving a more efficient allocation of soil conservation funds. It should aid in the systematic identification of areas in which the net benefits to society of reductions in soil loss are greatest, and suggest the degree to which farmers in those areas can be expected to act out of self interest to reduce erosion in the absence of any public intervention. The result should be to identify those geographic areas in which the marginal returns to society of public subsidies to conserve soil would appear to be the greatest. A number of intervening factors can influence the effectiveness of conservation policies built on these two parameters alone. Individual farmers' soil conservation decisions are conditioned by a variety of influences that are difficult to include in models but are nonetheless critically important to the ultimate success or failure of voluntary erosion control policies. It is thus appropriate to include a third dimension of analysis in the development of effective targeting strategies.

Institutional Parameters

A variety of legal, cultural, and social influences, broadly defined as "institutions," are important in molding farmers' attitudes and behavior toward land use and soil conservation (Barlowe, 1978). Government policies on taxation, agricultural price and income supports, and those influencing the allocation and pricing of credit exert great influence over production decisions. Cultural and religious factors influence farmers' attitudes toward soil stewardship and their responsibilities to their neighbors and to future generations. The level and type of education that farmers receive affects their ability to implement technologically complex conservation practices. And arrangements, both formal and informal, that allocate rights to the control and ownership of land are important in shaping resource use, by influencing time preferences and the distribution of returns from conservation investments.

Each of these factors may exert profound influences over farmers' perceptions of the returns, both monetary and nonmonetary, from soil conservation, and thus on their willingness to implement such measures on their own. A better understanding of the effects of these variables can aid in the identification of those farm owners or operators who, at least on the basis of some institutional classification, would appear to control soil erosion at desired levels without public intervention. Such an understanding could also provide valuable insights into the nature and extent of government involvement necessary to induce voluntary participation, be it education, technical assistance, or the payment of cash subsidies. It may also suggest institutional innovations that could promote conservation goals at lower cost.

There are a number of difficulties involved in the investigation of institutional influences on soil conservation. Relevent data in many cases are difficult or impossible to obtain, and that which is available may not capture the salient features of the institutions in question. Bromley (1980) noted in commenting on one such effort that

> ... ownership classes are legal descriptions which attempt to define different types of decision units, when in fact they merely define different types of income and cost accounting practices. I am skeptical that institutional arrangements designed for tax purposes are relevent to how people use their soil resource. (p. 1089)

Problems may also arise in isolating the effects of particular arrangements.

Does the conservation performance of large, corporate farms relate more to their legal status or size, or to some third factor? Is soil erosion on small farms a function of their size, or the family's income or education, or the mix of enterprises, or other factors, and to what degree is each important? The individual impacts of particular phenomena are difficult to assess. Nevertheless, there are important insights to be gained from such an exercise which can aid in the development of effective soil conservation policies. A better understanding of the general influences of some common institutional parameters can aid in focusing current conservation efforts, and suggest the likely impacts on soil conservation of long term changes in the legal and economic organization of agriculture.

An appropriate soil conservation targeting strategy must therefore rest on three types of parameters. Data describing the physical processes associated with soil erosion, in as fine a detail as possible, must serve as the foundation. Relating values to the physical quantities involved will allow priorities to be set based on the costs and benefits to society of erosion control in given areas and to suggest the degree of control that would be optimal. Physical and economic data together can thus be used to identify those areas where erosion control is most critical. Institutional parameters can then aid in the third important level of analysis, that of identifying farm owners and operators for whom public intervention can be most effective in meeting society's conservation goals. Institutional analysis thus affords the possibility of developing the most effective soil conservation targeting policy: one that focuses on "critical people" within "critical regions." The next section includes a discussion of the impacts of one such group of institutional arrangements on soil conservation practices, that of ownership and control of farmland.

Land Tenure Characteristics and Soil Erosion

The concept of land tenure concerns the many relationships established among people that determine their varying rights to control, occupy, and use landed property (Barlowe, 1978). The impact of these various relationships on the extent to which good soil conservation practices are followed is a topic that has long held the interest of economists, and it has attracted renewed attention with the recent rekindling of the debate over the evolving structure of American agriculture. In the following pages, both theoretical and empirical evidence bearing on the links between soil erosion and some common tenure arrangements will be examined. Implications for soil conservation policies will be drawn where possible, and topics for further investigation will be suggested.

Farm Tenancy

The impact of tenancy on farmers' soil conservation behavior has been of interest for many years,[2/] and has probably been the most studied tenure institution in relation to soil erosion. A number of economists have considered the effects of farm tenancy from a theoretical perspective. Bunce (1942), among others, suggested that the insecurity of tenure that often accompanies farm leasing encourages exploitation of the soil. Ciriacy-Wantrup (1952) also emphasized this point, noting that by introducing shorter planning

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[2/] George Washington, for example, wrote in 1784 that he would lease none of his land to his neighbors, "for this obvious reason, that the weight of their labour, and burden of their crops, whilst it was in a condition to bear them, would fall upon my Land, and the improvement upon his own." Writings of George Washington (Washington, DC: Government Printing Office, 1938), XXVII, p. 344, cited in Raleigh Barlowe (1978): Land Resource Economics (Englewood Cliffs, N.J.: Prentice-Hall), p. 495.

horizons of the tenants, conservation problems arise in cases where all expected revenues and costs functionally related to the actions of the tenant are not incident upon him. The tendency in such cases will be toward underinvestment in soil conservation. Ciriacy-Wantrup suggested that these obstacles could be overcome by the introduction of long term leases and the principle of compensation for deferred revenues and costs, and by policies to encourage the ownership of farms by their operators.

More recently, McConnel (1983) has applied principles of optimal control theory to derive conditions under which the interests and behavior of tenants and owners can be expected to diverge. Two assumptions are important to his analysis. First, he assumes that owners and renters have equal planning horizons. Second, he assumes that farm real estate values accurately reflect the effects of past soil conservation practices, and that erosion progressively lowers the eventual resale value of farmland. If farm owners seek to use (erode) their soil resources at a rate that maximizes the sum of annual discounted returns plus the eventual resale value of the farm, they face higher user costs from soil loss than do renters, who seek only to maximize the flow of annual returns. Under these circumstances rented farms can be expected to suffer more erosion than owner operated farms.

A number of investigators have attempted to validate empirically the relationship between farm tenancy and soil conservation. Two general approaches to this problem have predominated. One has been to use the techniques of farm enterprise analysis (generally linear programming) to identify those soil conservation practices that are profitable to individual farm operators over time, and from these results to make judgments about the relative attractiveness of conservation to owners and renters (Seitz et al, 1979; Erwin and Washburn, 1981; Banks, et al, 1983). The second approach has been to utilize data on the actual use of conservation practices or rates of erosion, at varying levels of aggregation, to search for differences in farmers' treatment of owned and rented cropland (Frey, 1952; Lee, 1980; Erwin, 1982).

The use of optimization modeling to provide insights into farmers' soil conservation decisions is of comparatively recent origin. It was spurred by the difficulty that researchers encountered in interpreting the results of analyses of actual farms, due to the confounding of the effects of soil conservation with those of other practices (Seitz and Swanson, 1980). The most frequent approach has been to model the problem as one of income maximization constrained by different allowable levels of soil loss. The general conclusion of these studies has been that investments in soil conservation, particularly those requiring large initial capital outlays, do not return great dividends to individual farmers. One such study, for example, which focused on an area in Illinois chosen to be generally representative of much of the Corn Belt, concluded that typical farmers there would not find it profitable to adopt soil-conserving practices unless their planning horizon exceeded 40 years and they did not discount future earnings (Seitz et al, 1979). If the farmers did discount future earnings at the relatively low rate of 5 percent, the planning horizon would need to be approximately 60 years. A Missouri study reached similar conclusions, particularly with regard to practices such as countour stripcropping and terracing, for which it was found that the costs significantly outweighed the benefits (Ervin and Washburn, 1981). Seitz and Swanson (1980), who have been very active in this area of research, have concluded that "In general, these studies support the weak private economic incentive hypothesis." (p. 1085)

One exception may be in the use of conservation tillage technologies. Crosson (1981) concluded that under the price and other conditions prevailing in 1979, conservation tillage enjoyed a cost advantage of 5 to 10 percent over conventional tillage, due largely to savings in labor. Since it generally requires little or no investment in land improvements or changes in cropping patterns, it can be compared directly with conventional tillage on the basis of annual costs and returns. The length of the farmer's planning horizon would thus appear not to be critical to the profitability of conservation tillage.

This conclusion is supported by the results of a recent study focusing on the management decisions of owner operators and crop-share tenants on a variety of Iowa soils (Banks et al, 1983). They assumed that maximization of net annual returns in 1985 was the sole objective for both tenure classes and that tenants enjoyed sufficiently long leases to realize the full return from any conservation investments they made. The analysis suggested that under most circumstances tenants face short-run incentives to adopt conservation tillage practices which are at least equal to those faced by owner operators. On some highly erosive soils, tenants whose leases require them to pay most or all of the production expenses in exchange for their crop share may prove even more inclined to adopt conserving practices than landlords. The analysis also indicated that neither owners nor tenants would find structural practices such as strip cropping or terraces to be profitable investments if only short-run returns were considered.

Conservation tillage is not appropriate in all areas, however. On poorly drained soils or where perennial weeds are a severe problem, the practice is not as attractive (Crosson, 1981). Tillage practices by themselves are also not always sufficient to control erosion at acceptable levels even where practicable. Menz and Sundquist (1983) estimated that conservation tillage practices are sufficient to reduce erosion to within tolerance levels (based loosely on the rate at which topsoil is thought to be formed naturally under good husbandry (Cook, 1982))on 83 percent of presently cultivated Corn Belt soils. Additional supporting practices such as crop rotations or terracing will be required on the remaining acres.

The distinction between soil conservation practices that provide benefits in the year in which they are used, such as conservation tillage, and those where the benefits are realized more slowly, such as contouring or crop rotations, is critical. In the first case, tenancy would appear to present no particular barrier to adoption, because the tenant is able to recognize gains from the practice even within the context of a very short planning horizon. In the case of conservation practices promising slower returns, tenants have even less incentive than owners to adopt them. On this basis, one would expect tenant operated farms to suffer higher levels of erosion, relative to erosion potential, than owner operated farms.

Empirical studies have generally confirmed that renters treat farmland differently than do owner operators. In a study of obstacles to soil erosion control in western Iowa in 1950, Frey (1952) concluded that farm tenancy was a significant barrier to conservation. The percentage of land in row crops, which are highly erosive, was much higher on tenant operated than on owner operated farms. More than a third of the farmers surveyed listed their rental arrangement as the reason they did not practice more soil conservation. More recently, Kraft (1978) surveyed a group of New York farmers and obtained similar results. The farmers, who rented on average one third of the acreage they operated, tended to manage their rented land much differently than their owned land. For example, they frequently grew corn on rented land for four to six years continuously as opposed to one or two years on their own land. Significantly, the farmers surveyed indicated that when they purchased land that they had formerly rented, they changed their cropping patterns by establishing more forage crops on the steeper slopes and moving to shorter corn rotations on the more level parcels. Both of these practices can be effective in reducing erosion.

Research focusing on the use of conservation practices such as terraces, grassed waterways, and contour farming, which tend to provide returns more slowly, has yielded more ambiguous evidence on the effects of tenancy. This is probably a reflection of the results obtained by optimization modeling, indicating that such investments are frequently only marginally profitable even for those owners who expect to hold their property for many years. A study of a watershed in northeast Nebraska, chosen because of the high rate of erosion it currently suffers, found no significant differences in the number of such conservation practices used on land operated by owners or tenants (Hoover and Wiitala, 1980). On the other hand, Baron (1981), in a study based on questionnaires completed by nearly 7,000 landowners in the Corn Belt, Delta, and Northern and Southern Plains production regions, concluded that landowners who operated at least a portion of their land were much more likely to have invested in conservation practices than nonoperators leasing their land for cash. Neither of these studies considered the amount of money invested in conservation practices, the amount of land affected, or their effectiveness in reducing erosion.

A study of one county in Missouri (Ervin, 1982) revealed that the percentages of conservation practices were significantly higher on owner operated land for terraces, grassed waterways, contour farming, and crop rotations with hay or pasture. No statistically significant difference was found in the use of conservation tillage by the two tenure classes, however. Ervin also calculated actual erosion rates on owned and rented farms using the USLE. His analysis, based on a random sample of 120 farms, showed that erosion was 40 percent higher on rented land, despite higher erosion potential on the owned land.

Lee (1980; Lee and Stewart, 1983) has used merged data from the 1977 National Resources Inventory and the 1978 Landownership survey to search for differences in soil conservation practices among tenure groups. Her earlier (1980) analysis focused on the impact of landownership arrangements on observed rates of soil erosion at the farm production region level. The results indicated that only in the Northeast region were average erosion rates on rented cropland significantly higher than on owner operated cropland. Differences in erosion rates among tenure groups in other regions were not statistically significant. It is difficult to draw conclusions about the effect of tenure institutions on soil conservation behavior from these results, however, since the data used did not allow the effects of management practices to be separated from those of physical factors.

Lee and Stewart's subsequent (1983) investigation of tenure status and conservation tillage, using the same data base, revealed that part-owner operators had significantly higher proportions of their total acreage under conservation tillage practices than did full-owner operators. This relationship held across all farm production regions, although it appears to be heavily influenced by the larger average size of farms operated by part-owners. The implication is that farm size, rather than tenure status, may be the most important variable in determining use of conservation tillage.

The weight of the empirical evidence thus appears to support the proposition that farm tenancy tends to impede the adoption of those soil conservation practices requiring large initial investments or imposing large opportunity costs on the tenant, but has little effect on operators' decision to use conservation tillage.

On this basis, the distinction between conservation tillage, for which tenancy does not appear to present obstacles to adoption, and other longer-term investments in soil conservation hold important implications for developing effective targeting policies. In those areas in which the desired level of erosion control can be achieved solely through the use of conservation tillage practices, there is little reason for policymakers to focus their attention on farm tenants as a group. In such areas, factors other than the tenure status of the farm operator may be most important to the adoption of conservation tillage. These might include receptivity to innovation, and the willingness and ability to use herbicides necessary for successful conservation tillage.

In areas requiring more intensive treatment such as contouring, terracing, or switching to high-forage crop rotations, however, there appear to be clear differences in the degrees to which owner operators and tenants face private economic incentives to control erosion. This in turn influences the extent to which each tenure group can be expected to practice conservation in the absence of government intervention. Thus a number of important questions arise concerning the most appropriate targets for additional conservation incentives. Ervin (1982), based on his study of erosion on owned versus rented cropland, has suggested that public conservation programs should focus on farm tenants by offering them cost sharing for capital improvements to reduce soil loss. On the other hand, it has also been suggested that landlords are the group meriting the most attention from policymakers, on the grounds that they have a direct economic stake in the deterioration of their assets, a stake that educational efforts can make them more aware of (Barkley, 1982; McConnel, 1983). Landowners would then be expected to require better soil conservation from their tenants. This issue has been given added urgency by the increasing separation between the ownership and control of farmland that characterized the 1970's (Raup, 1982).

The debate seems to turn on the degree to which farm real estate values reflect the extent of past soil conservation practices. If soil depth (as a measure of past erosion) does affect farm values, then educating landlords about that fact could be an effective policy instrument. If soil depth does not affect land values, or affects them only partially so that conservation investments are not profitable, then there is little evidence with which to educate landlords, and tenants are thus the proper focus of policy. The actual relationship between soil conservation and farmland values has received little or no attention from researchers in recent years. Such an analysis could yield important insights for the formulation of conservation policy.

Cash Versus Share Rents

Within the institution of tenancy, the types of rental arrangements employed have been thought to influence tenants' patterns of resource use.

Ciriacy-Wantrup (1952) concluded that under most circumstances a crop share rent or a variable cash rent was preferable to a fixed cash rent from the standpoint of soil conservation. He argued that fixed charges tend to speed resource depletion as compared with the case where the same amount is paid over the course of an entire business cycle. During periods of lower commodity prices fixed charges increase the proportion of income allocated to pay rents and reduce the prospective value of future production, thus increasing depletion. This is not materially offset during boom periods, he continued, because changes in income have smaller effects on time preferences as incomes increase. Applying this principle to farm leasing arrangements, he suggested that fixed land charges such as cash rents were obstacles to erosion control. The more equal sharing of risks between landlords and tenants under crop sharing mitigates the tendency toward exploitation of the soil. The greater involvement of landlords in the management of farms that is typical under crop share leases also offers the possibility of better soil conservation by circumscribing more closely the production decisions of tenants (Johnson, 1972).

A number of empirical studies have included lease type as an explanatory variable in their models. Baron (1981) found that in three of the four farm production regions studied, landlords who operated their property on a crop share basis were significantly more likely to have made some kind of investment in soil conservation than landlords using only cash leases. More localized studies have not observed significant differences in soil conservation under different lease types. Hoover and Wiitala (1980) reported that the type of rental arrangement in effect on the Nebraska farms they sampled was not a significant predictor of either the landlord's perception of the severity of erosion problems or of the number of conservation practices adopted. Ervin's

(1982) study of Missouri farms revealed that the type of lease used was not related, at statistically significant levels, to observed rates of erosion. Thus the particular relationship between types of rental arrangements and soil conservation practices remains open to question.

The most important feature of cash renting as it relates to farmers' soil conservation decisions is the potential it raises for imposing high fixed charges against the land resource. While the division of lease types into cash and share rentals affords an approximation of the likelihood that such conservation-detering charges against the land will arise, this phenomenon is not an exclusive feature of cash rent leases. Institutional distinctions that are useful in one context may be quite misleading in another. In this case, the most analytically relevent variables would seem to be the level and schedule of payments made by the farm operator to secure control of the land, whether holding legal title to the property or not.

A number of authors have made this point. Bunce (1942) noted that high economic rents capitalized into land values created fixed charges against land which would be difficult to meet in times of lower crop prices without exploiting the soil. He spoke with the experience of the 1920's fresh in mind, when good soil husbandry was largely abandoned to pay off mortgages taken on during the grain and land boom associated with World War I. Ciriacy-Wantrup (1952) observed that

> Farmers or ranchers who own their land but who are obligated to pay high interest and amortization charges may fear they will be dispossessed by their creditors in times of drought or economic depression; they have no more interest in soil conservation than a tenant with a short lease. (p. 145)

High fixed costs, and the constraints that they impose against any sacrifices in current income for the sake of conservation goals, characterize the situation facing much of agriculture in the mid-1980's. Current farmland values largely reflect the capitalization of the rents and expectations of a decade ago, at levels much higher than current returns would justify. Many landowners acquired their property during the 1970's (Lewis, 1980), often lured by the prospect of future capital gains, and must now contend with the cash flow difficulties resulting from falling farm incomes. Whether operators or landlords, farmers in these circumstances face strong incentives to abandon any conservation practices which reduce current income and thus jeopardize their continued landownership. The most extreme situation is that faced by those "owners" of farmland currently purchasing their property under contracts for deed. Since they do not hold legal title to the property their equity in it is less secure than those who purchase under mortgages. Thus they find it rational to exploit the soil to whatever degree necessary to make the contract payments and safeguard both their paid equity in the contract and any increases in the property's value that have occurred since the contract was written. The purchaser has little to gain and almost everything to lose from investing in soil conservation. The insecurity of property rights under this arrangement thus creates a climate that is extremely unfriendly to the control of erosion. This holds important implications for states like Minnesota, where in recent years 60 percent of all farmland transfers have utilized contracts for deed (Smith and Raup, 1983).

Based on this understanding of the effects of fixed charges on conservation decisions, one would expect that factors such as how long ago land was purchased, the instrument used to obtain it, the price paid and the terms under which it is to be paid for would all exert powerful influences on the degree to which soil conservation is practiced. Adjacent parcels of farmland which are identical in all respects except the level of debt could vary quite dramatically in the levels of erosion which their owners would find optimal to tolerate. This tendency would be reflected directly by the landowner's management decisions in the case of owner operatorship or rental for shares, or indirectly under cash tenancy through the landlord's ability to offer reduced rents to those tenants willing to practice conservation.

These issues merit the attention of researchers. Land payments are one of the least flexible constraints with which soil conservation policy must contend. A better understanding of the circumstances under which conservation investments become impossible from the landowner's point of view can aid in the development of effective targeting strategies. There are a number of serious obstacles, however. Relevent data are not available at present and would be extremely difficult to collect. This more than anything else probably explains why researchers have often used cash renting as a proxy for high fixed charges. Policies based on distinctions between the financial situations of otherwise comparable owners would raise thorny questions of equity as well. In the long run, policies aimed at achieving a level of land values that is sustainable by agricultural incomes under good soil management probably offers the best hope for promoting conservation goals.

Farm Size

In recent years the view has been expressed by some of those involved in the debate over the structure of American agriculture that large farms practice less soil conservation than small farms (Farm Structure Project, 1980).

Much of the economic literature, however, suggests that at least in theory small farms constitute more of an obstacle than an aid to soil conservation. Bunce (1942) argued that farms too small to support a family at an acceptable standard of living were a major cause of soil exploitation. Ciriacy-Wantrup (1952) suggested that the problem of high fixed rents was particularly acute on smaller properties. Imperfections in loan markets and limitations on managerial capacity and mobility, among other factors, tend to make demand for smaller properties greater then the potential income they can provide. Rents are bid up, and depletion is hastened. On the other hand, one might expect that the large cultivating and harvest machinery typically used on the largest farms would cause them to be more reluctant to invest in structural measures such as contouring and terraces, because of the difficulties in "farming around" these structures with big equipment.

A number of conceptual problems arise in evaluating the effects of farm size on erosion. How does one define a small farm? If in terms of acres, how many? Should one refer to the size of units operated, or the size of the ownership units involved? Or should one define farm size in terms of gross or net receipts? And how should the definition of small farms vary from one region to the next? Separating the effects of farm size from those of other factors, such as erosion potential, mix of enterprises, or the operator's level of education and willingness to innovate, also raises difficulties.

Empirical investigations have reflected these dilemmas, with some researchers using farm incomes and others using the acreage owned or operated to define farm size. Lee (1980) examined the relationship between net farm income and erosion at the national and regional levels. Her analysis indicated that among full owner operators, higher net farm income levels were associated with lower rates of erosion nationally and in five of the ten farm production regions. The association between farm income and erosion was not significant within other tenure groups. Lee noted that a much higher proportion of the cropland owned by the lowest income groups was classified as erosion-prone than that owned by the highest income group. In terms of management, on the other hand, a much higher proportion of the land owned by the highest income group was under conservation tillage practices. Differences in erosion rates between income classes thus appear to reflect a combination of less erosive soil and more conservation practices.

Studies defining farm size in terms of spatial extent have provided little evidence that there is any connection between size and soil conservation. Held and Timmons (1958) investigated twenty Iowa farms over a period of years to determine if changes in farm size affected the degree to which conservation practices were employed. They observed no clear pattern of changes in erosion losses related to changes in farm size. Baron (1981) tested for the effect of the number of acres owned on the number of investments made in soil conservation. In three of the four farm production regions sampled there was a statistically significant positive relationship between size of ownership unit and the number of conservation investments adopted, but with coefficients so small as to make it difficult to attach any practical significance to them. Hoover and Wiitala (1980) reported that for the Nebraska farms they surveyed, neither "total acres farmed" or "total acres owned" were significant predictors of whether a farmer perceived an erosion problem on his farm. They did not test for differences in actual rates of erosion by size of farm. Ervin's (1982) analysis of erosion on rented cropland in

Missouri detected no significant impacts on soil loss by the size of the farm operated or the size of the farm rented. A survey of New York and Michigan farmers (Buttel et al, 1981) recorded somewhat higher levels of concern about erosion among those operating smaller acreages, but not at statistically significant levels.

If there are any important effects of farm size on soil conservation practices, they may lie in the use of conservation tillage. As noted above, there is a farily strong association between the use of the practice and net farm income (Lee, 1980), and thus by implication to farm size defined in terms of acres as well. Choi and Coughenour (1979), in their study of the adoption of no-tillage agriculture in Kentucky, provide some valuable insights into the relationship between farm size and the adoption of new conservation technology. They reported that in the county studied, nearly all of the farmers operating 500 or more acres had tried no-till, but just slightly over half of the farmers operating 259 acres or less had done so. They cited a number of barriers to the adoption of no-till on small farms. These included the additional cost of a no-till planter, as well as lower opportunity costs for the labor that could be saved by use of no-till. They also noted that willingness to adopt the practice was positively related to the farmer's education level (as the practice demands much more expertise in chemical use), which in turn is positively related to farm size.

Choi and Coughenour also offer evidence to indicate that conservation tillage practices are most heavily used by aggressive, expanding farmers. Between 1972 and 1977, 59 percent of those using no-till expanded the size of their farms, versus only 17 percent of those who had never tried the practice. This suggests that, contrary to the fears expressed by some, the growth in the average size of farms may actually advance soil conservation goals by accelerating the spread of conservation tillage.

A better understanding of what barriers small farm size poses to the adoption of conservation tillage practices could contribute to more effective conservation policies. Research to identify the effects of particular factors, such as the operator's education, extent of off-farm employment, attitudes toward risk, and the degree to which the cost advantages of conservation tillage are affected by farm size, would be an important first step in developing targeting strategies which are sensitive to the situation faced by small farm operators making conservation decisions.

Conclusion

This paper has outlined an approach to targeting soil conservation policies that rests on an analysis of institutional as well as physical and economic parameters. Although such an approach presents difficulties in the collection, analysis, and interpretation of data in all of these dimensions, it represents a framework for identifying those public investments in soil conservation offering the highest net returns to society. Theoretical and empirical perspectives on the effects of tenure institutions on soil conservation were examined, and the implications for conservation policy and opportunities for further research were discussed.

The obstacles to allocating soil conservation incentives based on not only of tons of soil loss or proximity to a valuable river, but also on the ownership status or debt level or size of a farm, must be granted. Many will object to policies that make such distinctions, preferring instead to leave the present distribution of benefits intact. It is equally clear that if soil conservation goals are to be accomplished, the influences of institutions must be acknowledged and responded to. To ignore them is to risk the failure of soil conservation programs. Arthur C. Bunce (1942) made this point more than forty years ago.

> If, under the present institutional arrangements of farm size, taxes, population density, and rents, a level of living acceptable to the people cannot be maintained when conservation is introduced, it is a waste of public funds to attempt to induce conservation without remedying the basic maladjustments. (p. 53)

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