A Perspective on the Appropriate Role of

the Public Sector in Dealing with the

Uncertainties of the Impacts of Soil Loss

by

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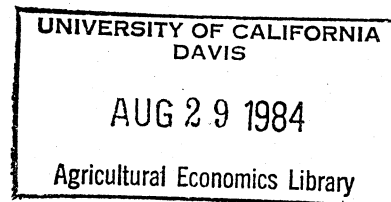
Introduction

Erosion may reduce the productivity of the nation's farmland and cause a variety of off-farm damages such as sedimentation of reservoirs and impairment of water quality. A market failure case can be made that both the on-farm and off-farm damages of erosion exceed socially desirable amounts.[1] There are grounds, therefore, for public intervention to obtain a greater amount of erosion control than farmers would provide on their own. There are great difficulties, however, in determining the appropriate amount of control and how best to achieve it. The difficulties arise in part from ambiguities in defining the social objectives of erosion control and in part from uncertainty about the present and future values of key variables determining the magnitudes of both on-farm and off-farm costs of erosion. This uncertainty will bedevil erosion control policies even if we achieve perfect clarity in defining policy objectives.

In this paper I consider the issue of how to define the objectives of erosion control policies, the uncertainties about costs of erosion, and some implications of these uncertainties for erosion control policies. The focus is on the on-farm (productivity) costs of erosion. This is not because I consider the off-farm costs unimportant. On the contrary, in a national perspective they may be more important than the productivity costs, and in some important producing regions they almost surely are. However, my research over the last several years has dealt with erosion-productivity relationships. Only recently have I begun to give major attention to off-farm damages. The perspective provided here, therefore, is partial. It is worth noting, however,

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[1] For an argument making this case see Crosson and Brubaker (1982, pp. 133-141).

that productivity effects of erosion seem to be the major preoccupation of the soil conservation community, and Agriculture Secretary Block has given amelioration of these effects top priority in the USDA's soil concercation program.

Erosion Control Objectives

For many years the objective of U.S. soil conservation policies, as defined by the Soil Conservation Service (SCS), has been reduction of erosion on all soils to T values--tolerable levels of soil loss. T values are stated in tons per acre per year and defined as "the maximum rate of annual soil erosion that will permit a high level of crop productivity to be obtained economically and indefinitely" (McCormack, Young, and Kimberlin, 1982, p. 7). On deep soils the T value is 5. On shallow soils where rooting zone limits are aproached T values range as low as 1. The values reflect rough estimates of the rates at which soils form an A horizon (topsoil). It is widely acknowledged in the SCS and among soil scientists generally that the scientific basis for currently accepted T values is weak.

Although there are ambiguities in the definition of T values, it generally is taken to mean that there should be no loss in the long-term productive capability of the soil (McCormack, Young, and Kimberlin, 1982). I take this to mean that with constant technology and management, erosion should subtract nothing from agricultural productivity over time. With improvements in technology and management I take it to mean that erosion should subtract nothing from the growth of agricultural productivity over time.

The rationale of T values is that each generation is but the temporary custodian of nature's endowment of resources and for a renewable resource such as the land is obligated to pass that endowment unimpaired to the next generation. This sense of intergenerational obligation is the core of the conser-

vation ethic, and the impulse which always has driven the conservationist movement. T values are an expression of the conservation ethic applied to agricultural land. But as guides to acceptable soil loss T values impose a stricter standard for many soils than is necessary to satisfy the obligation to intergenerational equity. Future generations will not be interested in the productivity of the soil as such but in the costs of producing food and fiber. Consequently, we meet our obligation to the next generation if we so manage the nation's land and other resources that real costs of producing food and fiber do not rise. In this formulation, losses of soil productivity are acceptable if, but only if, there are compensating increases in the quantity or productivity of other resources for production of food and fiber. I call this the constant cost criterion of intergenerational equity.[2]

Compared to T values the constant cost criterion has the advantage of focusing on the main issue in intergenerational equity. It has the disadvantage, however, of being much more complex. With T values the soil conservationist readily identifies those soils on which erosion should be reduced. The difficult issue is how to do it. The constant cost criterion, however, requires attention to a host of variables bearing on future costs of production: prospective domestic and foreign demands for food and fiber, trends in agricultural technology, prices of present and prospective inputs used in those technologies, and interest rates. If, for example, it appears that future demands will be weak relative to prospective new technology, then the conservationist can take a more relaxed view of soil loss than the T value criterion would imply. But if the conditions are strongly reversed then the

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[2]For an extended discussion of T values and the constant cost criterion as standards to guide soil conservation policy see Crosson (1982, chapter 6).

conservationist may want to apply an even stricter standard than T. Clearly, application of the constant cost criterion confronts great uncertainty.

I do not here discuss all the sources of this uncertainty. Rather I deal only with a subset of them, those relating to estimates of the effects of erosion on crop yields. These effects are the sole concern in setting T values. However, they must be considered also in applying the constant cost criterion.

Effects of Erosion on Crop Yields

Studies of these effects date back to the 1920s. However, until recently the studies always were on small experimental plots and there was no way of using the results to address the question, in a national or regional perspective, how much does erosion reduce crop yields? In the USDA's 1980 Resource Conservation Assessment (RCA) an effort was made to remedy this. The data from experimental plots was used in a Yield-Soil Loss Simultator (Y-SLS) to estimate the effect on crop yields of 1977 rates of erosion if continued over the fifty years 1980-2030. The results showed that yields would be 8 percent less than they otherwise would be.

Construction of the Y-SLS was a pioneering and badly needed effort. However, it was done under much time pressure and necessarily was based on some questionable assumptions, both about data and about the nature of the erosion-yield relationship. Consequently its results are widely viewed with many reservations.

Recognizing the limitations of the Y-SLS, analysts at the USDA, in connection with the 1985 RCA, are constructing another model for projecting the yield effects of erosion. This is a promising effort, but at this writing still far from complete.

Another approach is being taken by a group at the University of Minnesota under the direction of William Larson, a soil scientist. This work is described in two forthcoming publications (Pierce et al. and Larson et al.). The focus of it is a model which relates soil characteristics to crop yield and shows how yields change as erosion alters the characteristics.[3] Larson et al. and Pierce et al. used the model to estimate the effect of 1977 rates of erosion on yields over periods of 50 and 100 years in a number of Major Land Resource Areas (MLRAs) along the Missouri river in western Iowa, in southern Iowa and northern Missouri, along the Mississippi river in Arkansas, Tennessee, Louisiana, and Mississippi, and in southeastern Minnesota. Rates of erosion in all of the MLRAs were well in excess of 5 tons per acre per year, the maximum T value. Despite this, the average estimated yield losses over 100 years were small in all the MLRAs studied, varying from 3 percent to 7 percent. Larson et al. interpret their results, "plus similar unpublished data of the authors," as suggesting that continuation of 1977 rates of erosion for 100 years would reduce yields of the nation's cropland by 5 to 10 percent. These estimates assume that technology, management, and all other factors affecting yields except erosion are constant.

The work reported in Larson et al. and Pierce et al. still is in an early stage, and refinements both in conceptual aspects of the model and in data can be expected. Enough already has been done, however, to indicate that the work has high promise for reducing present uncertainty about the effect of erosion on crop yields.

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[3]The word "change" is used advisedly. Larson et al. (forthcoming) show that on some alluvial soils underlain with more productive material erosion increases yields. In the areas studied by Larson et al. the acreage of such land is small relative to the acres on which erosion reduces yields. That erosion should increase yields on any land, however, is noteworthy.

As a guide to policies for meeting the constant cost criterion, however, the work has some important limitations. This is because the model as presently structured cannot incorporate farmers' responses to offset some or all of the effects of erosion on yields. Figure 1 is convenient for considering these possibilities.
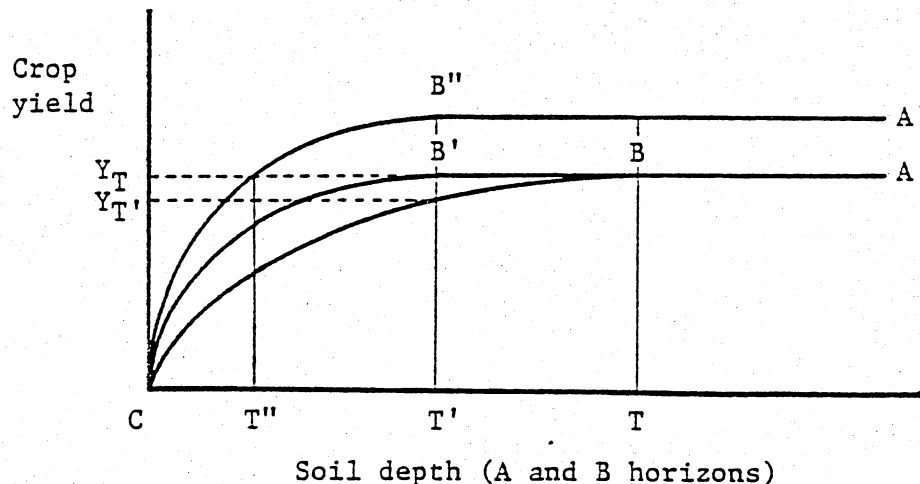

Figure 1. Illustrative Relationships Between Soil Depth and Crop Yield

The ABC curve shows the relationship between soil depth and yield with given management practices and technology. This curve is comparable to those produced by the Larson et al. model, although those relate amount of erosion, rather than soil depth, to yield. Curve ABC indicates that erosion which reduces soil depth from A to B has no effect on yields, but as it proceeds, eventually removing all topsoil and subsoil, yield is reduced to zero.

The curve AB'C illustrates the yield-soil depth relationship when management practices are changed, with given technology, to offset the effect of erosion on yields. The change may be simply the application of more fertilizer to replace lost soil nutrients, or the adoption of practices which restore soil organic matter.

The curve A'B"C illustrates the relationship when farmers adopt new technology to offset the effects of erosion on yields. The upward shift in the curve may reflect adoption of higher yielding, fertilizer responsive crop varieties, or new varieties more tolerant of toxic materials in the subsoil, thus extending the crop rooting zone. The possibilities are numerous.

If we had curves like those in Figure 1 for all the major soils in all the major producing areas in the country, and also knew where we presently are on the ABC curve for each soil and area, we would greatly reduce much of the uncertainty now surrounding soil conservation policy. If in addition we had information about the costs of reducing erosion, about the costs to farmers of moving from curve ABC to curve AB'C, and about the costs of developing and applying the new technologies underlying curve A'B"C, the uncertainty would be reduced even further. If the policy objective were to hold yields at CY_T, we could compare the costs of doing this by reducing erosion to maintain soil depth of CT with the cost of the management practices required to move from B to B' (permitting soil depth to decline from CT to CT') and with the cost of moving to the point on the A'B"C curve where yield equals CY_T (permitting soil depth to decline from CT to CT").

This schematic presentation of course does not capture the full complexity of the situation we would confront in trying to design policies consistent with the constant cost criterion. The presentation makes the point, however, that the criterion permits alternatives to erosion control in dealing with erosion and that to explore these alternatives we need information about soil depth-yield relationships of the sort depicted in Figure 1. The work of Larson et al. shows that information represented by curve ABC is attainable, although at present it is available only for the few areas studied by Larson et al. The information needed to estimate curves AB'C and A'B"C would be

harder to obtain, although there is no reason in principle why this could not be done.

Policy Implications of Uncertainty

For the present and foreseeable future we will lack much of the information needed to estimate Figure 1 type curves. We will continue, therefore, to have to make soil conservation policy under high uncertainty concerning some key relationships. What are some of the implications of this for thinking about policy?

First of all it is important to recognize that we do not face a crisis with respect to the productivity effects of erosion. Whether present rates of erosion would reduce yields by 8 percent in 50 years, as the 1980 RCA estimates, or by 5-10 percent in 100 years as Larson et al. conclude, the annual reduction is small. When allowance is made for prospective increases in yield from new technology already in the pipeline the erosion threat to productivity is smaller still. This does not mean that it can be ignored. It does mean, however, that we have time to find out more about the threat so that we can deal with it more effectively.

Two courses of action appear promising. They can be pursued simultaneously. One, to use the "buzz" word now commonplace among conservationists, is to target soil conservation resources on those areas where the erosion threat is greatest. The political momentum behind current policies assures that each year the federal government will spend some hundreds of millions of dollars on soil conservation. If we were starting anew and applying the constant cost criterion to soil conservation policy the amount spent no doubt would be different, and probably lower. But we are not starting anew, and political realities assure that sharp deviations from present levels of

spending are unlikely. Since the money will be spent anyway it makes sense
to spend it where we get the biggest pay-off in reduced erosion threat. These
are not necessarily the places where erosion is highest. If prevention of
productivity loss is the objective the threat may be greater in areas with
shallow soils and relatively low erosion than areas with high erosion but
deep soils.

The second course of action is to increase investment in research to
develop the information needed to implement the constant cost criterion for
soil conservation policy. This would require studies of future demands for
food and fiber, of trends in agricultural technologies, and of prices of
inputs used in present and prospective technologies. It also would require
studies of erosion (or soil depth)--yield relationships of the sort depicted
in Figure 1 for all important soils in all important producing areas, and of
the costs of reducing erosion on those soils relative to the costs of off-
setting its effects (a) by a shift in management practices and (b) by de-
veloping and applying new technology.

Research along these lines would gradually reduce the uncertainties that
now impede development and implementation of effective soil conservation
policies. Uncertainty will remain. Indeed, it is inherent in the constant
cost criterion because use of the criterion necessarily involves estimates
of future events. But research can reduce the area of uncertainty. Research
takes time, and to pay off it must be sustained over a long period. But we
have time. If we use it well we can significantly advance the nation's
efforts to reconcile the interests of the present and subsequent generations
in management of the land.

References

Crosson, P. and Brubaker, S. 1982. Resource and Environmental Effects of U.S. Agriculture. Resources for the Future, Washington, D.C.

Crosson, P. 1982. Productivity Effects of Cropland Erosion in the United States. Submitted for publication to Resources for the Future.

Larson, W. E., F. J. Pierce, and R. H. Dowdy. Forthcoming. "The Threat of Soil Erosion to Long-Term Crop Production." Science.

McCormack, D. E., K. K. Young, and L. W. Kimberlin. 1982. "Current Criteria for Determining Soil Loss Tolerance." In B. L. Schmidt, R. R. Allamaras, J. V. Mannering and R. J. Popendick, eds., Determinants of Soil Loss Tolerance. ASA Special Publication No. 45, American Society of Agronomy and Soil Science Society of America, Madison, Wisconsin.

Pierce, F. J., W. E. Larson, R. H. Dowdy, and W. Graham. Forthcoming. "Productivity of Soils--Assessing Long-Term Changes Due to Erosion." Journal of Soil and Water Conservation.