Nonpoint-source pollution control: A resource conservation perspective

Conflicts seemingly exist between practices to improve water quality and conserve soil and water resources

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The Federal Water Pollution Control Acts Amendments of 1972 (P.L. 92-500) and the Soil and Water Resources Conservation Act of 1977 (P.L. 95-192) have focused considerable attention on agriculture and forestry in the United States. Both statutes are rather specific in their goals and objectives. They should complement one another. But there are differences in the two laws that appear to be in conflict. Management practices are applied on farm fields for resource conservation, while nonpoint-source pollution control is often carried out on a much larger scale at some point in a major stream system. Inconsistencies result between soil and water resource conservation practices and nonpoint pollution control practices.

The approach to pollution control

Nonpoint sources of pollution are diffuse sources, such as agricultural land and forest land. Point sources of pollution discharge from pipes. Pollutants, of course, include any constituents that degrade water quality, such as sediment, plant nutrients, and pesticides.

P.L. 92-500 did not specify where in a stream system pollutants should be controlled or where pollution should be monitored to determine if control is needed. The assumption is that pollution should be controlled at its source, meaning that individual farmers must control the pollutants discharged from their farms. Logically, then, farming practices should be developed or modified to minimize the transport of pollutants from a field's edge. But surveillance of nonpoint-source pollution and its control on every farm is not feasible. Generally, surveillance is at some receiving body, such as a stream, lake, or coastal zone.

There are no established standards for water discharged from nonpoint sources. Water quality criteria exist, however, based upon the intended use of the water (20). Drinking water standards (4) are used for domestic water supply, but these may not be sufficient to protect fragile aquatic systems. For example, nitrogen and phosphorus concentrations in streamflow may meet drinking water standards, but they may be high enough to contribute to eutrophication and other undesirable characteristics. Organochlorine pesticides may occur at concentrations less than toxic levels, but continued accumulation of these pesticides in lake sediment and their biomagnification may result in concentrations in fish tissue at levels harmful to humans.

Sediment has been identified as the major nonpoint-source pollutant (10). Sediment can be removed from drinking water. How can criteria be established for sediment pollution, and at what scale must one be concerned? Sediment alone may not be a problem even though it fills reservoirs and covers fish spawning beds.

Resource conservation objectives

Conservation of the soil resource for long-term agricultural productivity is the major concern of the Soil and Water Resources Conservation Act (RCA). The focus is on source erosion rather than sediment yield or delivery of sediment to some point beyond the source. Sediment yield, of course, is the net result of erosion, transport, and deposition to the point of interest. Source erosion may be quite high, but sediment yield may be relatively low because of deposition in transport. In P.L. 95-192, Congress expressed growing concern for maintenance of a productive resource by keeping soil in place.

In the 1940s, the soil loss tolerance (T-value) for most soils was set at 5 tons per acre (11.2 metric tons/hectare) per year, based upon an estimated rate of soil formation, to maintain productivity indefinitely. There has been much discussion of the soil loss tolerance ever since. Many people think the T-value for deep soils should be higher while the T-value for shallow soils should be lower.

Acceptance of a soil loss tolerance in essence resulted in a criterion for erosion somewhat analogous to water quality criteria. The main difference is that scale was established for soil conservation but not for nonpoint-source pollution. Unfortunately, the T-value criterion has been over-extended. Many people think in terms of tolerable soil loss from a farm field that entails both source erosion and sediment transport. Sediment yield from a field may be less than the T-value at the same time that source erosion may be greater than the T-value, resulting in a significant reduction in long-term productivity.

Management practices

Researchers have worked at many locations for years to develop erosion control practices (12). Terraces and grass waterways effectively control erosion, but irregularly spaced terraces along the contour, with point rows, are objectionable to many farmers who wish to use large machinery efficiently to reduce operating costs.

A compromise between erosion control

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and machinery requirements produced the parallel terrace or parallel tile-outlet terrace. But even these structures are not without their disadvantages. While temporary impoundment of water on tile-outlet terraces increases infiltration, the greater infiltration may also increase nitrate leaching to shallow groundwater. In addition, fields with complex topography may require terrace segments with relatively steep grades so that farming parallel to the terraces does not control erosion.

Conservation tillage, including no-till, effectively controls erosion also. But the pesticides needed to make these practices work (6) often includes soluble chemicals that move readily in runoff or percolation. Not only do these soil-conserving measures potentially increase chemical pollution and the amounts of organic matter available for transport from a field, but they do not always maximize yields. Particularly in the Southern Coastal Plain, control of insects, weeds, and diseases continues to be a problem, and yields are likely to be depressed by lack of control.

Effective conservation practices on upland areas may result in new problems in downstream channels. Only extreme measures reduce storm runoff significantly in humid and subhumid regions (3). Few basic field conservation practices provide protection against storms of a 5-year recurrence interval or greater. If on-site erosion is reduced significantly by effective conservation practices, less sediment will enter the channel systems. Without a comparable reduction in runoff entering these systems, the carrying capacity of streamflow will be greater than the sediment input and an unstable channel will degrade rapidly to adjust gradient and load (17). Sediment-associated water quality at a downstream point may be no different than before con-
Sediment practices were applied on upland areas. Such a condition varies with land resource areas and with soils within a land resource area. In areas where channel stability is a significant problem, soil conservation may be achieved with little apparent overall improvement in water quality. Channel improvements, such as detention reservoirs, sediment traps, and stabilization measures, may be needed, along with field conservation practices, to improve downstream water quality.

Southern Coastal Plain. In the Coastal Plain of the southeastern United States, only those river basins with several hundred square miles of drainage have encircled channels. Concentrated flow occurs over broad alluvial valleys covered with hardwoods. Streams flow about nine months of the year when rainfall is normal. Adjacent to the alluvial hardwood valleys are grasslands that are not cultivated because of prolonged seepage from subsurface flow during the spring planting season. The grass buffer strips, hardwood, and underbrush in the alluvium filter out most of the sediment. Water quality from agricultural areas is good; there is little sediment and few chemicals (19). Riparian vegetation and swamps limit nutrient transport from the watersheds (2, 11).

In this setting, a nonpoint-source pollution problem is not apparent, but as one travels through the Coastal Plain, there is visual evidence of considerable erosion on short, steep slopes and long, gentle slopes. The eroded soil is deposited at the edge of the field or in the grass buffer strips. Large sediment deposits within the fields have been pushed into ridges along the fence or into the grass buffer strip. There is a severe erosion problem in these areas, but quality of streamflow from the sediment standpoint is good.

Cornbelt. Much of the cornbelt is characterized by rolling topography and short, steep slopes. These slopes drain into a valley, where concentrated flow crosses property lines and roadways. Although most farmers till across the path of concentrated flow, considerable erosion occurs on the slopes during seeder preparation, planting, and until significant plant canopy develops.

Application of a field-scale model for evaluating nonpoint-source pollution shows that, although some deposition of eroded material occurs in these valleys, average sediment transport may be on the order of 5 to 10 tons per acre (11.2-22.4 metric tons/hectare) (8). If the areas of concentrated flow are seeded to grass and/or if ponding occurs at the fence or property line, sediment transport, as calculated at the field edge, may be well within the 5-tens-per-acre soil loss tolerance. Therefore, one could say that the grass waterway is a best management practice (BMP) and that the nonpoint pollution from sediment is reduced to some permissible value.

But what has happened to erosion? Nothing. No management practice was applied on the hillside to reduce erosion. Only sediment transport from the field was altered by the BMP.

What effect has the BMP had on resource conservation? None. The landowner seemingly has been shortchanged by using a BMP that does nothing to reduce the loss of the soil resource.

Palouse. In the Palouse area of the Pacific Northwest, long, steep slopes are planted to wheat. Tremendous erosion occurs on these slopes during winter and early spring rains (9). The steep slopes flatter near a stream or channel, and grass or alfalfa buffer strips along the channel are effective means of reducing nonpoint pollution in the channels. But what has happened to erosion on the hillside? Nothing. A mechanical measure that has been applied in the Palouse is terracing. Terraces break the slope length, and net erosion from the fields is reduced by the terraces and grass or alfalfa buffer strips. Has erosion been reduced? Obviously interterrace erosion is not as great as the erosion would have been without terraces, but terraces are not feasible in much of the Palouse because of outlet blockage and outlet channels on steep slopes. Also, terrace-outlet channels on such steep slopes require careful consideration in design and maintenance or more serious erosion will occur because of large concentrations of flow. This can lead to more sediment being contributed to the main channel or stream system than is held on the field due to terracing. Residue management and chemical weed and grass control on the wheat-producing slopes would have been more effective in resource conservation (1).

Mississippi Delta. The Mississippi Delta is an area with substantial erosion even though slopes are flat. Organochlorine insecticides were used for more than 30 years, and accumulations in the soil remain a problem because of their adsorption on soil particles and subsequent erosion and transport into lakes. Chemicals applied for insect control may accumulate on and in cotton plants during the growing season. While plowing cotton residue under following harvest reduces washoff from dead vegetation, tillage results in soil conditions more susceptible to erosion and loss of adsorbed chemicals.

There are few alternative management practices in the Delta. Slopes are constructed to provide surface drainage. Therefore, terrace systems cannot be used. Grass buffer strips and waterways are effective measures for reducing sediment transport from fields or farms (5). But neither practice reduces erosion itself. Nonpoint-source pollution is reduced, but resource conservation is not affected. Winter cover crops or conservation tillage would reduce erosion. Both would aid resource conservation.

Southwest. Rangelands of the semiarid Southwest have special problems of resource conservation and nonpoint pollution by sediment. Because of low rainfall amounts and the poor distribution of rainfall throughout the year, range management is difficult. Many acres have been denuded of grass and invaded by brush as a result of overgrazing and low rainfall (there are differences of opinion on the cause of brush invasion). These areas contribute considerable amounts of sediment to stream systems (7, 16, 18). Sediment basins or traps may effectively reduce nonpoint-source pollution of rivers. However, the only way the soil resource can be conserved is by revegetating the range and managing it properly.

An economic perspective

It can be expensive to install on-field and off-field management practices necessary to achieve a desired level of soil conservation or water quality, and no practice is without some cost (13). For example, contour stripcropping may be an effective practice for reducing erosion, and the recommended crops for striping may be the same as those grown already on the farm. However, alternate strips within a field reduce machinery efficiency and result in greater fuel costs for the farmer.

Grazing of winter small grains is a common practice in many areas. Farmers can reduce costs of supplemental feed, feeding, and feed storage. But stripcropping does not lend itself well to such grazing practices. Livestock watering facilities may be a problem as well as livestock trampling of noncrop strips. Soil compaction may also be a problem in the noncrop strips because the soil water content generally is higher than in the small grain strips, where transpiration occurs. This compaction requires more power for subsequent tillage or lower infiltration if no-till is practiced.

Some management practices recommended for soil conservation or improved water quality may require purchases of different farm equipment, such as no-till planters, spray equipment for pest control,
two-way plows for contour tillage in terrace systems, and special equipment for terrace maintenance. Maintenance of grass cover in terrace outlet channels requires special attention. In regions where bermudagrass is adapted, good waterway protection is afforded, but preventing bermudagrass from extending stolons into cropped areas is a problem. Also, any protective waterway cover that effectively reduces water velocity will cause sediment deposition, which, over time, reduces the capacity of the waterway. Sediment removal from the waterway is costly in terms of the time required and the machinery necessary to accomplish the removal.

Conservation practices should increase crop returns over the long term as a result of erosion control (15). However, these practices entail both short- and long-term costs. For example, a terrace system with grass outlet channels, or simply grass waterways for protection from concentrated flow without terraces, take land out of cash crop production. A farmer must increase unit production merely to offset this reduction in cropped area. Grass buffer strips at the lower edge of a field effectively reduce sediment and chemical loads, but they too reduce the crop acreage.

Cost-sharing by the Agricultural Stabilization and Conservation Service for conservation practices continues to serve as an incentive for farmers to offset their costs of achieving resource conservation and environmental quality in the Rural Clean Water Program and Agricultural Conservation Program (14). Cost-sharing for terraces is limited to some percentage of the actual construction cost. This makes no provision for capital investment to purchase special machinery to farm a terrace system or for increased fuel costs related to lower machinery efficiency. Unlike industry, the farmer is unable to pass these increased costs on to the consumer. For example, since the energy crisis began in 1973, power suppliers have been allowed to add fuel cost adjustments to consumers' bills. Yet the farmer, as an individual, cannot set new prices for a bushel of wheat or pound of cotton to offset his increased fuel costs resulting from reduced machinery efficiency of farming in a new conservation or terrace system.

Field conservation practices do have potential long-term value to a farmer. But installation of channel measures to achieve good quality water downstream may not yield any benefit to the landowner. In fact, a detention reservoir generally takes pasture land out of production and reduces the stocking potential for a given area. Channel works or off-field structural measures are often expensive, and a landowner is unlikely to install such measures voluntarily, at his own expense, because these measures only benefit others.

Farming has undergone important changes in recent years that influence investment in pollution control or resource conservation practices. Further changes will occur in the future. Each year, more small farms are leased to larger farm operations. These leases may be short-term or long-term, and the short-term leases may be on a year-to-year basis. Although many lease agreements require the use of soil-conserving practices by the operator, such a year-by-year situation is not conducive to sound resource conservation. An operator's philosophy often is to "get as much out of the land for the least cost because I may not get the farm next year." Many landowners share with the operator increased costs of conservation practices, and in most cases bear all costs above ASCS cost-sharing. But there are a number of problems associated with lease-type operations that require planning to achieve either resource conservation or environmental quality.

Economic analysis is more important than ever in assessing the relative merits of different management systems. It is important to develop good economic models that interface with erosion-productivity and nonpoint-source pollution models to consider all facets of the problem.

**New criteria necessary**

There seemingly is a dichotomy in standards by which agricultural land might be managed as a result of the new emphasis on water quality and the continuing concern for resource conservation. Strict adherence to water quality standards in a stream system does not ensure that the soil resource is adequately protected. Likewise, resource conservation in the form of erosion control practices on farms does not insure that streamflow will meet water quality standards, particularly where channel degradation and soluble chemical transport may dominate a system. Better criteria are needed for land use planners to determine what measures, within current economic constraints, are necessary and sufficient to meet the increasing demands for food production and environmental quality.

**REFERENCES CITED**