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A REVIEW AND AN ANNOTATED BIBLIOGRAPHY OF STUDIES OF SOIL CONSERVATION PROGRAMS, PRACTICES AND STRATEGIES

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REVIEW

Introduction

In the 1950's and 1960's many of our U.S. farmers did a reasonably adequate job of holding down soil erosion rates. Farm prices were low and the emphasis was on reducing farm production. The result was that many of the lands that are subject to erosion were retired since these lands tended to be the least productive. However, this situation changed dramatically in the early 1970's. Agricultural product prices shot up and the emphasis shifted to all out farm production. This meant bringing marginal lands into production and taking out soil erosion control structures. Combine with this the push to larger farm equipment, increased land renting and heavy input applications and the stage was set for soil erosion problems in the 1970's.

The degree of the soil erosion during the 1970's is not clear and the problems facing us in the 1980's are also unclear. An indication of the significance of the problem is provided by Timmons, 1979. He reports that the past trend towards lower soil erosion rates which was started in 1949 in western Iowa was reversed in 1974 when erosion rates increased.

The seriousness of the potential soil erosion problem has had an impact on research work. During the 1950's and 1960's, not much was written about soil erosion. However, the 1970's show a renewed interest and a resulting stream of publications.

This paper provides a brief synthesis of articles, papers and studies concerned with soil conservation programs, practices and strategies and their effects on income and water quality. The emphasis is on publications during the 1970's to help bring researchers up-to-date on some of the current literature. However, the reader should not neglect materials from the earlier periods, some of which are summarized elsewhere [Easter, 1966].

Soil Conservation Programs and Strategies

For decades authors have found the array of U.S. soil conservation programs wanting, particularly in times of stress due to low farm incomes, high farm prices or bad weather. New government programs have been added over the years while the old ones have been continued with only moderate

changes. Still,Davis, 1977, finds that there is no conservation treatment on 42 percent of the U.S. cropland. He also suggests that there is little public awareness of the soil conservation problem among people in urban areas.

One of the programs which has been around since the 1930's and has not changed much is the Agricultural Conservation Program (ACP). It is administered by the ASCS, a production oriented agency in the USDA. Fitzgerald, 1979, points out that ACP has been production-oriented in the past but that in 1978 it was redirected towards more soil conservation practices. For example, drainage-type practices were eliminated in 1979. Fitzgerald also feels that the Rural Clean Water Program has helped improve water quality and conservation practices in areas where ACP has not been fully utilized. In considering Fitzgerald's paper, the reader should keep in mind that ACP has been redirected in the past only to return to its previous mode of operation a few years later. The basic administration of ACP has not been changed.

The Soil Conservation Service (SCS) is another Federal agency started in response to the soil erosion problems of the 1930's. The SCS does not seek out farmers with the most severe erosion problems, instead farmers are helped on a first-come, first-serve basis. The U.S. General Accounting Office (GAO), 1977b, found that too much time is spent preparing a formalized and detailed plan for a farmer. GAO also suggested that a more effective follow-up system is needed to answer any questions farmers have when installing the conservation practices.

The Great Plains Conservation Program was established in the USDA to focus just on the soil conservation problems of the Great Plains. The hope was that it would be more effective than SCS or ACP since it was targeted on an area with similar problems. Yet GAO, 1977b, found that the Great Plains Conservation Program, although helping some farmers, has not been very successful in relieving soil erosion problems on agricultural land in the Great Plains. Two reasons suggested for this lack of performance were: (1) the lack of incentive for farmers and (2) the inability to identify farmers with serious conservation needs.

In response to the concern for the water quality aspect of soil erosion several new programs were started in the 1970's. The Federal

Water Pollution Control Act of 1972 has, as one of its purposes, the prevention of pesticide residues and animal wastes from contaminating waterways. The Environmental Protection Agency has worked on this matter concerning nonpoint pollution from feedlots. Though nonpoint pollution is recognized, there has not been any consistent programs for dealing with it [Train, 1975].

Under Section 208 of this Act each state is required to submit to the Environmental Protection Agency (EPA) a plan to control pollution from identifiable sources and nonpoint sources. The various soil conservation districts will be used to confirm that the plan objectives are being followed [Carter, 1977].

EPA assistance is available to states and regions that establish area-wide waste treatment management planning agencies which deal with water quality problems [Train, 1975].

By July 1, 1983 the best available technology economically achievable must be used to reach effluent limits for all point sources excluding publicly-owned treatment works. The goal of complete elimination of pollutant discharge is hoped for by 1985 (Bregman and Beeland, 1976).

States may be relied on to provide more of the conservation assistance in the future. If so, Iowa's Sedimate Control Law is worth considering. The Iowa Sediment Control Law, which is part of the Iowa Conservancy District Law, offers cost-sharing assistance to landowners to cover 75 percent of the cost of installing permanent soil and water conservation practices. For temporary practices, the state committee sets the amount. Although the erosion problem has to be a nuisance before something officially can be done, the law is felt to be working well [Greiner, 1975].

Other alternative strategies will also have to be considered in the future. One possibility is cross-compliance system in which crop adjustment programs, crop insurance and soil conservation are all used in combination with each other to reduce erosion. If farmers do not apply conservation practices they do not have access to other federal farm programs [Risser, 1978]. Benbrook, 1979a, feels that commodity programs remain the stabilizing feature of farm policy. Thus, the conservation incentive programs should be integrated with commodity programs through

some type of extra price support incentive for conservation.

If the source of nonpoint pollution could be identified, then cost-sharing payment could be used much like ACP. A charge or tax could also be levied on the farmer or other polluters. This is considered to be the most cost-effective approach [Narayanan, Lee, Guntermann, Seitz, and Swanson, 1974].*

Effects of Conservation Tillage Practices on Soil Erosion

Terminology used when discussing the different tillage methods can be confusing so we will start this section with some definitions. Conservation tillage is defined as any tillage system which conserves soil, water, or energy as a major objective. Chisel-plant, disk-till, till-plant and no-till are all types of conservation tillage. Chisel-plant consists of chisel plowing, one disking and one field cultivation before planting. Disk-till utilizes one disking and one field cultivation followed by the planting. Till-plant is one field cultivation followed by planting. No-till is the seeding of the crop into untilled soil.

Till planting, ridge planting and conventional tillage were compared in controlling soil and water losses with up-and-down hill planting on a range of slopes from 3.4 to 9 percent in Iowa. Of the three methods ridge planting, which involves placing crop residues between rows, proved to be the most effective [Moldenhauer, Lovely, Swanson, and Currence, 1971].

The graded-furrow system, which conveys all runoff originating in the furrow to a waterway, was shown to be more effective in controlling runoff, soil loss, and improving efficiency of farm tillage than the standard terrace system [Richardson, 1973].

Water erosion on slopes of less than 10 percent can be controlled by individual practices or by a combination of tillage and residual management, contouring or terracing. All of these methods along with greater amounts of surface residues should be used on slopes of 10 to 20 percent. On slopes which exceed 20 percent soil erosion is difficult to control [Allmaras, Gupta, Pikul, and Johnson, 1979].

Limited tillage and no-tillage systems that keep crop residues on the soil surface increase the dry aggregate soil structure, reduce soil

*For reference, see page 33.

erosion and increase soil water storage capacity. Conventional tillage leaves bare soil which quickens the normal weathering process and over-time is counterproductive to soil improvement [Black and Siddoway, 1979].

There is felt to be a greater risk with no-till because of the use of pesticides and herbicides. With their heavy use comes the potential toxicity of the chemicals to humans and the ineffectiveness of herbicides. No-till is also felt to be more sensitive to adverse weather conditions. Yet no tillage has proven to be beneficial in wet springs when there is heavy rainfall [Pollard, Sharp, and Madison, 1979].

The per acre production costs are almost the same for most crops under no-tillage and conventional tillage. There are both advantages and disadvantages to no-till. The advantages of no-till over conventional tillage are: control of water and wind erosion; increased infiltration, reduced evaporation and lower soil temperature because of surface residue; lower energy and labor requirement; same or increased yields; greater flexibility in planting and harvesting; plants provide fertilizer and lime; reduced seedbed preparation time which makes double cropping possible; and more flexibility in land use. The disadvantages of no-till over conventional tillage are: higher chemical costs; requires better farm management; leaching of nitrogen might be high (on selected soil with certain crops and rainfall); buildup of residual herbicide; increase in resistant weed species; and, greater possibility of pest damage [Bennett, 1977].

Effects of Soil Conservation Programs and Practices on Income

The key question for any conservation practice being considered by most farmers is what will it mean for farm income now and in the future. The trade-off is likely to be between less income today and more income tomorrow. Government programs are required when the loss in current income from using soil conservation practices is too high for the individual farmer and there is significant downstream damage. For example, sediment damage was found to go as high as 16 percent of the net income per acre in parts of Illinois [Economic Analysis of Erosion and Sedimentation: Upper Embarras River Basin].

Simms, 1970, indicates that the benefits may be quite different between the individual farmer and society. It will also vary depending

on the length of run considered. Simms cites a 1945 study that found Midwestern farms under complete conservation plans averaged $5.63 more per acre per year than the nonconservation farms. This we suspect has changed significantly in the past three and a half decades.

A more recent study by Heady and Vocke, 1978, gives some insights into this change. They found that, with only a slight increase in production costs, annual soil loss can be reduced from 5.56 to 2.5 tons per acre.

Narayanan and others, 1974, found that if the total cost of soil erosion, which includes on-site erosion losses and off-site sediment damages, were included in the farmers cost-return calculations farming practices would likely change. Different rotations, conservation practices and tillage systems would be chosen by the farmer in response to the increased costs. In addition, Lee and others, 1974, found that net farm income loss per year was less than 1 percent from soil erosion when off-site sediment damages were excluded.

Miller and Gill, 1976, found that the procedure used to reach non-point pollution control levels will have an income distribution effect among farms of different sizes. A tax or subsidy appears to be more equitable for small farms than a fixed state standard on soil loss.

Finally Underwood, 1976, found that no-tillage farms resulted in significant benefits over conventional tillage. Crop yields increased 15 to 45 percent while soil loss was reduced 90 percent and water availability increased 25 percent.

Soil Erosion in Minnesota

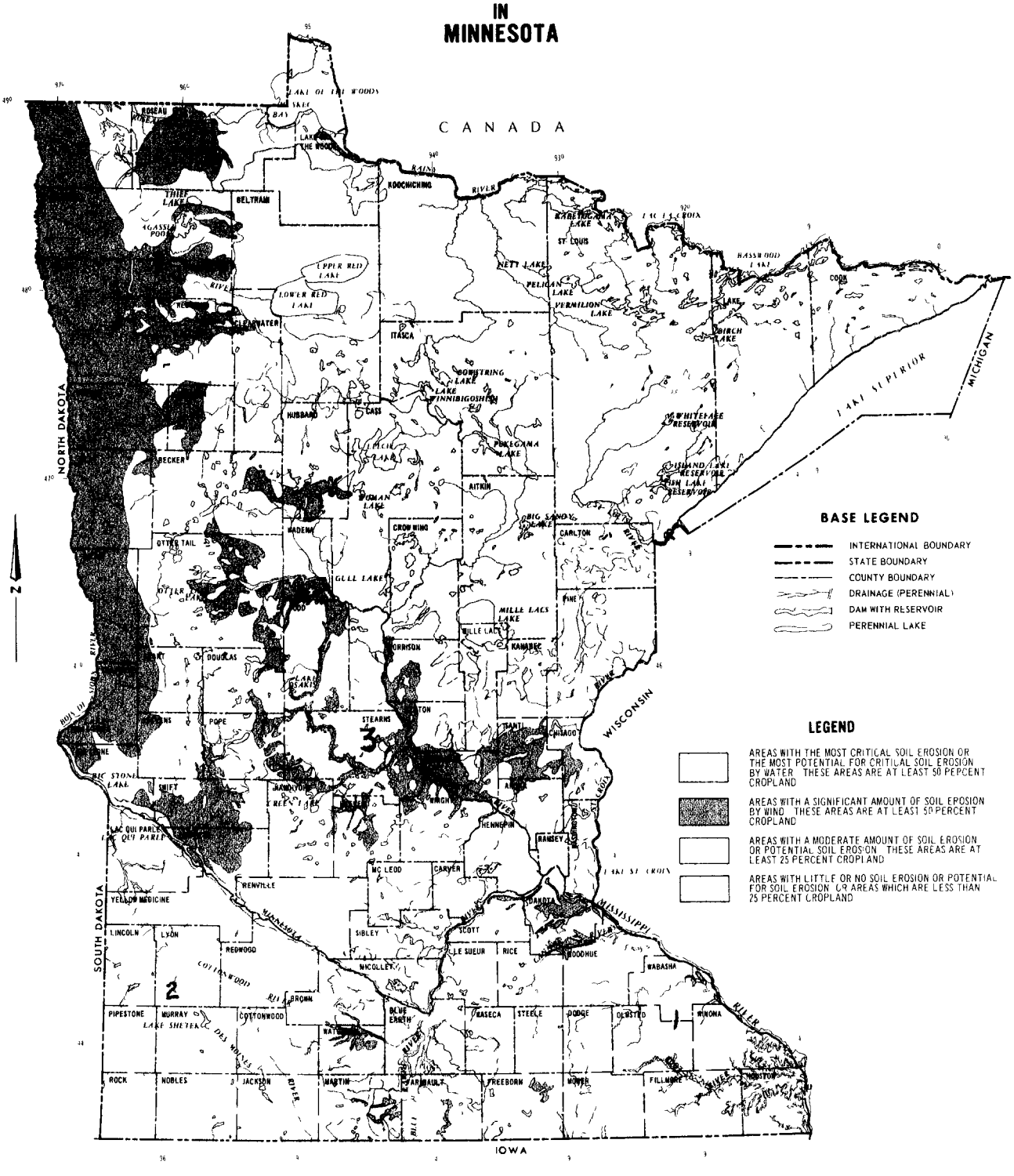
In Minnesota, the south central, southeastern and southwestern areas of the state account for much of the agricultural crop area. The soil in these areas might be less erosive than other areas but due to extensive cropping it becomes more erosion prone [Halsey].

In Minnesota, the worst erosion is in the southeastern part of the state (see map). The requests for technical assistance exceeds the personnel available. Conservation in this area of the state started back in 1930 with the Conservation Corps. This early work has been built on

U S DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

SOIL EROSION POTENTIAL IN MINNESOTA



BASE LEGEND

- INTERNATIONAL BOUNDARY
- STATE BOUNDARY
- COUNTY BOUNDARY
- DRAINAGE (PERENNIAL)
- DAM WITH RESERVOIR
- PERENNIAL LAKE

LEGEND

- AREAS WITH THE MOST CRITICAL SOIL EROSION OR THE MOST POTENTIAL FOR CRITICAL SOIL EROSION BY WATER. THESE AREAS ARE AT LEAST 50 PERCENT CROPLAND
- AREAS WITH A SIGNIFICANT AMOUNT OF SOIL EROSION BY WIND. THESE AREAS ARE AT LEAST 50 PERCENT CROPLAND
- AREAS WITH A MODERATE AMOUNT OF SOIL EROSION OR POTENTIAL SOIL EROSION. THESE AREAS ARE AT LEAST 25 PERCENT CROPLAND
- AREAS WITH LITTLE OR NO SOIL EROSION OR POTENTIAL FOR SOIL EROSION OR AREAS WHICH ARE LESS THAN 25 PERCENT CROPLAND

1/3,500,690

SCALE 0 10 20 30 40 50 60 MILES
0 10 20 30 40 50 60 70 80 90 KILOMETERS

SOURCE
FAMILY OF MAPS SCS DRWG NO 5 S-32 926 (4-75)
AND INFORMATION FROM FIELD TECHNICIANS
ALBERS EQUAL AREA PROJECTION

USDA-SCS-LINCOLN, NEBR. 1978

6 15 78
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by Soil Conservation Districts. Contour cropping took place on the dairy farms and erosion seemed under control. As dairy herds consolidated, more farmers switched to corn and soybeans. This led to the elimination of grass waterways and contour strip cropping. Row cropping and application of fertilizers now takes place and causes excess erosion [Oemichen, 1980].*

The Soil Conservation Service (SCS) views soil conservation programs as being voluntary and only as productive as the landowners want them to be. On the other hand, SCS feels that its follow-up system is not good enough because of staff size limitations [Oemichen, 1980]. Even with adequate staff it is not clear the current technical and financial assistance programs can do the job. Regulations or other strategies may have to be considered in some cases.

The maximum amount a Minnesota farmer can get from the Agricultural Stabilization and Conservation Service (ASCS) is $3,500 per year. If farmers join together in a pooling agreement then it is possible to obtain $10,000 per farm. Depending on the project the practice has to be maintained between five and ten years [Dawald, 1980].**

One-half of the cost-sharing money available goes toward water quality methods. The ASCS office now has a model which can be used on site at feedlots to estimate runoff. Most of the participants in the Agricultural Conservation Program are farmers of 300 acres or less. In 1979, 7,600 farms in Minnesota were using ACP practices [Dawald, 1980].

It seems clear from the above that more research is needed concerning the use of different tillage methods and conservation practices in relation to the soils in Minnesota. Such studies should consider soil loss, labor savings, fuel savings, yields per acre, fertilizer and herbicide costs, cropping combinations and net returns. Research is also needed concerning the effectiveness of alternative conservation programs and strategies in Minnesota. Are new strategies needed to deal with non-point pollution and water quality? Do programs need to focus on critical conservation problem areas and farms? Minnesota needs research to identify the most cost-effective erosion control strategy or strategies.

*For reference, see page 16.
**For reference, see page 12.

ANNOTATED BIBLIOGRAPHY

A. Soil Conservation Programs and Strategies

Akhavi-Pour, Hossein and Emerson, M. Jarvin. Measuring the Benefits to a State of Controlling Non-Point Source Pollution. Kansas State University, June 1979. (Paper given at Mid-Continent Regional Science Assoc. meetings, Minneapolis, MN)

The paper discusses a framework for estimating benefits from pollution control of non-point source pollutants. Benefits from water quality include agricultural, municipal, industrial, recreational and human health effects. Sediment is considered the major non-point source pollutants.

Armbrust, D. W. and Welch, N. H. "Evaluation of Zingg Conservation Bench Terraces on Amarillo Fine Sandy Loam Soil," Journal of Soil and Water Conservation 21(6), November-December 1966, pp. 224-226.

Report of a study done on Zingg conservation bench terraces. Zingg terraces proved to increase crop yields and conserve water on fine-textured soils. The testing was limited to Amarillo fine sandy loam soil in Big Spring, Texas. Because of the ability of Zingg terraces to conserve water and increase crop yields it was thought that more farmers would have an incentive to adopt the practice.

Bagley, George R., "Soil Conservation Today and Tomorrow," Soil Conservation 43(5), December 1977, pp. 6-10.

Article contains abridged remarks made by Mr. Bagley at the Annual Conference of SCS State Conservationists in 1977. Mr. Bagley is a farmer and the president of the National Association of Conservation Districts. He recaps how SCS has improved over the years, what they have done and what they will have to do in future years.

Barlow, Tom, "Three-quarters of the Conservation Job Not Being Done," Soil Conservation Policies an Assessment, Soil Conservation Society of America, 1979, pp. 128-132.

The author feels that our record of performance in meeting "conservation responsibilities is not only extremely poor, but the agency of the government responsible for meeting conservation needs, the U.S. Department of Agriculture (USDA), is not taking the lead in forthright laying before the American people the dismal facts".

Barnett, A. P. "Using Perennial Grasses and Legumes to Control Runoff and Erosion," Journal of Soil and Water Conservation 20(5), September-October 1965, pp. 212-215.

The erosion index is discussed and suggested as being very useful in evaluating the effectiveness of erosion control measures.

When a good cover crop is plowed under and a rowcrop is planted the erosion hazard increases. Data is presented in relation to crop rotations.

Benbrook, Charles, "Integrating Soil Conservation and Commodity Programs: A Policy Proposal," Journal of Soil and Water Conservation 34(4), July-August 1979a, pp. 160-167.

The author feels that commodity support programs remain the essential stabilizing feature of the federal farm policy. A Conservation Incentives Program is a policy that would integrate commodity support and soil conservation efforts. Marginally higher target and support prices, as incentives, would be offered to farmers who voluntarily join.

Benbrook, Charles, "The National Conference on Soil Conservation Policies: An Appraisal," Journal of Soil and Water Conservation 34(6), November-December 1979b, pp. 288-291.

Article sums up the National Conference on Soil Conservation Policies. Recurring themes of the convention were discussed. The author felt that the convention was good because it brought people, agencies, and organizations together that have to find common ground among their conservation ideas.

Berg, Norman A., "Soil Conservation: The Physical Resource Setting," Soil Conservation Policies on Assessment, Soil Conservation Society of America, 1979, pp. 8-17.

Berg states that "42 percent of our cropland is adequately treated against erosion along with 25 percent of our pasture and rangeland and 33 percent of our forestland." He finds that 13-14 percent of the U.S. cropland has serious erosion problems but only 4 to 5 percent has a critical problem. Properly focused programs should be able to deal with these problem areas. Texas, New Mexico and Colorado are noted as being particularly hard hit by wind erosion.

Bertrand, A. R., and Woodburn, Russell, "A Fresh Look at Gully Erosion in the South," Journal of Soil and Water Conservation 19(5), September-October 1964, pp. 173-175.

The paper considers gully erosion in relation to the soil conservation program. A classification for gullies is given. The fact that gullying increases the erosion hazard emphasizes the vital need for gully erosion control.

Boggess, William; McGrann, James; Boehlje, Michael; and Heady, Earl O. "Farm-level Impacts of Alternative Soil Loss Control Policies," Journal of Soil and Water Conservation 34(4), July-August 1979, pp. 177-183.

The study evaluates the impact of soil loss controls on individual farm firms. The evaluation is based on Iowa data from three soil associations. The authors recommend that more research be done on nonpoint pollution.

Branson, F.A., and Owen, J. B., "Plant Cover, Runoff, and Sediment Yield Relationships on Mancos Shale in Western Colorado," Water Resources Research 6(3), June 1970, pp. 783-790.

Article describes the study area and the correlation analysis that was done. Four vegetation measurement methods, six years of vegetation measurements and 15 years of hydrologic records were used to complete the analyses. Correlation coefficients were highly significant between bare soil and runoff, but the relationships between bare soil and sediment yields were not statistically significant. Data tables and figures are provided to illustrate the findings.

Bregman, J. I., and Beeland, Gene, "The Water Pollution Control Act (As Amended in 1972, P.L. 92-500)," Handbook of Water Resources and Pollution Control, ed. Harry W. Gehm and Jacob I. Bregman, pp. 780-802, New York: Van Nostrand Reinhold Co., 1976.

Describes the Federal Water Pollution Control Act, as amended in 1972. The various sections of the law are explained. This law is felt to be the most important of the water pollution control legislation.

Brink, R. A.; Densmore, J. W.; and Hill, G. A., "Soil Deterioration and the Growing World Demand for Food," Science 197(4304), August 1977, pp. 625-630.

The authors state that due to cropping and erosion problems the high quality soil of the world seems to be gone. In addition, the demand for food keeps increasing because of the growing world population which suggests little relief from soil erosion. The authors did a soil erosion study of five Wisconsin watersheds. The soil losses for each watershed were estimated and presented. Further research was felt to be needed on conservation tillage along with education.

Carreker, John R., "Wind Erosion in the Southeast," Journal of Soil and Water Conservation 21(3), May-June 1966, pp. 86-88.

Reports on a study done on wind erosion in South Carolina. Some of the soils have a high erodibility index which means that some type of conservation practice is needed so that the erosion might be stopped. Data from the study is presented but additional information is needed to look at which conservation practice would be the most suitable.

Carter, Luther J., "Soil Erosion: The Problem Persists Despite the Billions Spent On It," Science 196(4288), April 1977, pp. 409-411.

Carter discusses the soil erosion problem and the familiar engineering and biological methods and practices. He states that the government programs are failing because they aren't finding

the farmers with the most critical erosion problems. Section 208 of the Clean Water Act of 1972 is thought to be of growing importance in the future years because of reporting to the EPA and its inclusion of nonpoint pollution.

Davis, R. M., "Soil Conservation on Agricultural Land: The Challenge Ahead," Journal of Soil and Water Conservation 32(1), January-February 1977, pp. 5-8.

Article indicates there is a need for more conservation action, since 42 percent of the cropland has no conservation treatment. Farmer incentives and some type of long term financing are two alternatives considered for improving soil conservation. The author also feels that there needs to be more public involvement because of urban people who are unaware of the resource problems of the farmer.

Dawald, Don, Agricultural Stabilization and Conservation Service, Minnesota, Interview, August 6, 1980.

Farmers can get up to $3,500 per year from the Agricultural Stabilization and Conservation Service. If a pooling agreement is formed than it is possible to obtain $10,000 per farm. Water quality methods and practices are now receiving one-half of the cost-sharing money available. Dawald feels that conservation practices are doing a lot to improve water quality.

Easter, K. William, "An Evaluation of the Agricultural Conservation Program's Performance in Fulfilling Program and Political Objectives," Unpublished Ph.D. Dissertation, Michigan State University, 1966.

A review of conservation studies is presented along with an evaluation of the ACP program. The analysis shows that ACP has placed too much emphasis on production-oriented practices.

Fitzgerald, Ray, "Conservation Efforts and the Agricultural Stabilization and Conservation Service," in Soil Conservation Policies: An Assessment, Soil Conservation Society of America, Iowa, 1979, pp.83-86.

Discusses the Agricultural Conservation Program and its past actions. In the past it was production-oriented but in 1978 it was redirected towards more soil conservation. A breakdown of how the money was used in 1978 is given. The Rural Clean Water Program is also discussed.

Grant, Kenneth E., "Erosion in 1973-74: The Record and the Challenge," Journal of Soil and Water Conservation 30(1), January-February 1975, pp. 29-32.

The 1973-74 growing season is discussed with importance placed on soil and water resources. Acreage data is given concerning how much land was converted from idle cropland, grassland, and pasture to cropland. Soil structure and its relation to the different crop root structures is also discussed.

Greiner, William H., "Iowa's Experience with a Mandatory Sediment Control Law," Journal of Soil and Water Conservation 30(3), May-June 1975, pp. 132-134.

Article covers the Iowa Sediment Control Law. The law which came into action in 1971 is felt to be working well. Cost-sharing assistance is available to the farmers. If a permanent conservation practice is installed 75 percent of the cost will be paid to the farmer. For temporary practices, the amount is specified by a state committee.

Grissinger, E. H., and McDowell, L. L., "Sediment in Relation to Water Quality," Water Resources Bulletin 6(1), January-February 1970, pp. 7-14.

Water quality and sediment are defined in detail. It is stated that 50 percent of the erosional sediment is due to agricultural activities. Natural or geologic activities account for 30 percent and the remaining 20 percent of erosional sediment comes from industrial and individual activities. A list of ten areas impaired by sediment is also given.

Harder, S. M.; Daniel, T. C.; and Madison, F. W., "Guidelines for Mandatory Erosion Control Programs," Journal of Soil and Water Conservation 33(2), March-April 1978, pp. 80-84.

The authors feel that state governments are in the best position to enact legislation for conservation purposes. The local governments can then implement the laws to meet their needs. Financial assistance was also discussed in the article.

Ibrahim, Girmai, and Forester, D. Lynn, Sediment Deposits in Drainage Ditches: A Crop Externality, Paper presented at the American Agricultural Economics Association Annual Meetings, University of Illinois, Champaign, IL, July 28, 1980.

The cost of sediment removal is one of the externalities of soil loss from cropland. Use of the Universal Soil Loss Equation (USLE) is also discussed. The experiment was done using drainage ditches as collectors of sediment for measuring purposes. Use of the USLE is supported as a method for making gross erosion estimates as a proxy for water quality measurement.

Initial Report Team, Initial Report on the Land and Water Conservation Program of the U.S. Department of Agriculture, December 1, 1977.

Report lists various agricultural laws and programs and briefly describes each of them. Current program organization and funding are discussed. The report criticizes past program reviews because program beneifts have not been evaluated. Past studies have not followed programs over time to discover the long-term effects. The statistical significance of the results and sample selections are questioned.

Jacobs, James J., and Timmons, John F., "An Economic Analysis of Agricultural Land Use Practices to Control Water Quality," American Journal of Agricultural Economics 56(4), November 1974, pp. 791-798.

Article conveys information used in analyzing different levels of water quality. Formulas and explanations are provided for calculating soil and phosphorus losses. The benefits and costs of reducing the concentration of suspended sediments are also discussed.

Jacobson, Paul, "Keeping Soil and Water on the Farm," Journal of Soil and Water Conservation 22(2), March-April 1967, pp. 54-57.

The author bought a farm which was located in western Iowa. On this land he tested the idea of using engineering technology in combination with good agronomic practices to produce level land, straight rows and increased productivity. The plan that he used is explained along with some of the results and some personal comments about the project.

Johnson, Murray, and Berg, Norman, "A Framework for Nonpoint Pollution Control in the Great Lakes Basin," Journal of Soil and Water Conservation 32(2), March-April 1979, pp. 68-73.

The Great Lake Basin is described. The U.S. and Canada committed themselves to safeguard and restore uses of the Great Lakes water. A list of pollutants that are flowing into the Great Lakes is given.

Krivak, Joseph A., "Best Management Practices to Control Nonpoint Source Pollution from Agriculture," Journal of Soil and Water Conservation 33(4), July-August 1978, pp. 161-166.

The article explains the Clean Water Act and what it is supposed to do. The author feels that an evaluation of water quality improvements is needed on a continuing basis and that new technical and management practices should be utilized to improve water quality.

Laflen, John M., and Moldenhauer, W. C., "Soil Conservation on Agricultural Land," Journal of Soil and Water Conservation 26(6), November-December 1971, pp. 225-229.

Background information on soil conservation is presented briefly. The authors state that a soil conservation and pollution control system consists of one or more of the following: (1) land treatments, (2) land-formed structures, and (3) reservoirs. These three are then explained. A brief explanation is given on how the selection should be made when choosing these system components.

Lee, Linda K., The Impact of Landownership Factors on Soil Conservation, Paper prepared for the American Agricultural Economics Association Annual Meeting, University of Illinois, July 29, 1980.

Paper discusses factors affecting erosion. Erosion rates among landowners and nonlandowners is compared. Also, erosion rates for corporate and family farms is compared. No great difference in erosion rates was found to occur between any of the groups. More research was felt to be needed to varify or disprove these findings.

Longley, Andrew J., and Bondy, Earl J., "Reducing Soil Losses in Kansas," Journal of Soil and Water Conservation 18(4), July-August 1963, pp. 160-161.

Article discusses the research done in Kansas. A chart is provided which shows farmers alternative combinations of residue at seeding time and treatment needs that will produce the desired soil loss reduction goal. This chart was prepared for use in western Kansas. By using the methods applied in making this chart other charts could be made for any area in the United States.

Minnesota Water Planning Board, Toward Efficient Allocation and Management: A Strategy to Preserve and Protect Water and Related Land Resources, June 1979.

The report presents a framework water and related land resources plan which the legislature directed the Water Planning Board to prepare. Different issues, goals, and recommendations are discussed in relation to water quality, conservation and other selected areas. It is felt that management of Minnesota's water and related land resources is needed so that past mistakes will not be repeated.

Moldenhauer, W. C., and Onstad, C. A., "Achieving Specified Soil Loss Levels," Journal of Soil and Water Conservation 30(4), July-August 1975, pp. 166-168.

When establishing soil loss limits two objectives must be looked at: (1) high level of productivity for present and future generations, and (2) offsite sediment damage and onsite damage must be kept to a minimum. The level of erosion control for various soil and horizon characteristics is discussed. The paper goes on to discuss the implementation of soil loss limits and the problems associated with implementation.

Morrison, Jim, "Managing Farmland to Improve Water Quality," Journal of Soil and Water Conservation 32(5), September-October 1977, pp. 205-208.

Report on a study done in Indiana on the Black Creek watershed which was financed by the U.S. Environmental Protection Agency. The objective was to see if water quality could be achieved

through voluntary compliance and cost-sharing incentives. The SCS estimated that at the end of the project's land treatment phase, 75 percent of the watershed had been treated.

Murray, Glen E., "SCS and Water Quality: An Overview," Soil Conservation 42(4), November 1976, pp. 12-17.

The relationship between nonpoint source pollutants and water quality is discussed. A list of upstream water quality problems from a rural land user's viewpoint is given. It is felt that the SCS should take a strong position and advocate some type of incentive for control of nonpoint pollution.

Neubauer, T. A., "Cost Share Principles Under the Great Plains Conservation Program," Journal of Soil and Water Conservation 16(3), May-June 1961, pp. 116-118.

The article discusses the Great Plains Conservation Program and the amount of cost-sharing for permanent installations and annual recurring practices. The costs of programs is averaged and presented in a table. The article concludes with the progress that has been made in conservation practices.

Nicholson, H. P., "The Needs for Water Quality Models on Agricultural Watersheds," Journal of Environmental Quality 4(1), January-March 1975, pp. 21-23.

The author feels that management of nonpoint source agricultural pollutants is needed. Models for runoff control of pesticides and fertilizers are suggested as important management tools. Provisions of the Federal Water Pollution Control Act which are of importance to nonpoint sources of pollution are listed.

Oemichen, William P., Soil Conservation Service, Assistant State Conservationist of Minnesota, Interview, August 13, 1980.

William P. Oemichen feels that soil conservation programs can only be as good as landowners want them to be. The worst erosion in Minnesota is in the southeastern part of the state. This is due to the heavy row cropping. The Soil Conservation Service needs a better follow-up system and in Oemichen's opinion this could be solved if the staff was enlarged from its present size of 255 people in Minnesota.

Ogg, Clayton W., and Heimlich, Ralph E., Conservation Plans for Changing Market Conditions, Northeastern Resources Group, Natural Resources Economic Division, Economics Statistics and Cooperatives Service, United States Department of Agriculture, January 1979.

The hypothesis that optimal practice combinations for meeting conservation goals are sensitive to alternative farm output and price situations is tested by using a river basin linear

programming model. They found that studies which ignore market forces may develop conservation strategies that are attractive to individual farmers at some point in time but not at others.

Olson, R. A.; Seim, Edwin C.; and Muir, John, "Influence of Agricultural Practices on Water Quality in Nebraska: A Survey of Streams, Groundwater, and Precipitation," Water Resources Bulletin 9(2), April 1973, pp. 301-311.

The article describes research that was done to determine if agricultural practices, including fertilizer use, were polluting Nebraska's water resources. Rainfall, stream flow and groundwater have been systematically sampled in Nebraska since 1970. The results of the study indicate that the use of fertilizers was not a significant factor in the degradation of Nebraska's surface and groundwater.

Olson, Tamlin C., "Restoring the Productivity of a Glacial Till Soil After Topsoil Removal," Journal of Soil and Water Conservation, 32(3), May-June 1977, pp. 130-132.

This article explains the results of a study begun in 1966. The effects of topsoil on corn was evaluated by applying three soil removal treatments and six fertility treatments on a Bedle silty clay loam.

Park, William M., and Shabman, Leonard, Relative Cost Effectiveness of Agricultural and Urban Nonpoint Pollution Control, Prepared for the American Agricultural Economics Association Annual meetings, University of Illinois, Champaign, Illinois, July 27, 1980.

The study, done in the Occoquan River Basin in northern Virginia, compares the effectiveness of agricultural and urban best management practices in improving water quality. A cost-effectiveness analysis is presented along with some implications for policy and research.

Peterson, J. B., "The Relation of Soil Fertility to Soil Erosion," Journal of Soil and Water Conservation 19(1), January-February 1964, pp. 15-19.

Highly fertile soils reduce water erosion because of the excellent vegetative cover that can be grown. The impact force from rain is reduced by the vegetative cover. The leaves form a canopy and keep the rain from hitting the ground forcefully and destroying soil structure. Wischmeier and the universal soil loss equation are also discussed.

Pierce, J. Jeffrey, "Strategies to Control Nonpoint Source Water Pollution," Water Resources Bulletin 16(2), April 1980, pp. 220-225.

Different strategies used to control nonpoint pollution are discussed. Nonpoint water pollution originates from silviculture, construction, mining, on-site waste water disposal, residual waste disposal, agricultural runoff and urban storm water runoff. Various agencies were also considered. It was felt that technology is available to solve the nonpoint pollution problem, but existing programs need to be adjusted so that they can provide better solutions to the problems of nonpoint pollution.

Risser, James, "Soil Erosion Creates a Crisis Down on the Farm," Conservation Foundation Letter, December 1978.

The letter discusses soil erosion and related problems including the cross-compliance system and how it could be used. The author feels that regulations adopted by the Agricultural Stabilization and Conservation Service have led some farmers to plow up lands that were previously in grass under federal conservation programs.

Rosenberry, Paul E.; Daugherty, Arthur B.; and Pavelis, George A., "Technological Change and the Economics of Conservation," Journal of Soil and Water Conservation 23(4), July-August 1968, pp. 123-126.

Soil and water conservation are felt to be very necessary but right along with this is the fact that farmers need to know more about the different conservation practices. The economic impacts of conservation and the direct impacts of technology on agriculture are also discussed. Conservation practices and research efforts are also mentioned.

Rosenberry, Paul; Knutson, Russell; and Harmon, Lacy, "Predicting the Effects of Soil Depletion from Erosion," Journal of Soil and Water Conservation 35(3), May-June 1980, pp. 131-134.

The article describes a study that was done on soil loss in relation to energy, fertilizer and yields. Six different erosion control methods were used to prevent soil depletion. The impact of the erosion control methods is discussed.

Seitz, Wesley D., and Swanson, Earl R., "Economics of Soil Conservation from the Farmer's Perspective," Prepared for presentation at the American Agricultural Economics Association meetings, Urbana, Illinois, July 27-30, 1980.

The article briefly discusses the information from surveys done in the past. Different models are explained and from their results it is shown that the private economic incentives for soil conservation are weak. The authors feel that if they could model the farmer's soil conservation decision process more effectively then it would be possible to communicate more

efficiently with decision makers. A model of this type would have to be quite complex because of the numerous variables. They feel that there is a long way to go in developing a model which illustrates the considerations that influence farmer's decisions regrading soil conservation.

Seitz, W. D., and Spitze, R. G. F., "Soil Erosion Control Policies: Institutional Alternatives and Costs," Journal of Soil and Water Conservation 33(3), May-June 1978, pp. 118-125.

This article discusses the 1972 Federal Water Pollution Control Act (Public Law 92-500) and lists the five principle components of public policy. A long list of functions required by the government in relation to nonpoint sources of water pollution is given. The authors feel that restrictive policies are more expensive than voluntary policies.

Sharp, Basil M. H., and Bromley, Daniel W., "Agricultural Pollution: The Economics of Coordination," American Journal of Agricultural Economics 61(4), November 1979, pp. 591-600.

Agriculture is one of the main polluters to the nation's water. A diagram and a discussion are given of the agricultural pollution process. A model representing an agricultural firm and a model representing a management agency are explained. These models show that flexibility and analytic capacity is needed by agencies in determining the cost-share rules for on-farm abatement practices.

Shrader, William D.; Johnson, Howard P.; and Timmons, John F., "Applying Erosion Control Principles," Journal of Soil and Water Conservation 18(5), September-October 1963, pp. 195-199.

The article reviews the various erosion control practices. The costs and benefits of achieving erosion control are considered in relation to some specific soils. The authors feel that there are many combinations of practices to stop soil erosion and a land owner should choose the one which does the most for the least cost.

Spomer, R. G.; Shrader, W. D.; Rosenberry, P. E.; and Miller, E.I., "Level Terraces With Stabilized Backslopes on Loessial Cropland in the Missouri Valley: A Cost-effectiveness Study," Journal of Soil and Water Conservation 28(3), May-June 1973, pp. 127-130.

The authors report on a study done in Iowa concerning the use of terraces. Yields on terraced fields were slightly lower than unterraced fields but soil loss was significantly lower for terraced fields as compared to unterraced fields. Benefits and costs are shown for terraces.

Springer, D. K.; Breinig, C. B.; and Springer, M. E., "Predicting Soil Losses," Journal of Soil and Water Conservation 18(4), July-August 1963, pp. 157-158.

The authors explain the universal soil loss equation and state the uses and benefits of the equation. An example is given using a Tennessee farm.

Swader, F. N., "Soil Productivity and the Future of American Agriculture," The Future of American Agriculture as a Strategic Resource, ed. Sandra S. Batie and Robert G. Healy, The Conservation Foundation, Washington, D.C., July 14, 1980.

The article discusses soil productivity, constraints on maintenance of soil productivity, fertilizers and soil productivity, and various programs and policies for soil conservation. A table showing expected yields of crops for the year 2030 at the 1977 erosion rate is presented along with a map of the U.S. which shows the acreage of cropland exceeding the soil erosion tolerance level. The author points out that in 1977 soil erosion was a major conservation problem on over half of the nation's cropland.

Taylor, C. Robert; Frohberg, Klaus K.; and Seitz, Wesley D., "An Aggregate Economic Analysis of Potential Erosion and Plant Nutrient Controls in the Corn Belt," in Symposium on Impacts on Rural America of the Federal Water Pollution Control Act Amendments, P.L. 92-500, presented at the Joint Annual Meeting of the American Agricultural Economics Association and the Western Agricultural Economics Association, August 2, 1977.

The paper discusses various regulatory procedures for erosion and nitrogen fertilizer in the Corn Belt and presents estimates on the intermediate term economic effects of such regulations. A linear programming model was used in the analysis and shows that reasonable soil erosion control programs could be put into effect with little economic impact on the agricultural sector or on consumer expenditure. Stricter soil loss control such as 2 tons per year per acre would have a serious economic impact.

Taylor, C. Robert; Frohberg, Klaus K., "The Welfare Effects of Erosion Controls, Banning Pesticides, and Limiting Fertilizer Application in the Corn Belt," American Journal of Agricultural Economics 59(1), February 1977, pp. 25-35.

The article provides estimates of the partial welfare effects of seven different public policies related to agricultural pollution in the Corn Belt. The authors feel that future research should be done on administrative and enforcement costs of pollution controls. This information could be used to modify, the model presented, to include these costs and, therefore, give the socially optimal level of pollution.

Thomas, Adrian W.; Carreker, John R.; and Leverette, Walter B., "Soil Erosion on Tifton Loamy Sand," Journal of Soil and Water Conservation 22(6), November-December 1967, pp. 245-248.

The article discusses a 16-year study done in the southern Coastal Plain, along with the application of the soil loss equation.

Thoreson, A. S., and Maddy, John K., "Using the Soil Loss Equation in Iowa," Journal of Soil and Water Conservation 18(4), July-August 1963, pp. 159-160.

The article explains some of the past history of the universal soil loss equation and some of the recent variable additions. Each of the variables in the universal soil loss equation are explained in some detail. An example using numbers from central Iowa is provided.

Timmons, John F., "Agriculture's Natural Resource Base: Demand and Supply Interactions, Problems and Remedies," Soil Conservation Policies An Assessment, Soil Conservation Society of America, 1979, pp. 53-74.

The causes of soil erosion are grouped into micro and macro causes. The micro category focuses on individual farm level explanations while the macro category includes causes beyond the farm gate and extends to national and international factors. The paper concludes with a discussion of strategies for reducing soil erosion losses.

Train, Russell E., "EPA and Agriculture: Establishing a Partnership," Journal of Soil and Water Conservation 30(1), January-February 1975, pp. 33-35.

The work of the Environmental Protection Agency (EPA) is discussed in relation to the Federal Water Pollution Control Act of 1972. The EPA has tried to set up a feedlot permit program that will not overburden the farmer with paperwork. The problem of nonpoint pollution is recognized and the author feels that some program has to be established to deal with the problem.

Uchtmann, D. L., and Seitz, W. D., "Options for Controlling Non-point Source Water Pollution: A Legal Perspective," Natural Resources Journal 19(3), July 1979, pp. 587-609.

The article discusses and analyzes, from a legal perspective, the various alternative approaches for controlling agricultural non-point sources of pollution. Voluntary programs such as education, cost sharing and tax incentives are discussed. Mandatory sediment control programs are considered and, in this case, the limitation of row-crop agriculture is assumed. Row-crop limitation is assumed because it is the most severe of the possible regulations. If the limitation of row-cropping could survive legislation than the use of other less restrictive conser-

vation programs such as minimum tillage would surely survive. Some legal cases concerning land use are also mentioned.

Unger, David G., "Conservation Districts and Section 208," in Proceedings of Symposium on the Role of the Environmental Protection Agency in Land Use Planning, Soil Conservation Society of America, October 16, 1975.

Local conservation districts are interested in Section 208 of P.L. 92-500 because of the non-point sources of pollution. There are 3,000 districts nationwide which employ a total of 7,000 staff members. Programs have been voluntary and conservation district officials would like to keep them that way in order to keep enforcement to the minimum. Since the conservation districts already exist with technology and information about their areas it would seem that they have a solid foundation on which to establish a program.

United States Department of Agriculture, Palouse Cooperative River Basin Study, Soil Conservation Service, Forest Service and Economics, Statistics and Cooperative Service, U.S.G.P.O., 1979.

Report on a study done in the Palouse River Basin used to aid the implementation of Section 208 of the 1972 Federal Water Pollution Control Act. Non-point pollution was the main topic of the study. Sheet and rill erosion, tillage erosion, deep soil slips, gully erosion, stream channel erosion, wind erosion and water quality are all discussed along with different conservation practices.

United States General Accounting Office, Report to the Congress of the United States: A Framework and Checklist for Evaluating Soil and Water Conservation Programs, March 31, 1980, PAD-80-15.

The report describes a framework for evaluating soil and water conservation programs. Soil and water results and models are not apparently used in the decision making process. Local level officials do not seem to be getting all the information they need to make decisions. The allocation of funds at the local level is felt to need a better weighting system.

United States General Accounting Office, Report to the Congress of the United States: National Water Quality Goals Cannot Be Attained Without More Attention to Pollution from Diffused or "Nonpoint" Sources, December 20, 1977a, CED-78-6.

The report finds that the 1983 fishing and swimming goals of the Federal Water Pollution Control Act Amendments of 1972 will not be reached because of nonpoint sources of water pollution. The state and local planning agencies lack the data and funds necessary to develop a non-point source control program. More information is needed on non-point sources of pollution before effective plans can be drawn up.

United States General Accounting Office, Report to the Congress of the United States: To Protect Tomorrow's Food Supply, Soil Conservation Needs Priority Attention, February 14, 1977b, CED-77-30.

This report reviews the program and operation of the Soil Conservation Service, the Conservation Operations Programs, the Agricultural Conservation Program, and the Great Plains Conservation Program. A brief evaluation is done for each program.

U.S. Environmental Protection Agency, Methods and Practices for Controlling Water Pollution from Agricultural Non-point Sources, U.S.G.P.O., October 1973, EPA-430.

The report discusses water erosion, wind erosion, plant nutrients, pesticides and animal wastes. The various factors affecting pollution and the methods to control pollution are described. Terracing, strip cropping, contouring, and grassed waterways are mentioned briefly.

Wade, James C., and Heady, Earl O., "Controlling Non-point Sediment Sources with Cropland Management: A National Economic Assessment," American Journal of Agricultural Economics 59(1), February 1977, pp. 13-24.

This study was done to evaluate the modeling scheme designed to link demand for agricultural commodities to generation of cropland sediment. The evaluation involved comparing five alternative policies used to control sediment in the rivers and streams of the United States.

Wade, James C., and Heady, Earl O., "Measurement of Sediment Control Impacts on Agriculture," Water Resources Research 14(1), February 1978, pp. 1-8.

This study used a national agricultural model to evaluate hypothetical policies of sediment control. A formulation of the model is presented and some of the results are discussed. Relationships between sediment, water quality and agricultural production are shown.

Walker, David John, and Timmons, John F., In Search of the Best Solution for Non-Point Pollution: Effluent Taxes or Cost-Share Subsidies? Presented at the American Agricultural Economics Association Annual meetings, University of Illinois, Champaign, Illinois, July 28, 1980.

The paper compares effluent tax with subsidies and regulatory policies which are used in reducing sedimentation in an Iowa river basin. Social cost, equity, administrative cost, political acceptability and cost to farmers were all used to compare the policies. A soil loss tax and a cost-share subsidy both have good and bad points. The best approach would seem to be regulation but it would need political acceptability and more research before used on a wide scale basis.

Wegger, L. R., "Soil Physical Properties and Erosion Control," Journal of Soil and Water Conservation 19(1), January-February 1964, pp. 28-30.

This study measured soil and water losses on a 7 percent slope for 10 years. Different soil treatments were tried. The effect of erosion on organic matter content, aggregate stability and the volume of air-filled pore at low tensions of water was recorded.

Wells, Dan M.; Huddleston, Ellis W.; and Rekers, Robert G., "Concentrations of Pollutants in Agricultural Runoff," Water Resources Bulletin, 7(1), February 1971, pp. 124-132.

This study was done to determine whether or not runoff from intensively farmed agricultural areas contains significant concentrations of phosphates, nitrates, herbicides or insecticides. From the results of the research it was concluded that runoff from agricultural lands in the High Plains of West Texas is not a significant source of water pollution.

Yarn, Jane, "Natural Resources in an Age of Uncertainty," Soil Conservation Policies on Assessment, Soil Conservation Society of America, 1979, pp. 47-52.

The author argues for a new approach to resource management where "natural resource supplies will have to be viewed in terms of the effect each element of a farm ecosystem has on the others. Woodlands, soils, water and energy should be managed together rather than controlled separately."

B. Effect of Conservation Tillage Practices on Soil Erosion

Allmaras, R. R.; Gupta, S. C.; Pikul, J. L. Jr.; and Johnson, C. E., "Tillage and Plant Residue Management for Water Erosion Control on Agricultural Land in Eastern Oregon," Journal of Soil and Water Conservation 34(2), March-April 1979, pp. 85-90.

The article discusses water and erosion control in eastern Oregon. In addition to tillage and plant residue management, reduction of slope lengths and contouring are also important in controlling water erosion on the long steep slopes in eastern Oregon. An explanation of the soil erosion estimating model and how it is used is presented.

Ameniya, Minoru, "Conservation Tillage in the Western Corn Belt," Journal of Soil and Water Conservation 32(1), January-February, 1977, pp. 29-36.

Conventional tillage, disking, chisel plowing, till planting, slot planting, and rotary tillage are defined. Data is given

showing the crop response to the different tillage methods. Soil temperature, weed control, diseases, nematodes, insects, plant nutrient availability, seed placement and their relationship to conservation tillage is evaluated. A list of research needs is provided.

Bennett, L. L., "Conservation Tillage in the Northeast," Journal of Soil and Water Conservation 32(1), January-February 1977, pp. 9-12.

The author considers the region and its use of no-till corn and no-till soybeans. Pasture renovation using no-tillage and no-till fertilizer practices is also mentioned. A list of advantages and disadvantages of no-till production is given in the conclusion.

Black, A. L., and Siddoway, F. H., "Influences of Tillage and Wheat Straw Residue Management on Soil Properties in the Great Plains," Journal of Soil and Water Conservation 34(5), September-October 1979, pp. 220-223.

Primary tillage at the beginning of a cropping season helps to improve the porosity and roughness of the soil structure. Further tillage reduces the vegetative cover, decreases the soil structure and increases erosion. The article goes on to discuss limited tillage and no-tillage cropping systems and their benefits.

Burwell, R. E.; Sloneker, L. L.; and Nelson, W. W., "Tillage Influences Water Intake," Journal of Soil and Water Conservation 23(5), September-October 1968, pp. 185-187.

The article reports on studies conducted in west central and southwestern Minnesota. Different tillage methods were compared for their effects on the soil surface and water infiltration. Nonweathered, clean-tilled surfaces; weathered, clean-tilled surfaces; and mulch-tilled surfaces were compared for infiltration rates.

Doss, B. D.; Bennett, O. L.; and Ashley, D. A., "Effect of Plastic Mulch, Herbicide, and Tillage on Moisture Use and Yield of Corn," Journal of Soil and Water Conservation 21(3), May-June 1966, pp. 99-101.

The study determined the effect of black plastic mulch, herbicide, and tillage on moisture use and corn yields. The benefits of each practice depends on the moisture content during the particular growing season.

Drullinger, Richard H., and Schmidt, Berlie L., "Wind Erosion Problems and Controls in the Great Lakes Region," Journal of Soil and Water Conservation 23(2), March-April 1968, pp. 58-59.

Wind erosion is a big concern on heavily farmed soils in southern Michigan and northwestern Ohio. Coarse textured sandy soils of

of glacial outwash are the most prone for erosion. Silt loam and clay loam soils which are high in organic matter are also subject to erosion. Crop and soil losses along with the cost of conservation are considered. Different tillage practices and continuing research are both needed in the years to come.

Fenster, C. R., "Conservation Tillage in the Northern Plains," Journal of Soil and Water Conservation 32(1), January-February 1977, pp. 37-42.

Tillage systems used in the area such as disk-type implements, chisel plows, mulch treaders, sweep plows, rotary rodweeder and rodweeder with semi-chisels are evaluated. How to select tillage tools for various cropping conditions is mentioned along with the effect of tillage on erosion.

Griffith, Donald R.; Mannering, Jerry V.; and Moldenhauer, William C., "Conservation Tillage in the Eastern Corn Belt," Journal of Soil and Water Conservation 32(1), January-February 1977, pp. 20-28.

The authors critique past and present tillage methods used in the eastern Corn Belt. The article goes on to state tillage effects on erosion, water conservation, yields, fertilizer, and weed control. Residue, disease and insect problems are also covered.

Guntermann, Karl L.; Lee, Ming T.; and Swanson, Earl R., "The Off-site Sediment Damage Function in Selected Illinois Watersheds," Journal of Soil and Water Conservation 30(5), September-October 1975, pp. 219-224.

Erosion and sedimentation problems in agriculture impose costs on society in two ways: (1) erosion reduces on-site productivity, and (2) sediment damages off-site locations. The article lists five types of off-site damages for watersheds. A tax-subsidy is discussed as a way to stop agricultural erosion.

Halsey, Clifton, Minnesota's Soils and Their Uses, University of Minnesota, Agricultural Extension Service, Bulletin 383 (no date).

Classifies the soils in Minnesota into eight groups using the Soil Conservation Service classification system. The south central, southeastern and southwestern areas in Minnesota are intense agricultural areas and, therefore, are prone to erosion.

Harrold, L. L.; Triplett, G. B. Jr.; and Youker, R. E., "Watershed Tests of No-tillage Corn," Journal of Soil and Water Conservation 22(3), May-June 1967, pp. 98-100.

The study compares no-tillage corn with conventional-tillage and the results are presented in terms of runoff, corn yields and soil moisture.

Hays, Orville E., "New Tillage Methods Reduce Erosion and Runoff," Journal of Soil and Water Conservation 16(4), July-August 1961, pp. 172-175.

The article discusses some of the past tillage methods and a study done at LaCrosse. Minimum tillage and mulches are shown helping to reduce soil erosion.

Hest, David, "Drouth Didn't Stop His No-till Crops," The Farmer 98 (17), September 6, 1980, pp. 10, 13.

John Leppert used no-till planting on 585 of his 960 acres. Next year all of his farm except for 60 acres will be in no-till. While other farmers were plowing under their fields this year because of the drouth, Leppert's fields were able to survive. Leppert felt that his no-till crops survived because of: (1) the moisture from snow trapped by the stubble, and (2) the lower moisture loss from no-till. Leppert does not think no-till is something every farmer would want to adopt. An intense herbicide program is necessary for no-till to be successful.

Kelley, Hubert W., "Conservation Tillage: Hazards Ahead?" Soil Conservation, January 1977, pp. 7-11.

The article reports on a minimum tillage conference. The room for error with minimum till is considerably smaller than with conventional tillage. Weeds and insects both need to be kept in check under minimum tillage. More research is needed on plant diseases control.

Kent, R. L., "Erosion Control Practices for Pacific Northwest Wheat Lands," Journal of Soil and Water Conservation 21(6), November-December 1966, pp. 221-223.

On the wheat lands of the Pacific Northwest soil erosion is a critical problem. Diversions and terraces have been used by many farmers and have helped stop erosion, although some farmers object because they sometimes cannot use their large equipment. Minimum tillage and strip cropping have both been used more over the years.

Larson, W. E., "Tillage Requirements for Corn," Journal of Soil and Water Conservation 17(1), January-February 1962, pp. 3-7.

The article discusses the different tillage methods and how they are used. The requirements for tillage are listed for Marshall silt loam. Soil and water loss tables along with the current tillage practices are presented.

Lindstrom, M. J.; Gupta, S. C.; Onstad, C. A.; Larson, W. E.; and Holt, R. F., "Tillage and Crop Residue Effects on Soil Erosion in the Corn Belt," Journal of Soil and Water Conservation 34(2), March-April 1979, pp. 80-82.

The authors calculated potential soil erosion by water in the Corn Belt using the universal soil loss equation and present cropping practices. Using no conservation practices, only 36 percent of the crop area would have soil erosion rates less than or equal to the limits set up by the Soil Conservation Service. Tillage and residue management increase the 36 percent to 78 percent. The issue of non-point water pollution was also stressed.

Moldenhauer, W. C., and Amemiya, M., "Tillage Practices for Controlling Cropland Erosion," Journal of Soil and Water Conservation 24(1), January-February 1969, pp. 19-21.

The erosion problems of the Corn Belt and arguments against uncontrolled erosion are listed. Plow methods and no-plow methods are discussed and compared. Data concerning soil loss, corn yield, and the effect of mulching on the growth rate of corn is presented in a series of tables.

Moldenhauer, William C.; Lovely, W. G.; Swanson, N. P.; and Currence, H. D., "Effect of Row Grades and Tillage Systems on Soil and Water Losses," Journal of Soil and Water Conservation 26(5), September-October 1971, pp. 193-195.

The study compares the effectiveness of till planting, conventional tillage and ridge planting on slopes of 3.4 to 9 percent in controlling soil and water losses. Ridge planting proved to be the best in controlling soil losses.

Morgan, R. P. C., Soil Erosion, Longman Inc., New York, 1979, 103pp.

The author considers a wide range of question involved with soil erosion starting with the mechanics of soil erosion. The first part of the book also considers approaches for modeling soil erosion and strategies for erosion control. The last part of the book applies erosion risk evaluation and conservation planning to Peninsular Malaysia.

Mulkey, Lee A., and Falco, James W., "Sedimentation and Erosion Control Implications for Water Quality Management," in Proceedings of the National Symposium on Soil Erosion and Sedimentation by Water, American Society of Agricultural Engineers, St. Joseph, Michigan, 1977.

The article deals with water quality management and sediment transport in a watershed system. It lists guidelines which can be used in evaluation of non-point pollution controls, including soil erosion, for water quality management.

Onishi, H., and Swanson, E.R., "Effect of Nitrate and Sediment Constraints on Economically Optimal Crop Production," Journal of Environmental Quality 3(3), July-September 1974, pp. 234-238.

The study demonstrated a method for determining the optimum cropping rotations, tillage methods, and nitrogen application levels that meet with water quality standards pertaining to nitrates and sediment. Linear programming was used in the analysis.

Papendick, R. I., and Miller, D. E., "Conservation Tillage in the Pacific Northwest," Journal of Soil and Water Conservation 32(1), January-February 1977, pp. 49-56.

The article describes the area, its soils, crops, conservation problems and conservation tillage systems. Conservation cropping practices and their relationship to erosion, runoff and planting time is stressed. The authors feel that conservation tillage systems have the potential to deal with the soil erosion problem.

Phillips, S. H., and Young, H. M. Jr., No-Tillage Farming, Milwaukee, Wisconsin: Reiman Associates, Inc., 1973.

The benefits to no-tillage are listed such as time saving, wet spring planting, less soil structure damage, and conservation of moisture. Over a four year period a 20 percent decrease in water-stable aggregates was noted in the soil structure of the tilled areas.

Pimentel, David; Terhune, Elinor C.; Dyson-Hudson, Rada; Rochereau, Stephen; Samis, Robert; Smith, Eric A.; Denman, Daniel; Reifschneider, David; and Shepard, Michael, "Land Degradation: Effects on Food and Energy Resources," Science 194(4261), October 1976, pp. 149-155.

The article focuses on the land lost to highways, urbanization and erosion. The authors site examples of conservation technology along with the economic effects of erosion and conservation. Water and land quality are of growing concern because agriculture accounts for 96 percent of the water consumed. Better management of resources to prevent the further loss of valuable cropland is stressed.

Pollard, Richard W.; Sharp, Basil, M. H.; and Madison, Fedrick W., "Farmers' Experience with Conservation Tillage: A Wisconsin Survey," Journal of Soil and Water Conservation 34(5), September-October 1979, pp. 215-219.

The article reports the results of a study done in Dane County, Wisconsin. Farmers were offered cost sharing as a direct incentive to promote conservation tillage. The returns and yields from conservation tillage are presented along with farmers' statements on conservation tillage.

Reicosky, D. C.; Cassel, D. K.; Blevins, R. L.; Gill, W. R.; and Naderman, G. C., "Conservation Tillage in the Southeast," Journal of Soil and Water Conservation 32(1), January-February 1977, pp. 13-19.

The Southeast is the area where conservation tillage could provide the greatest payoff. The economics of no-till planting is evaluated along with the requirements for fertilization, insect management, and weed control. The authors feel more research is needed on the use of no-till planting, chiseling and subsoiling.

Richardson, Clarence W., "Runoff, Erosion, and Tillage Efficiency on Graded-Furrow and Terraced Watersheds," Journal of Soil and Water Conservation 28(4), July-August 1973, pp. 162-163.

Terrace and graded-furrow systems were compared for their effectiveness in farm tillage, and the control of runoff and soil loss. The graded-furrow system seemed to be more effective in conservation than the terrace system.

Richardson, C. W.; Baird, R. W.; and Fryrear, D. W., "Graded Furrows for Water Erosion Control," Journal of Soil and Water Conservation 24(2), March-April 1969, pp. 60-63.

Terraces and graded-furrows are critiqued and soil loss and yield data are presented. The article explains how to design a graded-furrow and how graded furrows were installed in a testing area. Although the authors feel that additional research is needed, graded-furrows appear to increase field operation efficiency and stop erosion.

Steenhuis, Tammo S., and Walter, Michael F., "Definitions and Qualitative Evaluation of Soil and Water Conservation Practices," in Effectiveness of Soil and Water Conservation Practices for Pollution Control, ed. Douglas A. Haith and Raymond C. Loehr, U.S. Environmental Protection Agency, October 1979.

Based on five years of monitoring in Ohio, the authors found that runoff is less under no-tillage farming than conventionally tillage and soil productivity is higher. The good and bad aspects of conservation tillage are also listed.

Stevens, W. W., "Planting Annuals in Perennial Sod is Good Conservation," Journal of Soil and Water Conservation 21(4), July-August 1966, pp. 136-137.

The author discusses the idea of planting seeded or drilled crops into perennial grass or legume sod. Data is presented from various test plots. For this type of planting to be successful the following factors must be considered: equipment,

sod, annual crop, fertilizer, herbicide, and soil or sod condition. Advantages of sod planting are listed along with some precautions that farmers should be aware of.

Soil Erosion: Prediction and Control, Soil Conservation Society of America, Special Publication No. 21, 1977, 390pp.

This book includes the proceedings from a conference on the prediction and control of soil erosion. The papers include work done in countries other than just the U.S. The emphasis tends to be on the technical and physical aspects of soil erosion rather than social and economic effects.

Triplett, G. B. Jr.; Conner, B. J.; and Edwards, W. M., "Transport of Atrazine and Simazine in Runoff from Conventional and No-tillage Corn," Journal of Environmental Quality 7(1), January-March 1978, pp. 77-84.

The amount of herbicides in runoff was compared for conventional tillage and no-tillage corn. The quantity of herbicide transported increased with the amount of runoff. Areas planted using no-tillage suffered less runoff and less herbicide loss than the conventionally planted corn. Multiple regression analysis was used to develop equations for predicting herbicide concentrations.

Unger, Paul W.; Wiese, Allen F.; and Allen, Ronalf R., "Conservation Tillage in the Southern Plains," Journal of Soil and Water Conservation 32(1), January-February 1977, pp. 43-48.

In the Southern Plains wind and water erosion are the main problems. Conservation tillage research in Texas, Kansas, and Oklahoma is reviewed and additional research is recommended. For conservation tillage to be accepted, the authors feel that the economic returns must be equal to or greater than from conventional methods.

U.S. Department of Agriculture, Agricultural Research Service, and Environmental Protection Agency, Office of Research and Development, Control of Water Pollution from Cropland, Vol. 1, U.S.G.P.O., November 1975, Report No. ARS-H-5-1.

The report discusses estimating the potential direct runoff, potential erosion, and potential percolation from cropland. The use of plant nutrients and pesticides on cropland is mentioned along with no-till planting, winter cover crops, contouring and other conservation practices.

C. Effect of Soil Conservation Programs and Practices on Income

Dickrell, Jim, "Reduced Tillage: Saves Labor, Fuel - But Not Much Money," The Farmer 98(7), April 1980, p. 9.

The article uses information taken from a study done by Judy Ohannesian, University of Minnesota. Conventional tillage,

chisel-plant, disk-till, till-plant, and no-till were compared for time, fuel costs and cash costs. Tillage energy is only 3 to 7 percent of farming costs but it could make the difference between profit and loss on some farms.

Economic Analysis of Erosion and Sedimentation: Lake Glendale Watershed, Illinois Institute for Environmental Quality Document No. 74-40, December 1974.

In this study four management alternatives were considered: forested area, a forested and cropland area, a public and private area, and forested public lands and private forest or unimproved pasture area.

Economic Analysis of Erosion and Sedimentation: Upper Embarras River Basin, Illinois Institute for Environmental Quality Document No. 74-41, April 1975.

Study done in Upper Embarras River Basin found that sediment damage goes as high as 16 percent of net income per acre. Each area should separately determine which combination of crop rotation, tillage system and conservation practice is the most profitable.

Forester, D. L.; Rask, N.; Bone, S. W.; and Schurle, B. W., Reduced Tillage Systems for Conservation and Profitability, Department of Agricultural Economics and Rural Sociology, Ohio State, April 1976.

This study investigated the profitability of various crop tillage systems to determine under what conditions the farmers' needs and society's needs can be served. Conventional, minimum and no-tillage were evaluated and examples of costs per acre are given.

Gray, Roy M., "A National Soil Conservancy Law: Implications for Public Soil Conservation Programs," Journal of Soil and Water Conservation 29(5), September-October 1974, pp. 210-212.

This article comments on the article entitled: "The impact of a national soil conservancy law." Using data from that study it looks at the question: "Can We Produce and Protect?"

Heady, Earl O., and Vocke, Gary F., "Trade-offs Between Erosion Control and Production Costs in U.S. Agriculture," Journal of Soil and Water Conservation 33(5), September-October 1978, pp. 227-232.

Using a linear programming model the authors placed a value on soil loss and production costs. From these, estimates were made between erosion control and production costs for the nation and 105 producing regions. Annual soil loss per acre was found to be reduced from 5.56 to 2.50 tons with only small production cost increases.

Johnson, Bruce, and Baker, Maurice, The Impact of Tax Policy on Soil Conservation, Presented at the American Agricultural Economics Association Annual meetings, University of Illinois, Champaign, IL, July 27-30, 1980.

This paper discussed the points of interface between the existing tax structure and soil conservation programs and policies. Conservation was defined from an economic point of view using the Ciriacy-Wantrup definition so that the impact from taxes could be judged. The federal income tax policy, the federal estate tax policy and property taxation are all considered.

Lee, M. T.; Narayonan, A. S.; and Swanson, E. R., Economic Analysis of Erosion and Sedimentation: Seven-mile Creek Southwest Branch Watershed, Department of Agricultural Economics, Agricultural Experiment Station, University of Illinois, Illinois Institute for Environmental Quality Document No. 74-30, December 1974.

This study of a watershed area, that covered 2,238 acres, concluded that farmers will not change their crops and tillage methods unless sediment damage is included in their income. Without sediment damage included, net farm income loss annually from erosion is less than 1 percent.

Miller, William L., and Gill, Joseph H., "Equity Considerations in Controlling Non-point Pollution from Agricultural Sources," Water Resources Bulletin 12(2), April 1976, pp. 253-261.

Previous research done on the social cost of soil loss is reviewed. A linear programming model is used to assess the equity consequences of two methods of achieving non-point pollution control. If a standard state soil loss was enacted the smaller farms would suffer a greater dollar per acre decline than large farms. A tax or subsidy would achieve the reduction in soil loss with a more equal loss in net revenue among small and large farms.

Narayanan, A. S.; Lee, M. T.; Guntermann, Karl; Seitz, W. D.; and Swanson, E. R., Economic Analysis of Erosion and Sedimentation: Mendota West Fork Watershed, Department of Agricultural Economics, Agricultural Experiment Station, Illinois Institute for Environmental Quality, Document No. 74-13, April 1974.

This study shows 15 combinations of crop rotation, conservation practices, and tillage systems, and their effect on net income, on-site erosion losses and off-site sediment damages for the watershed. If the total cost of soil erosion were included in a farmer's cost-return calculation, a different combination of rotation, conservation practice and tillage system would be used. Authors also discuss alternatives for increasing the farmers' incentive to adopt these systems.

Narayanan, A.V.S., and Swanson, E.R., "Estimating Trade-offs Between Sedimentation and Farm Income," Journal of Soil and Water Conservation 27(6), November-December 1972, pp. 262-264.

The study was conducted on a watershed with a planned recreational reservoir to determine the maximum farm income with different sedimentation levels. Conservation tillage methods reduced sedimentation by one-half and left farm income at its current level. Further reductions in sedimentation would decrease farm income.

Nicol, Kenneth J.; Madsen, Howard C.; and Heady, Earl O., "The Impact of a National Soil Conservancy Law," Journal of Soil and Water Conservation 29(5), September-October 1974, pp. 204-210.

Public programs which control agricultural production can also promote soil conservation. The article discusses three general groups of practices to control erosion and sedimentation: (a) new cropping and tillage combinations, (b) substitute land treatment practices, and (c) trapping of sediment and stabilizing of stream channels by various structures. Price-support programs are also discussed.

Rosenberry, Paul E., and Moldenhauer, W. C., "Economic Implications of Soil Conservation," Journal of Soil and Water Conservation 26(6), November-December 1971, pp. 220-224.

The article points out obstacles that keep farm operators and nonoperating landowners from reducing soil loss to under five tons per acre per year. The economic value of stopping erosion is given. The authors feel more research is needed so that more precise statements can be made about water quality, erosion, and non-point pollution. Five different ideas are suggested that the government could use to integrate soil conservation and pollution control programs with programs to control crop production.

Seitz, Wesley D.; Taylor, C. Robert; Spitze, Robert G. F.; Osteen, Craig; and Nelson, Mack C., "Economic Impacts of Soil Erosion Control," Land Economics 55(1), February 1979, pp. 28-42.

The study concludes that a more effective public policy is needed or within a 100-year period the A-horizon soil would be lost. Effects from such an effective policy are considered.

Simms, D. Harper, The Soil Conservation Service, New York: Praeger Publishers, Inc., 1970.

The book covers past experiences of the Soil Conservation Service and what they are doing now. It attempts to answer such questions as: "Does Soil Conservation Pay?" Soil Conservation Service estimates are given for soil loss and nutrient loss.

Stall, John B., "Effects of Sediment on Water Quality," Journal of Environmental Quality 1(4), October-December 1972, pp. 353-360.

Sediment yields in the Midwest are discussed along with the physical nature of sediment. The author states that erosion has very little effect on the selling price of land although it does reduce the productivity somewhat. He also felt that soil erosion on farm land could be stopped but that there will always be natural turbidity which will muddy the streams.

Swanson, Earl R., and MacCallum, David E., "Income Effects of Rainfall Erosion Control," Journal of Soil and Water Conservation 24(2), March-April 1969, pp. 56-59.

The study was done in Illinois with three different soils. The effects of different soil conservation measures on income were analyzed in four steps: soil losses, yield reductions, costs and returns, and discounting. Little incentive was found for a farmer to adopt soil conservation practices. To reach the prescribed limits of soil loss the incentives would have to be increased vastly.

Swanson, E. R., and Harshbarger, C. E., "An Economic Analysis of Effects of Soil Loss on Crop Yields," Journal of Soil and Water Conservation, 19(5), September-October 1964, pp. 183-186.

The amount of soil conservation and its related costs is discussed along with soil loss and the annual yield of crops. The total revenue and costs were obtained and calculated. A comparison of cropping systems was also completed.

Underwood, Richard C., " 'No-Till' Is the Word," Water Research in Action 1(3), July 1976, pp. 1-2.

The author lists the following benefits from no-till planting as compared to conventional tillage: (1) an increase of 15 to 45 percent in crop yields, (2) a 90 percent reduction in soil loss due to erosion, and (3) a 25 percent increase of available water to crops. These benefits and others have been documented by research sponsored by the Virginia Water Resources Research Center. A few of the drawbacks of no-till are also presented, for example, the increasing cost of herbicides and other agricultural chemicals.

White, G. B., and Partenheimer, E. J., "Economic Impacts of Erosion and Sedimentation Control Plans: Case Studies of Pennsylvania Dairy Farmers," Journal of Soil and Water Conservation 35(2), March-April 1980, pp. 76-78.

The study was done on various Pennsylvania dairy farmers. In the short-run a strict soil loss constraint could reduce the income of many of the farmers. A more flexible policy which would install more cost-effective practices, would probably be more acceptable to farmers.

Woodward, Harold A., "Small Acreage Pays Big Dividends," Soil Conservation 42(12), July 1977, pp. 16-17.

A story of Charlie Snapp, a small dairy farmer. The article tells how conservation methods helped him stay in farming. He has constructed 1,300 feet of diversion channels and 12,000 feet of terraces that empty into two acres of grassed waterways.