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OF THE
SOIL CONSERVATION SERVICE
EROSION CONTROL PROGRAM
IN MICHIGAN

By

John Louis Okay

A DISSERTATION

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ABSTRACT

AN ANALYSIS OF THE SOIL CONSERVATION SERVICE EROSION CONTROL PROGRAM IN MICHIGAN

By

John Louis Okay

The Soil Conservation Service (SCS) of the U.S. Department of Agriculture has been the leader in Federal erosion control work since 1935. Although additional program responsibilities such as flood prevention have been assigned to SCS, erosion control is generally considered to be its principal function.

This study examined the organization and management of the SCS field staff as related to erosion control needs and accomplishments. Factors which have influenced the application of erosion control measures were also investigated. A method was developed for estimating gross erosion reduction achieved through selected cropland treatment measures. Alternative county staff levels were evaluated for their impact on both treatment acreage and soil loss reduction volume.

Correlation and multiple regression analyses revealed that SCS field level staffing patterns have not been fully aligned with identified needs for erosion control treatment. County cropland acreage was indicated as a primary decision variable, and manpower allocations displayed a bias toward longer established soil conservation districts.

Correlation and multiple regression techniques were utilized to investigate linkages between SCS manpower levels and erosion control accomplishments on other land, pastureland, and cropland. The results indicate that SCS has not organized a specific effort to treat other land or pastureland. Acreage of erosion control measures applied on these two land use types was not related to SCS technical assistance inputs. There was some evidence that pastureland treatment is often achieved in conjunction with cropland treatment; but this relationship did not hold for other land. The acreage of cropland erosion control measures was found to be positively related to manpower levels. Accomplishments did not correspond with either total cropland acreage or needs for cropland erosion control.

Data derived from the Universal Soil Loss Equation were combined with erosion control needs estimates and observed treatment acreages to compute a composite erosion reduction rate per acre of cropland treatment. This rate differed considerably among counties, ranging from less than one ton to over seven tons per acre.

Alternate SCS county staffing levels were studied with regard to their effect upon total treated acreage and gross erosion reduction. Regression equations developed earlier were used to estimate cropland erosion control accomplishments for various levels of technical assistance time. Manpower was reallocated among counties according to rankings based on marginal productivity concepts, and the resulting acreage and soil loss estimates compared. No improvement in erosion control acreage

was achieved by reallocating manpower for maximum acreage treatment. A statistically significant increase in tons of soil saved was estimated with manpower reallocated to maximize soil loss reduction.

The importance of clearly defining erosion control objectives is emphasized by these results. A program designed to treat a maximum cropland acreage will not necessarily produce the greatest reduction in soil loss. Concern for the volume of sediment to be controlled will lead to a different program structure and staffing pattern.

Existing SCS management records and land resource data are inadequate to provide decision makers with information to plan a comprehensive sediment control program. The soil loss model developed here may be utilized until suggested improvements in data bases are implemented.

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CHAPTER I

INTRODUCTION

Problem Setting

Public awareness and regard for the environment has been growing for a number of years. Since the mid 1960's there has developed

...a deep collective concern for the fact that industrial and urban civilization threatens to destroy the natural values that have been identified for so long with the richest emotions of mankind. One of the most painful dilemmas of our times is that we still regard nature as the ultimate source of beauty and other fundamental blessings, yet exploit and despoil it for the sake of wealth and power. We place in the parts of it that are not yet economically useful the highest qualities of nature and its beauty, but paradoxically accept the belief that economic profits justify the creation of ugliness. The sense of guilt comes from the knowledge that it is crudely hypocritical to praise the values of the wilderness, while converting the land into a gigantic dump.¹

Such concerns have focused widespread attention on many factors affecting the quality of our natural resources. Among the issues are the use and abuse of the land itself. In this setting, soil erosion and sedimentation are once again being examined critically, just as some forty years ago.

Sediment is recognized as the largest pollutants of surface waters on a volume basis.

¹ René Jules Dubos, "Air, Water, and Earth," Environmental Improvement, ed. Ralph W. Marquis (Washington: USDA Graduate School Press, 1966), p. 4.

The greatest quantity of pollutants in surface waters is the sediment produced by erosion of the land. On the average probably at least 4 billion tons of soil material are moved from place each year, transported by flowing water, and deposited at another location. About one-fourth of this material, or more than one billion tons of sediment, reaches the major streams of the United States annually from agricultural and other sources.

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Soil erosion and its effects are damaging many times over. First, there is the irreparable loss of soil that usually has taken many thousands of years to form. Second, sediments not only contribute heavily to suspended-solids pollution but also add to the dissolved-solids problem. Third, sediment frequently damages the area where it comes to rest, for example, lined canals where sediment furnishes a place for aquatic and other weeds to grow.²

Many complex chemical relationships in water are affected by the presence and concentration of sediment: turbidity, temperature, taste, odor, and abrasiveness.³ Reduced visual quality of surface waters is an easily recognized effect of erosion and sedimentation. A recent survey has shown that dark, cloudy water is perceived by the public as an indicator of pollution.⁴ Sediment produces other less visible changes in water quality, although the severity of the impact on public health is generally not as great as that of municipal and industrial wastes. Suspended sediment can upset the aquatic food chain by reducing light

²U.S., Secretary of Agriculture, and Director of the Office of Science and Technology, Control of Agriculture-Related Pollution, A Report to the President (Washington, January 1969), p. 10.

³W. R. Oschwald, "Sediment-Water Interactions," Journal of Environmental Quality, Vol. 1, No. 4 (1972), pp. 360-366.

⁴Elizabeth L. David, "Public Perceptions of Water Quality," Water Resources Research, VII (June 1971), pp. 453-57.

penetration and interrupting photosynthesis. Sediment may also kill fish and other aquatic organisms through abrasion, by impairing respiration, and by covering spawning beds.⁵

The Soil Conservation Service (SCS) of the U.S. Department of Agriculture has led the erosion control effort since the agency was established in 1935. Millions of acres of private and public land have been improved with technical assistance from SCS, working in cooperation with local soil conservation districts. Cost-share payments to landowners for installing selected soil conservation practices began in the 1930's with the Agricultural Conservation Program (ACP) of the Agricultural Adjustment Administration (AAA). Subsequent financial assistance programs administered by the Production and Marketing Administration (PMA) and, currently, the Agricultural Stabilization and Conservation Service (ASCS) have substantially aided soil conservation work.

While much effective erosion control has been achieved, many problems remain. The 1967 Conservation Needs Inventory (CNI) reported that sixty-three percent of the land inventoried in the United States was in need of some conservation treatment. The same report showed that fifty-four percent of the land inventoried in Michigan needed treatment.⁶

⁵ Ralph Stone and Herbert Smallwood, Intermedia Aspects of Air and Water Pollution Control, Environmental Protection Agency, Socioeconomic Environmental Studies Series, 600/5-73-003 (Washington: U.S. Government Printing Office, 1973), p. 78.

⁶ Computed from data in: U.S., Department of Agriculture, Basic Statistics - National Inventory of Soil and Water Conservation Needs, 1967, Statistical Bulletin No. 461 (Washington: U.S. Government Printing Office, 1971), pp. 4-15, 90-92.

The Soil Conservation Service has expanded its technical assistance programs beyond the original goal of erosion control. Through legislative direction and administrative policies, the SCS mission has grown to encompass other objectives. It includes water conservation and management, environmental quality control, land inventorying, and assistance to developing urban areas to foster better land use.

While SCS has extended its work to new concerns, erosion is still regarded as a serious matter. In a recent statement, the agency reaffirmed the goal of reducing soil erosion and sediment delivery to an acceptable level, stating that "Soil erosion and sediment damage continue to be major conservation problems."⁷

Special attention has turned to erosion control in conjunction with current agricultural policies aimed at increased farm output. Elimination of most crop production controls is going to mean more land use changes to cropland, and more intensive use of existing cropland. While calling for greater production, the Secretary of Agriculture also stated:

It is self-defeating for the farmer and our nation to ignore all that we have learned at such high cost about preventing soil from blowing and washing away. The nation loses a basic resource needed to sustain life for generations.

.....

In 1974 Soil Conservation Service field people and conservation district leaders will spend more of their time working with farmers and ranchers on conservation plans and practices.⁸

⁷U.S., Department of Agriculture, Soil Conservation Service, A Framework Plan - Soil and Water Conservation for A Better America (Washington, 1971), p. 19.

⁸Earl L. Butz, "Produce and Protect," Journal of Soil and Water Conservation, XXVIII (November-December, 1973), p. 250.

Given erosion control as a major agency objective, one might inquire as to the magnitude of the task and the level of accomplishment to date. Some information is available on both aspects of the question.

In order to gauge performance, SCS has developed an elaborate progress reporting and timekeeping system. Inputs are recorded in terms of dollars and man-hours. Outputs are reported in physical terms such as acres of stripcropping or pasture planting and feet of field windbreak. Completely lacking is identification of particular acre, or the severity of the problem being treated.

While these data are suitable for control and management functions, their use for program analysis and planning is limited. The relationship to a particular agency objective such as erosion control is not clear. Without such a link, management is in danger of focusing too strongly on the activities. The system tends to emphasize per unit output of whatever type in order to foster an "efficient" program. The broader objective may be lost simply because the management system doesn't relate to it.

The Soil Conservation Service provides technical assistance to the public in cooperation with soil conservation districts in each of Michigan's eighty-three counties. These districts are local subdivisions of state government organized specifically to assist landowners and occupiers to reduce erosion and to utilize soil and water resources for sustained long term productivity. Districts are operated by a locally elected five-member board of directors. Each district enters into a Memorandum of Understanding with the Secretary of Agriculture, and a supplemental memorandum with the Soil Conservation Service. These documents ensure

that technical assistance will be provided to the district by the Department of Agriculture, and the Soil Conservation Service in particular. The agreements also cover items of district responsibility in conducting a joint soil conservation program.⁹

The organization of the Soil Conservation Service in Michigan is typical of that in most states. The state conservationist, a career civil service employee, has overall administrative responsibility for all SCS activities in the state. He is a line officer, reporting directly to the agency administrator in Washington, D. C. He is assisted by administrative and technical personnel assigned to the state office.

Six areas, each covering twelve to fifteen counties, comprise the next administrative level. An area conservationist, also a line officer, provides administrative leadership to the counties in his area. His staff usually includes an engineer and a soil scientist who furnish technical services to field offices.

The district conservationist, the line officer at the local level, provides direct technical assistance to farmers, other landowners, and units of government. SCS field offices are located in most counties, but a few offices serve more than one county. The technical staff in these offices, comprised of the district conservationist and additional technicians, if any, ranges from one to four persons, with considerable variation among counties.

⁹ Additional information on the organization and operation of districts may be found in Michigan, Department of Agriculture, State Soil Conservation Committee, Michigan Soil Conservation Districts (East Lansing, 1971), and U.S., Department of Agriculture, Soil Conservation Service, Working Together (Washington, 1967).

Current SCS guidelines for the preparation of workload analyses, program priorities, and staffing plans are quite general in nature.¹⁰ Annual plans of operations are required at the state, area, and field office levels. Each soil conservation district, through the Memorandum of Understanding, has also agreed to prepare an annual plan. Joint annual planning between the SCS field office staff and the soil conservation district is strongly encouraged.¹¹

Long range plans for SCS operations within a state are optional at the discretion of the state conservationist. Emphasis on annual plans, without a requirement that they mesh with a multiyear plan, perpetuates an incremental approach to management decisions. Under such procedures, a statewide SCS program is unlikely to develop as a unified approach to carefully evaluated future problems and needs. Rather, it will evolve as a conglomerate of actions based largely on previous decisions. The merit of some of those decisions can only be judged from a larger viewpoint. In fiscal year 1972 (July 1, 1971-June 30, 1972), a total of 160 man-years were allocated by SCS to field offices for technical assistance in planning and applying soil and water conservation measures. How effective was this manpower pool in achieving the agency's objectives? What

¹⁰Current policies are contained in two documents: U.S., Department of Agriculture, Soil Conservation Service, Annual Plans of Operations, Workload Analyses, and Multiyear Plans, Management Memorandum-3 (Rev. 3), March 30, 1973; and Joint SCS-District Annual Work Planning, Districts Memorandum-5 (Rev. 2), April 18, 1973.

¹¹Relationships between district annual plans and SCS program planning is documented in Robert J. Morgan, Governing Soil Conservation: Thirty Years of the New Decentralization (Baltimore: Johns Hopkins Press, 1968), pp. 270-280.

progress was made toward more complete erosion control? Could management increase erosion control effectiveness by altering manpower organization? The answers to these questions would offer guidance in designing an improved management system.

Study Objectives

This study begins with the premise that soil erosion control is a desirable public goal. The purpose here is not to conduct a comprehensive analysis of the net monetary benefits of erosion control. The approach is rather within the framework of program planning and management. That is, given the goal of reducing soil erosion, what relevant information might be provided to a program manager in order to evaluate and improve program effectiveness.

This study will examine staffing and output relationships for the Soil Conservation Service erosion control program in Michigan. Specific objectives are:

1. Analyze the relationship between SCS staffing levels and needs for erosion control and total land treatment by county;
2. Identify factors which have influenced application of erosion control measures;
3. Develop a procedure to calculate gross erosion reduction produced by various land treatment practices;
4. Develop and evaluate a procedure to specify alternative SCS staffing levels by county in order to maximize (a) gross erosion reduction, (b) acres of erosion control practices applied.

Limitations of the Study

This study is confined to data for one state and one time period. Although the model developed here may be applied elsewhere, extension of specific quantitative results is not warranted.

Shortcomings exist in much of the data. Indeed, a discussion of some of these is presented in the second chapter. Yet the data problems also provide an opportunity to suggest improvements. Both the Conservation Needs Inventory and the SCS reporting system need substantial revisions which could improve the reliability of results reported here.

Analysis of program output as related to manpower levels ignores interpersonal differences which might contribute to varying productivity rates under the same environmental conditions. The task of working with landowners to help them apply conservation practices requires both technical ability and a degree of salesmanship which have been assumed to be constant among all employees.

Other government programs which contribute to erosion control efforts have not been included in this analysis. Principal activities of this type include Federal cost-sharing assistance programs of the Agricultural Stabilization and Conservation Service, information and education efforts of the Cooperative Extension Service, and the programs of local soil conservation districts.

Finally, agency goals other than erosion control have been largely ignored. Staffing decisions oriented to the needs of watershed protection and flood prevention activities, for example, may result in a distribution of manpower which varies from an optimum for erosion control alone. This single purpose approach which aids analysis also renders the results limited in direct application to program management. Nevertheless, focusing upon a very fundamental agency objective provides a basis from which other programs may be evaluated.

Outline

Background information on previous related studies and the SCS data base is presented in Chapter II. Methodology is described in Chapter III. Analyses of the present SCS staffing pattern and erosion control accomplishments are discussed in Chapter IV. Results of the effort in building a gross erosion reduction model are presented in Chapter V. Studies of alternate staffing patterns are reported in Chapter VI. Chapter VII provides a summary, and recommendations for program management and further research.

CHAPTER II

EXISTING RESEARCH AND DATA

Antecedent Research

This study has its roots in two major lines of systematic inquiry: (1) natural resource economics, and (2) public program analysis. The first subject area has been an established discipline for a number of years. The second has only recently come to the forefront.

Natural resource economists have been investigating the soil erosion question since 1935.¹² Most studies have been from a farm management approach. The major concern was with changes in net returns to the farmer under alternative land conservation practices.

An example of this avenue of research is reported by Swanson and MacCallum.¹³ They examined several combinations of crop rotations and soil conserving practices on three Illinois soils. Estimates of net income (in present value terms) for planning periods of ten, twenty, and

¹²Rainer Schickele, J. P. Himmel, and R. M. Hurd, Economic Phases of Erosion Control in Southern Iowa and Northern Missouri (Iowa Agr. Expt. Sta. Bull. 333, 1935), cited by Leonard A. Salter, Jr. A Critical Review of Research In Land Economics (Madison: University of Wisconsin Press, 1967) p. 236.

¹³Earl R. Swanson and David D. MacCallum, "Income Effects of Rain-fall Erosion Control," Journal of Soil and Water Conservation, XXIV (March-April, 1969), pp. 56-59.

fifty years were computed. It was determined that a profit-maximizing entrepreneur would not choose the combination of crops and practices needed to reduce annual erosion to the recommended upper limit, even if long term soil losses and productivity were considered. The authors concluded that increased public incentives must be provided in order to increase the application practices needed to achieve desired levels of erosion and sediment control.

Other research has analyzed factors in addition to farm income which affect the progress of erosion control work. A long term series of studies was conducted in western Iowa, and summarized by Blase and Timmons.¹⁴ The initial work in 1949 found that lack of capital and problems associated with the tenant status of over one-third of the farmers were obstacles to adoption of erosion control practices. A follow-up study in 1952 generally confirmed the earlier results; but it also showed that some progress had been made in both actual erosion reduction and farmers' goals toward soil loss prevention. The third study, in 1957, utilized multiple regression to study the relationship between average soil losses and major impediments to erosion control. It was found that expectations of short term income reductions if erosion control measures were adopted, and failure to recognize the need for a particular land treatment measure were major obstacles to reducing erosion rates. The authors recommended integration of farm budgeting with farm planning for erosion control. They viewed this as a means of assisting farmers with

¹⁴Melvin G. Blase and John F. Timmons, "Soil Erosion Control-Problems and Progress," Journal of Soil and Water Conservation, XVI (1961), pp. 157-62.

the complete job of enterprise and soil management in order to maintain or improve farm income while meeting erosion control goals. They also called for a stronger educational effort to build more awareness of the need for, and benefits of, various land treatment measures. They also cited a need for a national viewpoint in planning an attack on soil erosion. They recommended that research be undertaken to analyze national land use and erosion control needs on a regional basis to guide long range plans of both farmers and public agencies.

It was several years before that final recommendation of Blase and Timmons was implemented. The first truly comprehensive effort in this regard was completed in 1972 by an Iowa State team led by Heady.¹⁵ This study utilized a national linear programming model to evaluate the effects of alternative national land and water policies on total U. S. food and fiber production. The model also provided estimates of regional agricultural income and production levels under various policy alternatives. One alternative was the removal of "fragile land" from the total land base in order to reduce total erosion and sedimentation. This formulation used 1967 Conservation Needs Inventory data, and classified "fragile land" as soils in capability classes V, VI, VII, and VIII, which are generally considered not suitable for growing most field crops. The procedure reduced the total land base by approximately fifty percent (656.3 million acres) with nearly all of the decrease confined to permanent

¹⁵Earl O. Heady, et. al., Agricultural and Water Policies and the Environment, Iowa State University, Center for Agricultural and Rural Development, CARD Report 40T (Ames, 1972).

pasture and range lands. The model estimated that even with this restriction in land use, food and fiber demands projected to the year 2000 could be met through more intensive use of remaining land. It was estimated that irrigation water consumption would increase only slightly, although crop and livestock prices would increase about twelve percent compared to the levels in 2000 without land use restrictions. This study thus provides evidence that environmental improvement in the form of reduced erosion is feasible at a relatively low cost.

The research just cited was limited in its approach to the evaluation of cropland erosion reduction. Removal of "fragile land" from production would undoubtedly impact total gross erosion; but this impact could not be quantified in terms of total tons of soil saved, or reduction in average per-acre erosion rates. It also ignored possibly excessive erosion rates on land remaining in production.

Considerable improvement in methodology for evaluating alternative erosion control strategies was achieved in a more recent study which utilized a mathematical soil loss model to estimate average erosion rates for all classes of land used for agricultural production.¹⁶ Heady's earlier linear programming model was modified to treat each of several combinations of crop rotation and conservation treatments as an activity. Constraints were then specified for three alternate levels of allowable soil loss: ten, five, and three tons per acre. Results once again showed

¹⁶ Kenneth J. Nicol, Earl O. Heady and Howard C. Madsen, Models of Soil Loss, Land and Water Use, Spatial Agricultural Structure, and the Environment, Iowa State University, Center for Agricultural and Rural Development, CARD Report 49T (Ames, 1972).

that agriculture could meet production requirements even with a policy restricting average soil losses to three tons per acre. In order to achieve this, however, higher applications of both pesticides and fertilizers are required. The increase in consumer prices was estimated to be approximately five percent with a three ton limit. This policy would produce a total reduction in annual soil loss of over eighty percent, from 2.7 to 0.5 billion tons. This approach appears to have considerable value for further studies of the economics of erosion control policies.

Held and Clawson have produced the one comprehensive study of soil conservation to date.¹⁷ They examined the soil conservation movement as a whole, rather than focus on a particular agency or program. Their approach was primarily economic, although they did touch on many social and political relationships affecting soil management.

After attempting to measure soil conservation progress since 1930, they concluded that firm data are not available, and the evidence is mixed as to the real magnitude of accomplishments. They conceded that some level of improvement has been attained since 1930, but added: "To stress the gains does not mean that the gains achieved were worth the cost, nor that all efforts were as efficient for accomplishing the aim of soil conservation as they might have been."¹⁸

¹⁷Burnell Held and Marion Clawson, Soil Conservation in Perspective (Baltimore: Johns Hopkins Press, 1965).

¹⁸Ibid., p. 233. A companion book which provides a more detailed analysis of the organization and political structure of the soil conservation movement is Morgan, op. cit. Another study which examined some aspects of soil conservation programs at the Federal level is K. William Easter, "An Evaluation of the Agricultural Conservation Program's Performance in Fulfilling Program and Political Objectives" (Unpublished Ph.D. dissertation, Dept. of Agricultural Economics, Michigan State University, 1966).

Research in the physical sciences has facilitated investigations of erosion control methods and their economic implications. Long term work by the Agricultural Research Service and others resulted in development of a procedure for estimating soil losses when certain physical parameters are known.¹⁹ This procedure, commonly referred to as the Universal Soil Loss Equation, has been an important development. It enables one to predict ex ante soil losses under various land use and treatment alternatives. Both physical and farm income impacts may thus be estimated for various cropland management systems. This was in fact the soil loss model used by Nicol and by Swanson and MacCallum in the works cited earlier.

Some research in Michigan has been concerned primarily with physical aspects of soil erosion, but also considers implications for land use and treatment policies. Schmidt and Summers concentrated on the problem of erosion hazards associated with urbanization.²⁰ They found annual erosion rates on unprotected development sites as high as 540 tons per acre. Estimated costs to a developer for controlling erosion during construction to a rate of five tons per acre averaged less than \$20 per acre for the nine sites studied. Social costs of uncontrolled sedimentation were assumed to be the cost of dredging and hauling the estimated volume of sediment from the body of water or drainage-way associated with the site.

¹⁹W. H. Wischmeier and D. D. Smith, Predicting Rainfall Erosion Losses from Cropland East of the Rocky Mountains, Agr. Handbook No. 282 (Washington: U.S. Government Printing Office, 1965).

²⁰John H. Schmidt and Allen W. Summers, "The Effect of Urbanization on Sedimentation in the Clinton River Basin" (Unpublished Master's level research report, School of Graduate Studies, University of Michigan, 1967).

This approach produced benefit-cost ratios from 1.2 to 16.7 for imposing soil loss restrictions upon developers. At each site studied erosion control costs amounted to just a fraction of one percent of the total development cost which ranged from \$500,000 to \$10 million. The authors concluded that erosion control measures are urgently needed at urban development sites, and that economical treatment measures are available. They recommended that local planning and subdivision regulations be updated to include consideration of necessary erosion control practices.

Another recent Michigan study also investigated erosion in a developing urban area.²¹ The author evaluated not only the physical extent and control methods of accelerated erosion, but also institutional arrangements for achieving proper land treatment. He concluded that both enactment of a state sediment control law and revision in the enabling act for soil conservation districts were needed for effective action.

Public program analysis had its practical beginning with enactment of the Flood Control Act of 1936. That act required for the first time that a federal agency evaluate the benefits and costs of its projects.

Economic inquiry remained centered in the water resource field for a number of years. Agencies developed and worked to standardize

²¹Terry Allen Ringler, "The Nature, Extent and Control of Soil Erosion in an Urbanizing Watershed in Western Lower Michigan" (Unpublished Master's thesis, Dept. of Resource Development, Michigan State University, 1969).

techniques to evaluate projects.²² Theoretical treatises dealt with concepts to refine water resource evaluations.²³

A major change in emphasis occurred in the mid 1960's. Systematic analysis of government programs outside of water resources began in the Department of Defense. The rise of planning-programming-budgeting (PPB) in the Federal Government has been well documented.²⁴

Much of the early optimism surrounding PPB has faded. The term itself was lost during the change in administrations in 1969. The lack of success in estimating program benefits and a number of other obstacles served to slow the PPB movement.²⁵

²²Federal efforts produced two major documents: Inter-Agency Committee on Water Resources, Sub-committee on Evaluation Standards, Proposed Practices for Economic Analysis of River Basin Projects (Washington: May 1950, revised May 1958); U.S., Congress, Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources, Senate Document 97, 87th Congress, 2d. Sess.

²³For example, Otto Eckstein, Water Resource Development: The Economics of Project Evaluation (Cambridge: Harvard University Press, 1958); Roland McKean, Efficiency in Government Through Systems Analysis (New York: John Wiley & Sons, 1958); A. R. Prest and R. Turvey, "Cost-Benefit Analysis: A Survey," The Economic Journal, Vol. 65, No. 300 (December, 1965), pp. 683-735.

²⁴One of several comprehensive collections of articles is Fremont J. Lyden and Ernest G. Millar (eds.), Planning, Programming, Budgeting: A Systems Approach to Management (Chicago: Markham Publishing Co., 1967).

²⁵These problems are well summarized in Robert H. Havemen, "The Analysis and Evaluation of Public Expenditures: An Overview," The Analysis and Evaluation of Public Expenditures: The PPB System, U.S. Congress, Joint Economic Committee, Vol. 1 (Washington: Government Printing Office, 1969). A more recent status report is in John A. Worthley, "PPB: Dead or Alive?," Public Administration Review, XXXIV (1974), pp. 392-394.

One aspect of PPB still in evidence is program review and analysis. The Secretary of Agriculture, for example, has directed USDA agencies to conduct "systematic reviews of all aspects of program objectives," as called for in OMB Circular No. A-44, Revised.²⁶

Conservation Indicators

A great quantity of statistics does exist regarding the status of soil erosion. It has been compiled, and is still being collected, primarily by the Soil Conservation Service as part of its program responsibility.

Yet the fact of existence says nothing of the reliability or suitability of data for a particular purpose. This study was hampered somewhat, as are most investigations using secondary data. Specific problems are discussed later in reporting results. This section will serve as an overview of the two major data sources and their inherent weaknesses.

Conservation Needs Inventory

Information on the status of erosion problems was obtained from the 1967 Conservation Needs Inventory. This report was the result of a U.S. Department of Agriculture effort to provide information on land use and conservation problems. The inventory was an updating of a previous study completed in 1962.²⁷ The Department's CNI Committee cited land use change as the primary impetus for updating.

²⁶U.S., Department of Agriculture, Planning and Budgeting System, Secretary's Memorandum No. 1777, Supplement 1, August 22, 1972.

²⁷U.S., Department of Agriculture, Basic Statistics of the National Inventory of Soil and Water Conservation Needs, Statistical Bulletin No. 317 (Washington: U.S. Government Printing Office, 1962).

Shifts in land use and changes in land treatment call for periodic review and inventory of conservation treatment needs. Accordingly, the 1966-67 Inventory is being made to obtain current information on this subject. The data obtained will be useful for formulating programs, planning conservation work, conducting research and other purposes by the agencies of this Department, other public agencies, and private institutions. The updated Inventory is wider in scope and includes more detailed data than the 1958-60 Conservation Needs Inventory.²⁸

The Inventory included determination of land and water areas, land use, soil capability classification, and conservation treatment needs. This information was compiled on a county basis for all non-federal rural land in the United States.

Data were collected according to a sampling design set up by the Iowa State Statistical Laboratory. The basic sampling rate was two percent. Sample areas were located on county maps sent to each County CNI Committee. Sample areas in the Eastern States were 100 acres in size, while in the remainder of the U.S. they were a quarter section (160 acres).

Sample areas were field inspected by SCS technicians who recorded soils, land use, and treatment needs information on specially designed forms. The data forms were then forwarded to the statistical laboratory where sample data were expanded to county acreages.

The County CNI Committee was responsible for adopting the "official" county estimates. For land use acreages, the Committee was to give prime weight to the expanded sample area data. Other data, however were to be

²⁸U.S., Department of Agriculture, Conservation Needs Inventory Committee, National Handbook for Updating the Conservation Needs Inventory (Washington, 1966), p. 1.

compiled and compared to sample information, including land use from the 1962 CNI, and 1959 and 1964 Agricultural Census estimates of land in farms.

Special instructions governed in the case of forest land.

"Use forest acreage data by counties and groups of counties from the Forest Service Experiment Stations. These data are the accepted Department figures. Where the sample area estimates differ, some adjustment should be mutually made by the State Committee and the Forest Service Experiment Stations to obtain the adopted estimates."²⁹

The Forest Experiment Stations also provided data on forest land treatment needs.

These procedures indicate that the CNI is not a rigorous statistical sampling of land use and problems. It is, rather, a subjective combination of data from at least two sources. On forest land, the independent Forest Survey held precedent. Any conflicts were apparently resolved in favor of the Forest Survey data or somehow negotiated to a mutually agreeable figure. Having superimposed a forest land acreage on the sample data, the County CNI Committee was then required to adjust other land use categories to balance total county land areas. This also had an impact on the conservation treatment needs data, which had been determined on land use acreages from the CNI sample. The validity of all CNI data is thus circumscribed by the accuracy of the Forest Survey.

Questionable derivation of land use and needs acreages is only part of the problem. The inventory of conservation treatment needs does not provide quantitative data on the actual physical status of land problems.

²⁹Ibid., p. 17.

There was no recording of the present erosion rate, or even of the crop rotation and tillage practices from which the erosion rate could be calculated by the Universal Soil Loss Equation. There is no information on any conservation practices now applied which may be providing partial protection.

The inventory does contain judgments by individual field technicians of the "needs" for land treatment practices. This subjective approach weakens the CNI as an analytical source on physical conditions of the land. Comparisons among counties are hazardous since the judgment of what lands need crop residue use, for example, might vary widely among SCS technicians. Interpretations are difficult even within a county. One acre may have been judged to need only contouring because of its present crop management system although no other land treatments had been applied. Another acre also identified as needing only contouring may have an entirely different crop rotation, but with diversions or gully control structures already in place. Physical conditions and erosion hazards could be entirely different on these two sites.

Problems of interpretations were also inherent in the treatment categories allowed. Using non-irrigated cropland as an example, consider this list of needs:

<u>Codes</u>	<u>Categories</u> ³⁰
0	Land adequately treated.
1	Crop residue, annual cover crops, etc. <u>only</u> .
2	Sod in crop rotation <u>only</u> .
3	Contouring <u>only</u> .
4	Stripcropping, terraces or diversions.
5	Change in land use.
6	Adequate drainage system.

³⁰Ibid., Appendix 2, p. 10. Complete definitions for these and other needs categories used in the CNI are shown in Appendix A.

The field technician was to select one of the above categories which best applied to a particular sample area, and record the appropriate code number on the sample form. He was guided by these instructions:

At the time of inspection determine the type of conservation treatment needs for the land in the sample area. The technician will base this determination on his judgment of the conservation treatment needs as guided by the local technical guides and the prevailing agricultural operation on the sample area. Further criteria would be the practical bases and guides used and exercised in the development of basic conservation plans.

These treatment needs data should be mutually exclusive by types of treatment. That is, no overlapping of acreage should be shown among the types of treatment required or still needed for the land.³¹

There is nothing unique about the needs categories to give a clue as to the severity of the problem. One can only speculate as to the average erosion rate for land associated with any particular need. The severity of erosion generally increases from category one to category five; but this is the extent of interpretation possible.

Broad ranges of possible erosion hazards are encompassed by a category such as stripping, terracing, and diversions. Since terracing is a more effective erosion control measure than stripcropping, it would ordinarily be recommended for the more severely eroding sites. Installation and farm operation costs are also different for these two measures. Reporting this category raises more questions about the existing state of erosion than it answers.

³¹Ibid., Appendix 2, p. 6.

Ambiguities exist in other needs categories. A recommendation for a change to permanent cover might apply to a severely eroded area which should be planted to trees for proper protection. Or it might correspond to land with a lower erosion hazard which could safely be used for pasture.

By adding some details on needed treatment measures, the 1967 CNI did improve the method of reporting erosion problems from that used in the 1958 inventory. The earlier study simply listed acres with an erosion problem with no indication of a type of recommended treatment. The 1967 survey also added information on the capability class of land needing treatment. Both changes satisfied some of the criticism aimed at the previous inventory. However, the CNI still failed to adequately quantify the erosion and sedimentation problem.³²

Time and Progress Reporting System

The Soil Conservation Service maintains an accounting system to meet its needs for budget control and management. This accounting system encompasses numerous reporting forms and statistical summaries designed to keep the agency, the Congress, and the public informed as to dollars spent and results achieved.³³

Two elements in this broad accounting system are of interest for this study: manpower inputs and erosion control outputs. Data on these are contained in the Time and Progress Reporting System.

³²Held and Clawson, op. cit., pp. 239-240.

³³U.S., Department of Agriculture, Soil Conservation Service, Budget and Finance Division, Examples of Budgets, Time and Progress Reports, and Cost and Performance Statements in SCS Accounting System, Unpublished Handbook, 1972.

Manpower time and cost inputs receive very detailed attention in the record system. A Time and Attendance Report is prepared at the close of each two week pay period for each SCS employee.³⁴ These are sent to an ADP center for processing. Periodic cost and time summaries are prepared from these data, including an annual report.³⁵ Data may be compiled for any administrative unit, from the individual field office or county to the state and national level.

SCS field employees maintain daily records of conservation practice installation as they work with landowners. These records are entered on special forms which are sent to the ADP center every two weeks with the time and attendance reports. Periodic summaries are generated from these data for various management purposes.³⁶ The system maintains a cumulative total of accomplishments as well as records for the current fiscal year.

Installation of erosion control measures is recorded by physical units of individual conservation practices. The Progress Summary provides data on the extent of acres or other units of practices such as contour farming, stripcropping, or others which have been applied.

Such data are of little value in determining the amount of erosion reduction. No information is recorded on estimated annual soil loss either before or after installation of one or more practices. Neither is there any record of soil and site parameters which could be used to calculate soil loss by the soil loss equation.

³⁴Ibid., p. 28.

³⁵Ibid., p. 30.

³⁶Ibid., p. 36.

The Progress Summary shows that x acres have been treated. Were those acres slightly or severely eroding? Were they brought down to the level of allowable soil loss by the installation of the reported practices?³⁷ Such questions cannot be answered with data in the present reporting system.

³⁷ Allowable soil loss is a term used by SCS to define the maximum annual level of erosion for a given soil which is consistent with long term productivity. In determining the rate, consideration is given to soil profile characteristics and the action of soil forming factors. For a discussion, see B. D. Blakely, J. J. Coyle, and J. G. Steele, "Erosion on Cultivated Land," Soil, Yearbook of Agriculture, 1957 (Washington: U.S. Government Printing Office), pp. 302-304.

CHAPTER III

METHODOLOGY

A fundamental premise of this study is that public program performance may be analyzed through systematic quantitative evaluation of resource inputs and resulting program effects. Research methods were chosen to permit quantitative statements about the status of the existing erosion control program, and to suggest resource adjustments in the framework of economic efficiency criteria. Information from such an analysis will provide decision makers with a rational basis for implementing needed management adjustments.

Analysis of SCS Staffing Levels

The first objective of this research was to examine the relationship between SCS staffing levels and identified needs for erosion control and other land treatment measures.

The Soil Conservation Service has field offices serving each of Michigan's eighty-three counties (Figure 1). Several offices serve more than one county; the Cadillac office serving Wexford and Missaukee counties is an example. More than one soil conservation district may be located in a county served by one SCS field office, as in Livingston County. The county was chosen as the unit of interest for this study since it is the most common organizational subdivision. This approach facilitates use of several secondary data sources.

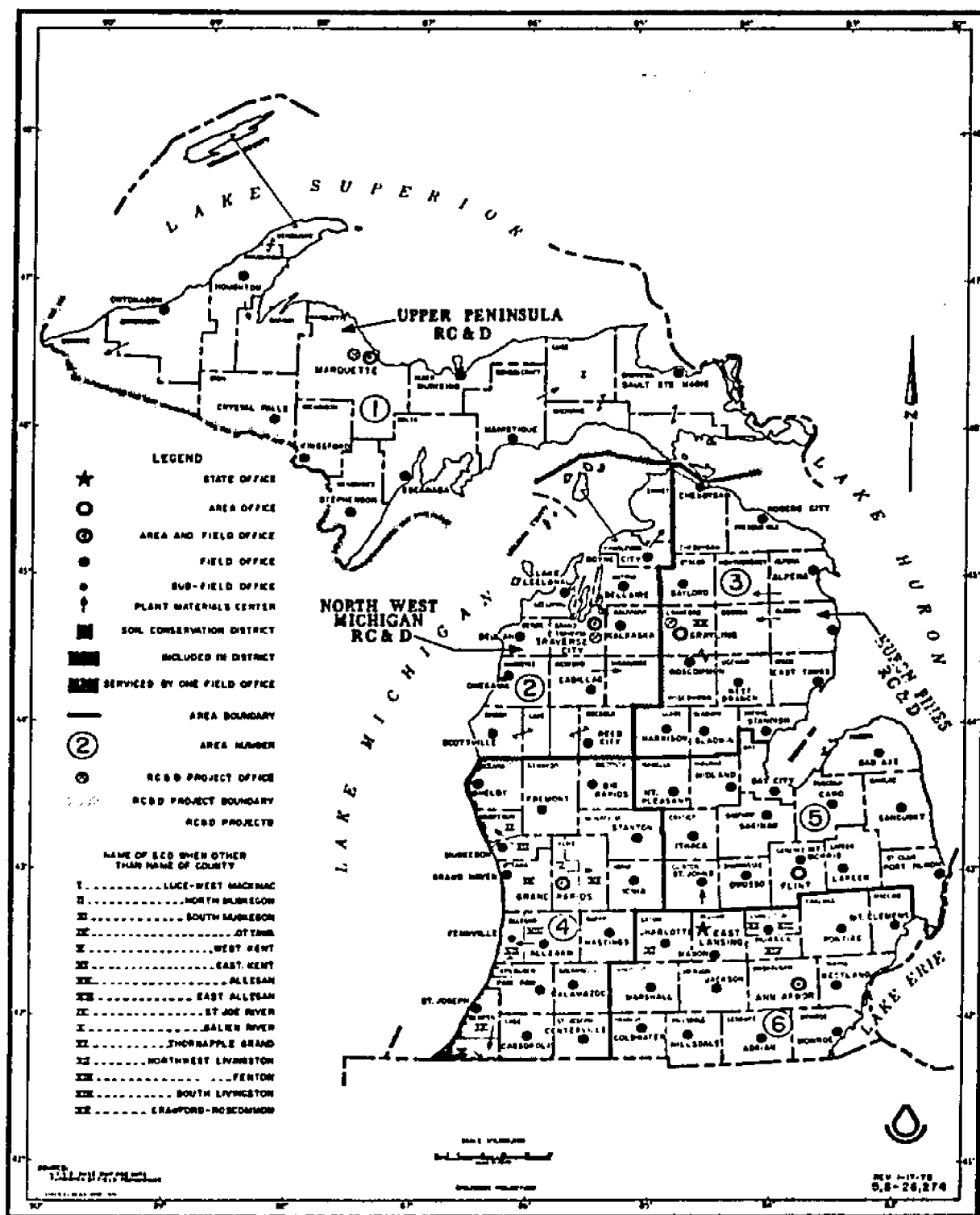


Figure 1.—Soil Conservation Service Organization Map of Michigan.

Correlation and multiple regression techniques were utilized to study the relationships between staffing and treatment needs. Correlation analysis measures the degree of association that exists between two independent variables. Regression analysis quantifies the parameters of such an association, and provides estimates of the value of dependent variable from known values of one or more independent variables. These methods also permit statistical inference and testing of hypotheses concerning population parameters.

The general regression equation was set up in the form

$$Y = a + b_1 X_1 + \dots + b_n X_n, \text{ where}$$

Y = man-days SCS technical assistance in one year (TIME)³⁸

X_1 = total acres needing treatment (TNT)

X_2 = acres needing erosion control (ENT)

X_3 = cropland acres needing treatment (CNT)

X_4 = portion of county area needing treatment (RTN)

X_5 = portion of county non-forested area needing treatment (RNFN)

X_6 = total acres of cropland (CPT)

X_7 = total acres of urban and built-up land (UBT)

X_8 = 1970 total population (P70)

X_9 = 1970 rural population (PR70)

X_{10} = 1960 to 1970 population change (PCH)

X_{11} = years the soil conservation district has been organized (YRS)

³⁸Variable labels from the computer programs will be used here and throughout the remainder of this report. See Appendix C for complete definitions.

Selection of independent variables in the absence of previous research was based on the following rationale. As noted above, USDA intended that the CNI be a tool for program management. The variables $X_1 \dots X_7$ were chosen to test the relationship of staffing level to these CNI parameters. Three population variables were included to test how strongly the size of the potential clientele for assistance has influenced staffing decisions. The last variable was added to explore any possible bias toward older districts. Were higher staff levels set many years ago when the number of farmers was greater and the conservation ethic stronger than in recent years?

Intercorrelation of independent variables was tested by computing correlation coefficients for each pair. One of each pair of highly correlated variables ($r^2 > 0.70$) was deleted from the regression equation. The individual regression coefficients were tested at the ten percent level to test the null hypothesis $H_0: B_1 = 0$.

Analysis of Erosion Control Accomplishments

The second objective was to develop predictive models of erosion control output. Such models will allow efficiency comparisons among counties and permit the trial of alternative staff allocations.

The relationship between erosion control accomplishments and manpower inputs, CNI needs, and other factors was also examined by multiple regression analysis. Data were available by county, with eighty-three observations. Differences in land use, conservation needs, and staffing levels exist between Northern and Southern Michigan. Separate equations were therefore developed for the two regions split along a Muskegon to Arenac County line (Figure 2).

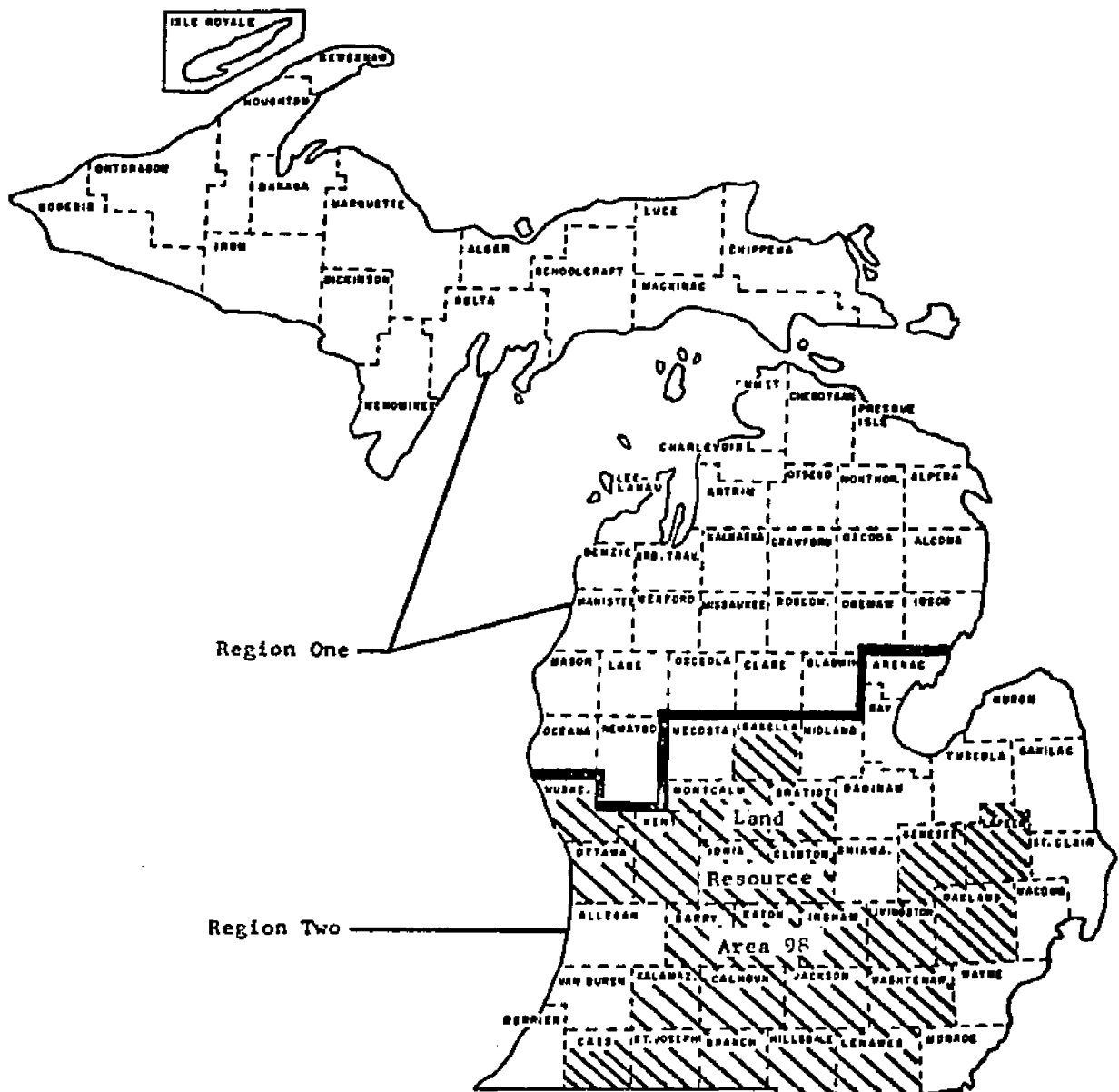


Figure 2.--Study Areas.

The total amount of erosion control was measured by the sum of acres of cropland, pasture, and other land treated with erosion control practices. A separate equation was to be developed for each land use type. This approach was modified after equations were fitted to data for pasture and other land, as discussed in Chapter V.

Specifically, the initial equation set was as follows:

$$Y_1 = a + b_1X_1 + b_4X_4 + b_8X_8 + \dots + b_{12}X_{12}$$

$$Y_2 = a + b_2X_2 + b_5X_5 + b_8X_8 + \dots + b_{12}X_{12}$$

$$Y_3 = a + b_3X_3 + b_6X_6 + b_7X_7 + b_8X_8 + \dots + b_{12}X_{12}$$

Where

Y_1 = acres of cropland erosion control practices applied (CECA)

Y_2 = acres of pastureland erosion control practices applied (PECA)

Y_3 = acres of other land erosion control practices applies (OECA)

X_1 = 1967 CNI needs acreage for cropland erosion control (CNE)

X_2 = 1967 CNI needs acreage for pastureland erosion control (PNT)

X_3 = 1967 CNI needs acreage for other land erosion control (ONT)

X_4 = 1967 CNI cropland acreage (CPT)

X_5 = 1967 CNI pastureland acreage (PT)

X_6 = 1967 CNI other land acreage (OT)

X_7 = 1967 CNI urban and built-up land acreage (UBT)

X_8 = total man-days technical assistance time (TIME)

X_9 = average value agricultural products sold per farm, 1969 (VAPS)

X_{10} = 1970 population (P70)

X_{11} = 1970 rural population (PR70)

X_{12} = 1, 0 variable for presence or absence of a modern soil survey report (SS)

Independent variables were selected on hypothesized relationships to erosion control accomplishments. Needs and land use acreages from CNI ($X_1 \dots X_7$) are important if accomplishments are linked to the size of the erosion control job to be done. The value of agricultural products sold per farm is used as an indicator of farm income and capital available for investment in conservation practices. Two population variables indicate the size of the potential clientele. The presence of a soil survey should increase the efficiency of conservation planning by providing complete up-to-date soils information.

Components of the dependent variables, erosion control accomplishments, were selected to complement CNI erosion control needs categories (Table 1). Some compromises were necessary because of a lack of correspondence between CNI and practices shown in the Progress Reporting System.³⁹

Cropland erosion control accomplishments (CECA) were represented by the sum of seven reportable practices: Crop Residue Use, Contour Farming, Minimum Tillage, Stripcropping, and Cropland Conversion-Grassland, Woodland, Wildlife-Recreation.

Several other practices which have some effect on erosion and sedimentation were not included. Terraces and Diversions were omitted because relatively few units of these practices have been installed in Michigan. Grassed Waterways are used to control limited areas, usually in conjunction

³⁹ Suggestions for selecting conservation practices were obtained in an interview with Warren Fitzgerald, Assistant State Conservationist, SCS, Michigan, October 26, 1973.

Table 1.--CNI treatment needs for cropland, and other land, with selected corresponding conservation practices primarily for erosion control.

Land Use	Treatment Need ^a	Corresponding Conservation Practice ^b
Cropland	Residue and Annual Cover	Crop Residue Use Minimum Tillage
	Sod in Rotation	c
	Contouring	Contour Farming
	Stripcropping, terracing diversions	Stripcropping
	Permanent Cover	Cropland Conversion to: Grassland Woodland Wildlife/Recreation
Pastureland	Change in Land Use	c
	Protection Only	Proper Grazing Use
	Improvement	Pasture and Hayland Management
	Reestablishment	Pastureland and Hayland Planting
Other Land	Treatment Needed	Critical Area Planting

^aDefinitions of CNI Treatment Needs are shown in Appendix A.

^bDefinitions of SCS Reportable Practices are shown in Appendix B.

^cNo corresponding practice reported.

with other practices. Field Windbreaks in Michigan have been limited principally to organic soils for wind erosion control; they cannot be evaluated by the soil loss equation for water erosion utilized in this study. Conservation Cropping System was omitted because of possible double-counting in SCS data. For example, an acre which was reported as having Crop Residue Use could also be reported for Conservation Cropping System if the addition of crop residues to land thus satisfied the requirements of the latter practice. Similar combinations of Conservation Cropping with other cropland treatment practices could also occur.⁴⁰

Pasture erosion control accomplishments (PECA) were represented by the sum of two reportable practices: Pasture and Hayland Management and Pasture and Hayland Planting. Although it pertains to the CNI need category "Protection Only," Proper Grazing Use was omitted because it is not a reportable practice in Michigan.⁴¹

Other land erosion control accomplishments (OECA) were represented by the one reportable practice: Critical Area Planting. A problem exists here in the fact that this practice could be reported on urban land, while urban and built-up areas were excluded from the CNI. Another reportable item, Land Protected During Development, would also be a measure of Other Land treatment. It was omitted because a double-counting problem arises here also. Individual practices such as Waterways and Critical Area Planting applied on an area under development would also be reported.

⁴⁰ Interview with Palmer Skalland, State Resource Conservationist, SCS, Michigan, November 9, 1973.

⁴¹ Interview with Richard Drullinger, Agronomist, SCS, Michigan, November 5, 1973.

Tree planting is also a practice very effective in erosion control. SCS maintains no records of land on which tree planting takes place. The Progress Reports only contain a total of the acres planted. No other studies have been conducted in Michigan to give an indication of the amount of tree planting done on cropland, pasture, or other land.⁴² Tree planting undoubtedly would meet the need for change in pastureland use on some acres. It would also be involved in establishing permanent cover on cropland by Conversion to Woodland. Critical Area Planting might also employ tree planting. These possibilities of double counting plus the lack of information on affected land use type make tree planting data unsuitable for this analysis.

Fiscal year 1972 data from the SCS Timekeeping and Progress Reporting System were used in this study. Although data were available for FY 1973, this time period was not considered representative of SCS activities in recent years for two reasons. First, an Administration policy was established to reduce overall Federal employment. This led to a decline in numbers of Michigan SCS personnel in FY 1973 relative to the staff levels of the preceding three to four years. Second, the Administration also withheld a substantial portion of funds appropriated for the Rural Environmental Assistance Program (REAP) administered by the Agricultural Stabilization and Conservation Service. The REAP program made cost-share funds available to land owners for a number of soil conservation

⁴²Interview with Jacques Pinkard, Woodland Conservationist, SCS, Michigan, November 9, 1973.

practices for which SCS provided technical assistance and which were reported as accomplishments in its data system. Elimination of REAP cost-sharing in mid-FY 1973 is believed to have reduced farmer investments in conservation practices and, therefore, SCS accomplishments.⁴³

Estimating Gross Erosion Reduction

The present SCS reporting system provides no direct information concerning gross erosion reduction due to land treatment measures. A procedure was developed to estimate gross erosion reduction utilizing progress reporting data plus additional sources. This procedure was then applied to one sub-region in Southern Michigan.

The Universal Soil Loss Equation provides a method for calculating gross erosion when certain physical parameters are quantified.⁴⁴ The equation is $A = RKLSCP$ where

A = average annual computed soil loss per unit area;
 R = rainfall factor
 K = soil-erodibility factor
 L = slope-length factor
 S = slope-gradient factor
 C = cropping-management factor
 P = erosion control practice factor

Values for each factor have been established from research data. The R factor values have been determined on a geographical basis from long term rainfall records. Values for K, L, and S have been established for the major soil series. Tables are available with C factor values for various

⁴³Both the personnel ceiling and REAP impacts on FY 1973 data were pointed out in an interview with Warren Fitzgerald, Assistant State Conservationist, SCS, Michigan, October 26, 1973.

⁴⁴W. H. Wischmeier and D. D. Smith, op. cit.

crop rotations in combination with alternative soil management methods (conventional tillage, crop residue retained on soil surface, or minimum tillage). Prepared tables also give P factor values for selected erosion-control practices (up and down hill farming, contouring, stripcropping, or terracing).

For the purpose of this analysis it was assumed that the Universal Soil Loss Equation predicts soil loss without error. There is, in fact, some level of variance associated with estimates derived from the Equation. The assumption of zero variance implies a lower error of estimate for soil loss values computed in this study than might actually be observed.

This study utilized computed per-acre soil loss values prepared by Iowa State University using the Universal Soil Loss Equation, and made available by the Soil Conservation Service. Erosion losses were computed for each Major Land Resource Area,⁴⁵ by land capability class and subclass,⁴⁶ for several typical crop rotations, for various combinations of crop management systems and erosion control practices.⁴⁷

⁴⁵U.S., Department of Agriculture, Soil Conservation Service, Land Resource Regions and Major Land Resource Areas of the United States, Agriculture Handbook 296 (Washington: U.S. Government Printing Office, 1965).

⁴⁶U.S., Department of Agriculture, Soil Conservation Service, Land-Capability Classification, Agriculture Handbook No. 210 (Washington: U.S. Government Printing Office, 1961).

⁴⁷Development of these erosion loss data is described in Kenneth John Nicol's, "Modeling Approach to the Economic and Regional Impacts of Sediment Loss Control" (Unpublished Ph.D. dissertation, Dept. of Agr. Econ., Iowa State Univ., 1974) pp. 289-308.

The per acre reduction in gross erosion (ERED) for the general case may be stated as

$$\text{ERED}_{ijkn} = \text{EROS}_{ijklm} - \text{EROS}_{ijkl'm'}$$

where EROS = gross erosion per acre calculated by the Universal Soil Loss Equation

i = Major Land Resource Area (LRA)
 j = Land Capability Class and Subclass (LCCc)
 k = crop rotation
 l = tillage condition without treatment
 l' = tillage condition with treatment
 m = mechanical practice without treatment
 m' = mechanical practice with treatment
 n = conservation treatment applied

and

n = 1 for crop residue use
 2 for minimum tillage
 3 for contouring
 4 for stripcropping
 5 for permanent cover

and

l = 1 for conventional tillage
 2 for crop residue use
 3 for minimum tillage

and

m = 1 for up and down hill farming
 2 for contour farming
 3 for stripcropping
 4 for terracing

A twenty-four county area in Southern Michigan which comprises LRA 98 was selected for application of the procedure. This region is the Southern Michigan Drift Plain, which has a diversity of general field crops and productive agricultural soils (Figure 2, page 31).

There are fourteen land capability classes and subclasses (LCCc) in LRA 98 included in this analysis: I, IIe, IIw, IIIs, IIIe, IIIw, IIIs, IVe, IVw, IVs, VIe, VIs, VIIe, VIIs. The other LCCc's did not have sufficient cropland acreage to be considered pertinent.

The available soil loss data had originally been computed by LCCc for several crop rotations known to be utilized by farmers in Land Resource Area 98. Application of those data to this study required specification of a typical crop rotation from within the original list for each LCCc by county.

It was assumed that farming practices and crop rotations within a county are uniform among some closely related land capability classes with the same major limitation. That is, three fields with fertile soils and level topography having excessive soil moisture ("w" subclass) might have been placed in capability class II, III, and IV respectively due to differences in the degree of drainage problem; but they are all likely to have a similar crop rotation with a relatively high proportion of row crops. More sloping areas with a higher erosion hazard ("e" subclass) would probably be managed with a rotation higher in close-grown crops than the wet soils although once again differences among class II, III and IV would be minor.

On this basis, six LCCc groupings were established: I; IIe-IIIE-IVE; IIw-IIIW-IVw; IIs-IIIs-IVs; VIe-VIIe; VIs-VIIIs. This procedure simplified the selection of typical crop rotations for each grouping on a county basis (Table 2).

The CNI does not provide information on the physical condition of land identified as needing treatment. It was necessary to assume certain land management conditions for with and without treatment (Table 3). The assumed condition without treatment was conventional tillage with up and down hill farming.

Table 2.--Typical crop rotations for land capability class and subclass groupings, by county, LRA 98.^a

County	Capability Class and Subclass Group					
	I	II-IVe	II-IVw	II-IVs	VI-VIIe	VI-VIIIs
Crop Rotation Code ^b						
Barry	84	84	84	84	85	85
Branch	20	84	84	84	85	85
Calhoun	20	84	84	84	85	85
Cass	20	84	84	84	85	85
Clinton	20	84	89	84	85	85
Eaton	20	84	89	84	85	85
Genesee	20	89	89	84	85	85
Gratiot	20	89	301	84	85	85
Hillsdale	20	84	89	84	85	85
Ingham	20	84	89	84	85	85
Ionia	20	89	89	84	85	85
Isabella	20	89	89	84	85	85
Jackson	20	84	89	84	85	85
Kalamazoo	20	84	84	84	85	85
Kent	20	84	84	84	85	85
Lapeer	20	89	89	84	85	85
Lenawee	20	89	89	84	85	85
Livingston	20	84	89	84	85	85
Montcalm	20	84	84	84	85	85
Muskegon	20	84	84	84	85	85
Oakland	20	84	89	84	85	85
Ottawa	20	84	84	84	85	85
St. Joseph	20	84	89	84	85	85
Washtenaw	20	84	89	84	85	85

^aSource: Interview with Richard Drullinger, Agronomist, SCS, Michigan, December 19, 1973.

^bCrop rotation codes - 20: continuous corn; 84: corn-corn-oats-hay-hay-hay; 85: corn-oats-hay-hay-hay-hay; 88: corn-corn-wheat-soybeans; 301: corn-corn-wheat-sugar beets.

Table 3.--Assumed land management conditions by cropland treatment need category,
without and with treatment.

Cropland Treatment Need Category	<u>Assumed Management Condition</u>			
	Without Treatment		With Treatment	
	<u>Tillage</u>	<u>Mechanical</u>	<u>Tillage</u>	<u>Mechanical</u>
Crop Residue Use	Conventional	Up-down Hill	Crop Residue Use	Up-down Hill
Minimum Tillage	Conventional	Up-down Hill	Minimum Tillage	Up-down Hill
Contouring Only	Conventional	Up-down Hill	Crop Residue Use	Contouring
Stripcropping	Conventional	Up-down Hill	Crop Residue Use	Stripcropping
Permanent Cover	Conventional	Up-down Hill	Minimum Tillage	Terraces

Assumed conditions after treatment show the effect of each particular conservation measure. For crop residue use and minimum tillage, only the tillage condition is assumed to be improved. It was assumed that either contouring or stripcropping would only be applied as part of a comprehensive conservation program for that land, and that tillage practice would also be changed from conventional to crop residue use. Soil loss values for a change to permanent cover are not included in the data used for this study. Conditions with permanent cover in place were therefore assumed to be the most soil conserving combination possible within the data: minimum tillage on terraced land.

The foregoing simplifications make it possible to express the general erosion reduction model as

$$ERED_{crn} = EROS_{crlm} - EROS_{crl'm'}$$

where c = county, and

r = the LCCc - crop rotation complex, with remaining subscripts as described above.

For the previously defined treatment condition n (Table 3), the per acre erosion reduction for a given c r is

$$ERED_1 = EROS_{1,1} - EROS_{2,1}$$

$$ERED_2 = EROS_{1,1} - EROS_{3,1}$$

$$ERED_3 = EROS_{1,1} - EROS_{2,2}$$

$$ERED_4 = EROS_{1,1} - EROS_{2,3}$$

$$ERED_5 = EROS_{1,1} - EROS_{3,4}$$

In order to utilize this model, it is necessary to know the LCCc - crop rotation complex upon which erosion control measures are applied. Since SCS progress reports contain no information on this point, a generalized approach was used.

It was assumed that conservation treatments would be distributed by LCCc in the same proportion as acres needing that treatment, as reported in the CNI by county. That is,

$$DN_{crp} = NT_{crp} \div \sum_{r=1}^{14} NT_{cp}$$

where NT = acres needing treatment, and

p = treatment need category:

1. residue and annual cover
3. contouring only
4. stripcropping
5. permanent cover

Since both crop residue use and minimum tillage correspond to residue and annual cover needs, $DN_{cr2} = DN_{cr1}$

A weighted erosion reduction value is then calculated as

$$WERED_{crn} = ERED_{crn} \times DN_{crp}$$

It is now necessary to know the distribution of values of CECA among the five component conservation treatments for cropland erosion control. For the current estimate, the actual distribution calculated from fiscal year 1972 data was used. For projections, it was assumed that the distribution within each county would be the same as that reported in FY 1972.

Thus

$$PTR_{cn} = \frac{TR_{cn}}{\sum_{n=1}^5 TR_c} = \frac{TR_{cn}}{CECA_c}$$

where TR = acres of conservation treatment n.

Finally, total erosion reduction per acre of cropland erosion control applied (CECA) is given by

$$TERED_c = \sum_{r=1}^{14} \sum_{n=1}^5 (WERED_{crn} \times PTR_{cn})$$

Alternative Staffing Patterns

The fourth major objective of this study was to specify alternative SCS staffing levels by county in order to maximize acres of erosion control, and, alternatively, gross erosion reduction. As mentioned in the previous section, results of the regression analysis for estimating pastureland and other land treatment acreages made it necessary to confine further work to cropland erosion control alone.

Proposed adjustments in staffing levels among counties were based upon marginal analysis. Regression estimators described earlier were considered production functions of the form $Y = f(X_1 | X_2 \dots X_n)$ where Y is total acres of erosion control (or gross erosion reduction); X_1 is SCS manpower inputs; and $X_2 \dots X_n$ are the remaining variables in the regression equation. Total output (Y) was then calculated while parametrically varying manpower (X_1). Comparison and rankings among counties in terms of incremental changes in output provided the basis for shifting manpower to counties with the highest marginal productivity.

Limits were established to eliminate the possibility of allocating all manpower resources to the county with the highest marginal productivity. Such a solution would be totally unrealistic in consideration of other SCS management objectives. In addition, the reliability of the regression estimators declines as one extrapolates beyond the range of observed values of the independent variables.⁴⁸

⁴⁸Morris Hamburg, Statistical Analysis for Decision Making (New York: Harcourt, Brace & World, Inc., 1970), p. 503.

Present and adjusted manpower levels were studied for each of the two regions in the state described earlier. This approach was used for two reasons. First, separate regression equations which would provide the means of predicting erosion control output had been developed for each region. Second, the range of present manpower levels is smaller within each region than for the state as a whole. The possibility of extreme shifts in manpower would be reduced by operating within the range exhibited in a particular region.

The limits of allowable manpower levels were thus established so that within each region no county would have less manpower than the lowest amount recorded in FY 1972 data; and no county would have more manpower than the highest amount recorded in FY 1972. The total manpower pool for each region was allocated among the counties in that region in descending order when ranked from high to low on marginal output expressed as acres of erosion control.

Within each region, actual FY 1972 acres of cropland erosion treatment were compared to the predicted values with manpower allocated as described above. The significance of the difference between these values was measured through a t-test on the mean of the acreage for each condition. This tested the null hypothesis that there is no difference between the means; i.e.

$$H_0: (\bar{Y}_1 - \bar{Y}_2) = 0$$

at a ten percent level of significance.

The effects of changes in manpower allocations upon gross erosion reduction were evaluated for the twenty-four county sub-region comprising Land Resource Area 98. This was the one area to which the erosion reduction model was applied.

The basic allocation procedure was just as outlined above. Marginal output was measured in terms of total tons of gross erosion reduction, which was computed as the product of acres treated and gross erosion reduction per acre. Counties were ranked from high to low on marginal output, and the available manpower pool was allocated to counties in descending order. Allowable manpower allocation was again limited to the range of observed values within Region Two (Southern Lower Michigan). Comparisons were made of total gross erosion reduction under three conditions: (1) observed in FY 1972, (2) with manpower allocation to maximize acres of cropland erosion control, (3) with manpower allocation to maximize total tons of erosion reduction.

Differences among these conditions were again measured through a t-test on each of four pairs of means. These tests evaluated the null hypothesis of no difference between means at the ten percent significance level.

CHAPTER IV

STAFF ORGANIZATION AND EROSION CONTROL ACCOMPLISHMENTS

The Soil Conservation Service has provided technical assistance to farmers and other landowners and landusers in Michigan since the first soil conservation district was organized in 1938 in Ottawa County. The agency's total program and staff have grown substantially since that time, and now serve all eighty-three counties in the state. The agency mission which originally centered on erosion control now encompasses multiple objectives. The analysis described in this chapter was initially concerned with how well SCS has organized its staff to carry out an erosion control effort. Additional work was directed toward examination of factors which influence erosion control accomplishments.

Results of Staffing Patterns Analysis

The current SCS staffing pattern among the eighty-three counties in Michigan was investigated first. Both correlation and multiple regression techniques confirmed that county manpower levels do not necessarily agree with the relative severity of the erosion control problem.

Simple correlations were utilized primarily to identify highly inter-correlated variables prior to multiple regression analysis. They also provide a measure of the degree of association between several pairs of key variables. It was found that the correlation coefficient exceeded

0.70, the critical level previously chosen, for seven pairs of independent variables. The intercorrelated variables and their correlation coefficient were CNT, ENT (.914); CNT, RNFN (.943); CNT, CPT (.920); CPT, ENT (.890); CPT, RNFN (.874); ENT, RNFN (.919); UBT, P70 (.937) (Table 4).

These results raised a problem for further analysis of the main question under investigation: Has SCS staffing been sensitive to county total erosion control needs? The independent variable of primary interest in the regression equation (ENT) was highly correlated with three other independent variables.

Some simplification was achieved by dropping RNFN, which was correlated at greater than 0.90 with three other independent variables, (CNT, CPT, ENT) but correlated with TIME to a slightly lesser degree than any of those three. From the set P70-UBT, the variable P70 was dropped since its correlation with TIME was less than that of UBT.

These steps left three intercorrelated independent variables (CPT, CNT, ENT) which were tested in separate regression equations in combination with UBT, PR70, YRS, TNT, RTN, and PCH. After the equations were computed, independent variables which were not significant at the ten percent level were dropped and a new computation made. Three equations were finally derived for which the coefficient of multiple determination (R^2) was significant at less than ten percent (see first three equations in Table 5).

The results of these first three equations indicated that both acres of cropland (CPT) and total cropland acres needing treatment (CNT) explained more of the variation in TIME than total erosion control needs (ENT). The prominence of these two cropland variables suggested a possible relationship between TIME and cropland erosion needs (CNE).

Table 4.—Simple correlation coefficients for variables in staffing pattern analysis.^a

TIME	1.000													
UBT	.130	1.000												
CPT	.752	.121	1.000											
P70	.015	.937	.035	1.000										
PR70	.597	.589	.658	.387	1.000									
COAR	-.050	-.014	-.085	-.026	-.066	1.000								
YRS	.488	-.042	.260	-.187	.292	-.227	1.000							
CNE	.611	.040	.872	.001	.500	-.112	.184	1.000						
CNT	.655	.032	.920	-.001	.482	-.061	.123	.919	1.000					
ENT	.650	.031	.890	-.019	.510	-.129	.224	.979	.914	1.000				
TNT	.130	-.267	.195	-.255	-.106	.626	-.072	.256	.334	.262	1.000			
RTN	.217	-.392	.305	-.359	-.115	-.186	.139	.440	.471	.465	.606	1.000		
RNFM	.649	-.006	.874	-.025	.475	-.265	.194	.908	.943	.919	.177	.517	1.000	
PCH	.123	.534	.152	.372	.514	-.040	.132	.016	.008	.023	-.204	-.254	.014	1.000
TIME	UBT	CPT	P70	PR70	COAR	YRS	CNE	CNT	ENT	TNT	RTN	RNFM	PCH	

^aFor eighty-three county observations.

Table 5.--Regression coefficients and related statistics for man-hours of SCS technical assistance.^a

	Dependent Variable	Constant	Independent Variable						$\bar{R}^2$
	TIME		PR70	YRS	CPT	CNT	ENT	CNE	
Equation 1	(1296.1) ^b	297.1	0.025* (0.007)	84.051* (20.384)	- -	- -	0.017* (0.003)	- -	.6030 ^c
Equation 2	(1225.4)	264.3	0.023* (0.007)	96.475* (19.197)	- -	0.014* (0.002)	- -	- -	.6451
Equation 3	(1195.2)	382.8	- -	85.698* (18.543)	0.012* (0.001)	- -	- -	- -	.6581
Equation 4	(1327.4)	420.5	0.026* (0.007)	89.299* (20.812)	- -	- -	- -	0.017* (0.004)	.5836

^aNumber in parentheses beneath the regression coefficient is the standard error.

^bStandard error of estimate.

^cAdjusted for degrees of freedom.

*Significant at less than 10 percent.

It was found that CNE was correlated with TIME at 0.611, and with CPT and CNT at 0.872 and 0.918 respectively, so it was desirable to separate CNE for regression analysis. A fourth equation was therefore computed with CNE, but with CPT, CNT, and ENT omitted (Table 5).

It may be noted that rural 1970 population contributes significantly to the total R^2 only in equations 1, 2, and 4. It is not significant at the ten percent level when CPT enters the equation. The correlation coefficient for PR70 with CPT of 0.66 suggests that PR70 may actually be operating as an indicator of variation in CPT for those three equations.

These four equations were then compared quantitatively to test the null hypothesis of no differences in the value of R^2 . The method utilized was an F-test of the form

$$F_{(p_1 - p_2, n)} = \frac{(R_1^2 - R_2^2)}{1 - R_2^2} \cdot \frac{n}{p_1 - p_2}$$

where p_1 and p_2 are the number of variables in two equations.⁴⁹ Calculation of the F statistic for three pairs of equations indicated that the null hypothesis would be rejected at the ten percent level. The specific F values were:

1. Equation (3) vs. Equation (1), $F = 13.38$ (significant at 1 percent)
2. Equation (3) vs. Equation (2), $F = 3.16$ (significant at 10 percent)
3. Equation (3) vs. Equation (4), $F = 18.09$ (significant at 1 percent)

These results support the alternate hypothesis that equation (3) does provide a significantly better explanation of observed variance in TIME

⁴⁹Elliot M. Cramer, "Significance Tests and Tests of Models in Multiple Regression," The American Statistician, XXVI, No. 4 (October, 1972), pp. 26-30.

than do the other equations tested. That is, county variations in man-hours of SCS technical assistance are best explained by the years a soil conservation district has been organized and the acres of cropland in a county.

Equation (3), which includes total cropland acres, provides a significantly better explanation of TIME distribution than similar equations which substitute total erosion control needs, cropland erosion control needs or total cropland treatment needs. This would indicate that SCS staffing decisions have been made with regard to total county cropland acreage more so than the three treatment need variables tested. If cropland acreage has in fact been a decision rule, manpower allocations have been directed toward erosion needs only because of high correlation of CNE and ENT with CPT (.918 and .890 respectively). Similarly, the staffing pattern follows total cropland treatment needs only to the extent that they correspond to total cropland acreage (.920 correlation of CNT with CPT).

Inspection of some of those independent variables which were deleted from the final equations is also revealing. Total county land area (COAR) was not even tested in regression analysis because of its very low and negative simple correlation with TIME (-0.050). In fact, COAR displayed a negative correlation with all other independent variables with the exception of TNT (0.626). Analysis of the total acreage values represented by these variables shows these results to be entirely consistent.

Both COAR and TNT are weighted heavily by forest land area. For the State of Michigan, forest land comprises over fifty-three percent of the total inventoried land area, while cropland makes up just under thirty-six

percent. Forest land accounts for over seventy percent of total county land area in all fifteen counties in the Upper Peninsula and in several counties in the Northern Lower Peninsula. In only one county (Sanilac) does the sum of pasture and other land exceed forest land acreage. Thus COAR differs from CPT largely by the amount of forest land acreage.

The state acreage total for TNT is approximately 16,256,000, of which cropland treatment needs (CNT) comprises 5,554,000 acres (thirty-four percent), forest treatment needs 9,392,000 acres (fifty-eight percent), and the sum of pasture and other land 1,310,000 acres (eight percent). Statewide, the difference between TNT and CNT is due principally to treatment needs on forest land, and this relationship is true for nearly all of the individual county observations.

Total land treatment needs apparently have not been considered by SCS decision-makers in allocating manpower among counties. This is evidenced by the low correlation of TIME with TNT (0.130), and the fact that TNT was one of the first independent variables deleted from each of the four regression equations. This action, along with an apparent disregard for total county land area, has not necessarily been contrary to agency objectives. While the SCS mission is concerned with conservation of all lands, it is not the only agency involved in forest land treatment. The Forest Service is the USDA's principal forest conservation agency. It provides technical assistance for public and private forest land treatment through the Michigan Department of Natural Resources. The Forest Service also provided the forest acreage and needs data for the Conservation Needs Inventory, as discussed earlier. It is therefore not inappropriate that SCS omit both TNT and COAR, which are biased toward forest land acreage, as primary decision variables in allocating manpower for its own programs.

The number of years a soil conservation district has been organized in a county (YRS) is a highly significant independent variable with a positive regression coefficient in each of the four equations (t-value significant at less than 0.1 percent). Although this relationship may not be the consequence of conscious design by SCS, it probably results from a failure to undertake a staffing policy to offset historical events.

A number of early soil conservation districts were organized on less than a county basis. Examples are South Muskegon (organized in 1938) and North Muskegon (1938); Fenton (1939) and Southeast Livingston (1941); Allegan (1940) and East Allegan (1945). Even a policy of equal staffing in each soil conservation district would have provided additional manpower per county in such cases. Overall county staff levels were considerably higher in that era than at present. This was to be expected with a new and popular farm program which was able to attract much Congressional support. In 1942, SCS had thirty field employees serving nine soil conservation districts in six counties. That average of five employees per county may be compared to the 1972 average of approximately two employees per county.⁵⁰

Two factors have probably been operating over the years to maintain higher staff levels in older soil conservation district counties. First is the political difficulty of reducing assistance to an established clientele group. As more districts were organized, but agency funding

⁵⁰"History of the Soil Conservation Service in Michigan" (Unpublished report prepared for 1972 Statewide Training Meeting of Michigan SCS Personnel, April, 1972), pp. 11-12, 33-34.

and personnel levels did not increase proportionately, some redistributions of staff were necessitated. It seems reasonable that the agency would seek to maintain the support of cooperators in established SCD's by providing technical assistance as nearly as possible at the customary level. Newly organized districts would then be provided with a relatively smaller staff as determined by budgetary constraints. Results of the regression analyses suggests that this criterion was tempered principally by consideration of county cropland area.

A second factor contributing to additional staffing in older soil conservation districts might have been the agency's response to its own reporting system. As expected, the independent variable YRS was correlated with cumulative number of both conservation plans (PLANS) and district cooperators (COOP) at 0.68. SCS records could thus indicate to a decision-maker that older districts have a greater work load and therefore need to retain a relatively large staff.

The relationships between YRS and the several land treatment need variables (TNT, ENT, CNT, CNE, RTN, RNFN) are not clearly established in the data analyzed here. Only the simple correlation coefficient of YRS with ENT (0.224) is statistically significant at the five percent level. This is quite limited evidence that the older soil conservation districts were started in counties which did have the most serious erosion problems. This issue is clouded, however, because YRS is also correlated with CPT at 0.260, and the relatively high correlation of CPT and ENT was cited earlier. It seems most likely that districts were first established wherever sufficient public support could be generated, without specific planning to select the most critical erosion areas.

Analysis of Erosion Control Accomplishments

Three land use types--cropland, pastureland, and other land--were studied separately with regard to factors influencing the application of erosion control practices with SCS technical assistance. The hypothesized relationships were found to be deficient in explaining the variation in erosion control accomplishments. Alternative formulations were then tested with varying degrees of success among land use types and regions of the state.

Other Land Erosion Control

The relationships between Other Land Erosion Control Accomplishments (OECA) and the independent variables selected for analysis were extremely thin. Simple correlations for each pair of variables did not approach the selected value of 0.70 in any instance. Therefore, initial multiple regression equations were computed for each region as originally formulated. In neither region did the equation prove to have explanatory value. The F-value for R^2 in each equation and the t-values for all regression coefficients were not statistically significant at the ten percent level.

Alternative multiple regression equations were then tested in an effort to explain variations in OECA. Simple correlations suggested several additional independent variables. Equations for each region were computed with all variables in original form, with log transformation of OECA, and with log transformation of all variables.

Three equations were finally developed which contained the independent variables of major interest, and for which the F-value was significant at less than the ten percent level (Table 6). Although the relationships among OECA and several variables are much weaker than originally expected, such results are also revealing.

Table 6.--Regression coefficients and related statistics for other land erosion control application.^a

Dependent Variable		Constant	Independent Variables							$\bar{R}^2$	
OECA			TIME	PT	PNT	ONT	COOP	GOVTU	CECA		
Region 1 (1)	(64.290) ^b	-29.288	-0.0209 (0.013)	0.0054 (0.004)	-0.0098* (0.005)	-0.0036 (0.003)	0.2708* (0.072)	0.9262 (0.591)	- -	.4777 ^c	
	(2)	(66.139)	-47.283	- -	0.0070 (0.004)	-0.0116* (0.005)	-0.0020 (0.003)	0.1919* (0.051)	0.8022 (0.644)	-0.0053 (0.007)	.4472
	(3)	(65.693)	-48.096	- -	0.0068 (0.004)	-0.0116* (0.005)	-0.0023 (0.002)	0.1786* (0.047)	0.9504 (0.604)	- -	.4542
Region 2 (1)	(24.726)	-7.4352	0.0008 (0.003)	0.0056* (0.001)	-0.0063* (0.002)	-0.0011* (0.001)	-0.0118 (0.012)	-0.3896* (0.108)	- -	.4738	
	(2)	(24.689)	-7.5427	- -	0.0057* (0.001)	-0.0064* (0.002)	-0.0011* (0.001)	-0.0102 (0.010)	0.4016* (0.111)	0.0002 (0.001)	.4754
	(3)	(24.369)	-5.6936	- -	0.0056* (0.001)	-0.0063* (0.002)	-0.0011* (0.001)	-0.0103 (0.010)	0.3917* (0.106)	- -	.4883

^aNumber in parentheses beneath regression coefficient is the standard error.

^bStandard error of estimate.

^cAdjusted for degrees of freedom.

*Significant at less than 10 percent.

In Region One, only the regression coefficients for COOP and PNT are significantly different from zero at the ten percent level in all three equations. Of these, only COOP is logically related to OECA, for one would expect the number of district cooperators, representing clients for SCS services, to have some influence on land treatment accomplishments. The variable PNT, with a negative coefficient, has no real practical meaning.

In Region Two, PT, PNT, ONT, and GOVTU have regression coefficients significantly different from zero at less than the ten percent level in each equation. In this case, GOVTU is a rational variable, for a higher number of units of government in a county implies more urban growth and land undergoing development, hence a likelihood of more Critical Area Planting.

The regression coefficient for TIME was not significant at the ten percent level in either region. Nor did TIME improve the explanatory value of the equation in either region. This was verified by comparing R^2 for equations (1) and (3) by means of an F-test which confirmed no significant difference between these equations in either region at the ten percent level.

Another equation was tested with CECA substituted for TIME. It was conjectured that although OECA was unrelated to manpower inputs, it might be related to the level of cropland erosion control activities. In both regions, the regression coefficient for CECA did not differ significantly from zero. An F-test comparing equations (2) and (3) confirmed that there was no improvement in R^2 by adding CECA to the equation.

These three equations provided a sufficient test of the independent variables of primary interest: TIME, ONT, and CECA. There was no need to further refine the equations by recomputing with non-significant variables deleted. The results indicate that erosion control accomplishments on other land are not significantly affected by SCS manpower levels, or by the level of relationship between OECA and the acres of other land needing treatment.

This suggests that the Soil Conservation Service has not really established a statewide erosion control program for other land. Treatment is applied almost at random as individual SCS technicians work with landowners on other practices. Such a situation is not surprising, since other land comprises just over four percent of the land area of Michigan. It is also of little direct economic productive importance. Nevertheless, other land which is being transformed from an idle investment tract to an urban development is subject to severe erosion hazards. As noted earlier, land undergoing development may experience erosion rates over one hundred times those of cropland on the same soil type. Attention to the problem is certainly warranted. The only evidence that some positive efforts in this regard are underway is found in Region Two. A positive and statistically significant regression coefficient for GOVTU was computed in each equation as noted above.

Analysis of other land erosion control accomplishments is limited by a problem of definitions. Only one reportable practice--Critical Area Planting--represents OECA. This practice may be applied on any land use type and not necessarily other land. The lack of a positive relationship between OECA and OT or ONT may be partially explained by this divergence

of the Progress Reporting System and the Conservation Needs Inventory. The actual data for OECA are also somewhat limited. Just over 3,100 acres were reported for the entire state, with approximately 2,100 acres and 1,000 acres in Regions One and Two respectively. No acreage of OECA was reported in twenty counties.

The second objective of this analysis--to develop a predictive equation for OECA in order to study staffing pattern adjustments--could not be met due to the results reported here. It was determined that OECA is not sensitive to SCS county manpower levels. Use of these equations for even general estimating applications would be of limited value since they explain less than one-half of the variation in OECA.

Pastureland Erosion Control

Erosion control accomplishments on pastureland were more amenable to analysis by multiple regression techniques than on other land. Once again, however, hypothesized relationships proved to be only a point of departure from which alternative variables were scrutinized.

The seven independent variables previously chosen were of limited value in explaining variations in pastureland erosion control accomplishments. The specified equation was found to produce a value for the coefficient of multiple determination which was statistically significant from zero at the ten percent level as determined by an F-test. The value of R^2 was so low (< 0.25 in each region) as to render the equations of little value for prediction purposes.

Simple correlations offer some evidence that PECA is related to cropland erosion control accomplishments (CECA) in Region One. The simple correlation coefficient of 0.738 with CECA was the highest observed for

PECA in either region. This indicates that in Region One, technical assistance provided to a landowner primarily for cropland treatment may result in his applying some pastureland erosion control measures as well. Although there may be no explicit pastureland erosion control effort, there seems to be some attempt to "sell" pastureland treatment along with cropland protection at least in Region One.

In Region Two, such a pattern is not supported by the data. There the simple correlation coefficient of PECA with CECA was 0.027. Only PLANS and COOP were significantly correlated with PECA, at 0.468 and 0.390 respectively. Both the number of conservation plans and number of soil district cooperators are cumulative values and thus represent stocks for technical assistance and recorded decisions to apply conservation practices. It is reasonable that the annual flow of land treatment accomplishments should be related to the magnitude of these stocks. The high correlation of these two stock variables, exceeding 0.92 in each region, was expected, since one of the primary SCS goals over the years has been to prepare a complete conservation plan for every district cooperator.⁵¹

Further analysis was conducted in an attempt to develop predictive equations for PECA. A number of additional multiple regression equations

⁵¹This policy has currently been modified somewhat due partly to recognition that some landowners may wish to become district cooperators in order to receive technical assistance for one or two specific practices, but do not need or desire a complete conservation plan. The task of preparing a complete plan for each new cooperator with the reduced manpower levels of recent years undoubtedly hastened this policy shift. Current guidelines for preparing conservation plans or acceptable alternatives are found in U.S., Department of Agriculture, Soil Conservation Service, Resource Conservation Planning Handbook (Washington, 1970), pars. 720.1-720.31; 740.2-740.5.

were computed using variables significant in the hypothesized equation plus those suggested by simple correlations. Equations were also tested with log transformation of the dependent variable only, and with log transformation of all variables, with the latter formulation providing the best estimates.⁵²

Log transformations required some adjustments in the basic data. The observed value of PECA was zero in four counties in Region One, and one county in Region Two. The observed value of VAPS was zero in one county in Region One. The observed value of CECA was zero in four counties in Region One. Since the log of zero is undefined, the value 0.01 was added to all observations of these three variables in order to allow the log transformation subroutine of the multiple regression program to proceed normally.

Three equations were derived in each region for which the coefficient of multiple determination exceeded 0.66 (Table 7). Each of the equations provided a slightly better fit of the data in Region One than in Region Two, although no other combination of independent variables tested in Region Two was superior to those shown here.

In Region One, the first equation included LGTIME, for which the regression coefficient was positive and significant at less than the ten percent level. Equation (2), which substituted LGCECA for LGTIME, also displayed positive and significant regression coefficients for all independent variables. Both LGTIME and LGCECA were deleted in equation (3).

⁵² All log transformations throughout the analysis were to common logarithms; variables thus created were labeled LG... .

Table 7.--Regression coefficients and related statistics for pastureland erosion control application.^a

	Dependent Variable	Constant	Independent Variables				$\bar{R}^2$
	LGPECA		LGTIME	LGYRS	LGVAPS	LGCECA	
Region 1 (1)	(0.8035) ^b	-6.908	1.0908* (0.466)	1.3419* (0.248)	0.8295* (0.179)	- -	.7258 ^c
(2)	(0.7044)	-2.8624	- -	1.2239* (0.216)	0.7717* (0.146)	0.3606* (0.082)	.7892
(3)	(0.8468)	-3.5589	- -	1.5614* (0.242)	1.0685* (0.156)	- -	.6952
Region 2 (1)	(0.5617) ¹	-14.892	0.9264 (0.744)	3.6872* (0.513)	2.1719 (1.296)	- -	.6689
(2)	(0.4796)	-11.997	- -	3.0820* (0.463)	2.0305* (1.048)	0.5345* (0.137)	.7587
(3)	(0.5660)	-14.124	- -	3.9064* (0.486)	2.7606* (1.216)	- -	.6636

^aNumber in parentheses beneath the regression coefficient is the standard error.

^bStandard error of estimate.

^cAdjusted for degrees of freedom.

*Significant at less than 10 percent.

An F-test was used to compare R^2 in the three equations with the following results:

Equation (1) vs. Equation (3), $F = 5.36$ (significant at 5 percent)

Equation (2) vs. Equation (3), $F = 14.29$ (significant at 1 percent)

These values indicate that while the first two equations are both useful for predicting values of LGPECA in Region One, it appears that equation (2) would yield better estimates. This conclusion is somewhat strengthened by simple correlation coefficients for LGPECA with LGTIME and LGCECA of 0.670 and 0.723, respectively. It is somewhat clouded, however, by a relatively high correlation of 0.650 for LGTIME with LGCECA.

In Region Two, the results were mixed. Equation (1) included two independent variables--LGTIME and LGVAPS--for which the t-value of the regression coefficient was not significant at the ten percent level. Substituting LGCECA for LGTIME increased R^2 from 0.66 to 0.76, and produced significant regression coefficients for the independent variables. Once again, an F-test evaluated the differences in R^2 for equations (1) and (2) compared to equation (3) which omitted both LGTIME and LGCECA. These test results were as follows:

Equation (1) vs. Equation (3), $F = 1.65$ (not significant at 10 percent)

Equation (2) vs. Equation (3), $F = 11.78$ (significant at 1 percent)

This outcome confirmed that LGTIME is not of significant value in explaining variations in LGPECA in Region Two, but LGCECA is.

The importance of LGCECA in each region supports the scenario outlined above for the link between cropland and pastureland treatment in Region One. Some attempt is apparently made by SCS technicians statewide to achieve pastureland erosion control in conjunction with measures for cropland treatment. A more consistent effort seems to be applied in

Region One, for it was only through log transformation of the data that this relationship was revealed in Region Two. The reasons for this difference in emphasis are not apparent. The total area of pasture land in Region One (644,000 acres) is nearly equal to that in Region Two (624,000 acres). The proportion of pastureland needing treatment in the two regions is also approximately equal (sixty-nine and seventy-one percent, respectively). In any case, a strong policy of linking cropland and pastureland treatment is not evident. Although LGCECA is statistically significant in each region, deleting it from the equation still leaves over sixty-six percent of the variation in LGPECA explained by two remaining variables.

The hypothesis that pastureland erosion control accomplishments are influenced by the county value of agricultural products sold is supported in each region. The link between LGPECA and LGVAPS is strongest in Region One. In Region Two, it is not significant (at ten percent) when LGTIME enters the equation although it is in equations (2) and (3). A simple correlation coefficient in Region Two of 0.373 for LGTIME vs. LGVAPS is statistically significant at less than five percent, and suggests some interaction. The same is true in Region One, where the correlation coefficient of LGTIME with LGVAPS is 0.557.

A rationale for LGYRS remaining in the final equations in each region is not clear. It was added as a result of the staffing pattern analysis which showed YRS to be highly related to SCS program levels. Although those results confirmed a link between TIME and YRS, it is doubtful that LGYRS is acting for LGTIME in the equations under consideration here. Simple correlations show a stronger relationship between LGYRS and LGPECA in both regions (0.600 and 0.790), respectively) than between LGYRS and

LGTIME (0.358 and 0.352). Perhaps the most to be said for LGYRS is that it improves the predictive value of the equations in both regions.

The objective of using regression equations to predict pastureland treatment acreage with SCS manpower adjustments could not be fully implemented. Only in Region One was LGTIME significant. Even there, some evidence was found that using LGCECA in place of LGTIME would provide better estimates of LGPECA. In Region Two this was clearly the case. The alternative of using equation (2), including LGCECA, in both regions was rejected. Using estimated values of LGCECA derived from another regression equation in order to predict values of LGPECA would have knowingly introduced errors into the analysis. Pastureland treatment does not consistently occur with application of cropland erosion control measures, as a two-stage estimating procedure would imply. The decision was made to concentrate further analysis on acreage estimators and erosion reduction indicators for cropland alone.

Cropland Erosion Control

The analytical model originally specified for land treatment accomplishments on cropland was somewhat more successful than it had been on the other two land use types. Nevertheless, there still remained a large proportion of variation in CECA unexplained by the model. Substantial revisions of the original model were successful in producing better predictive equations.

The original equation yielded a coefficient of multiple determination which was significant at the ten percent level in both regions, but in each case explained less than one-half the variation in CECA. Additional variables were evaluated to determine some pattern for the SCS cropland treatment program.

Simple correlations suggested further analysis of acres of cropland needing drainage (DRN) in Region Two. It was found that CECA had a higher correlation with DRN (0.568) than any of the other variables tested in Region Two (Table 8). It should also be noted that DRN is highly correlated with CNT (0.838), but not with CNE. This was expected, since by definition, CNE differs from CNT by the acreage of cropland needing drainage.

Table 8.--Simple correlation coefficients for selected variables in cropland erosion control analysis, Region Two.

CECA	1.000						
TIME	.365	1.000					
CPT	.404	.504	1.000				
CNE	.322	.226	.689	1.000			
CNT	.549	.376	.838	.816	1.000		
ENT	.348	.299	.742	.968	.830	1.000	
DRN	.568	.383	.655	.287	.838	.342	1.000
	CECA	TIME	CPT	CNE	CNT	ENT	DRN

A new regression equation was computed for CECA, which included TIME, CPT, and DRN as independent variables. While the major interest was in Region Two, the same equation was tested in Region One as well. This showed a definite relationship between CECA and DRN in Region Two (Table 9). The regression coefficient for DRN was positive and significant at less than the ten percent level. Results in Region One confirmed that CECA is significantly related to TIME and CPT; but the regression coefficient for DRN did not differ significantly from zero at the ten percent level.

Table 9.--Regression coefficients and related statistics for cropland erosion application.^a

Dependent Variable		Constant	Independent Variable				$\bar{R}^2$
CECA			TIME	CPT	DRN		
Region 1 (1)	(1303.4) ^b	-700.78	0.4771* (0.174)	0.0096 (0.006)	0.0432 (0.061)		.3901 ^c
Region 2 (1)	(8554.7)	-2834.9	1.1454 (1.007)	-0.0028 (0.023)	0.1281* (0.045)		.3118

LGCECA			LGTIME	LGVAPS	LGRNFN	P70	
Region 1 (2)	(1.2115)	-7.8266	3.0046* (0.541)	- -	- -	- -	.4237
(3)	(0.4981)	-3.2666	2.1819* (0.379)	-0.2410* (0.126)	0.4495* (0.208)	- -	.6528
Region 2 (2)	(0.2933)	-1.3076	1.3884* (0.385)	- -	- -	-0.000001* (0.000)	.8020

^aNumber in parentheses beneath the regression coefficient is the standard error.

^bStandard error of estimate.

^cAdjusted for degrees of freedom.

*Significant at less than 10 percent.

It is clear that in Region Two, cropland erosion control accomplishments are more highly related to cropland drainage needs than any of the other independent variables tested. It is quite probable that many farmers would initially seek SCS assistance for drainage improvements rather than erosion control. Improved drainage is required on some Michigan soils just to enable a farmer to plant and harvest a crop. Erosion control is not ordinarily so critical in the short-term. Having established contact with SCS and the soil conservation district as a result of a drainage problem, a farmer might then be encouraged to adopt a complete conservation plan including appropriate erosion control measures.

Divergent results regarding the importance of DRN in Regions One and Two are probably due to the relative magnitude of cropland drainage needs (Table 10). In Region Two, DRN accounts for thirty percent of total cropland treatment needs compared to just thirteen percent in Region One. Over 1.4 million acres of cropland need drainage in Region Two and represent over ninety percent of the state total.

Table 10.—Total cropland treatment needs and cropland drainage needs, Regions One and Two.^a

Cropland Need Category	Region One		Region Two		Michigan Total	
	Acres	Per- cent	Acres	Per- cent	Acres	Per- cent
Drainage (DRN)	110,500	13	1,420,900	30	1,531,400	28
Erosion Control (CNE)	741,800	87	3,280,400	70	4,022,200	72
Total (CNT)	852,300	100	4,701,300	100	5,553,600	100

^aSource: Computed from Michigan Conservation Needs Inventory, 1967.

Although the alternative equation was useful for interpretation, it was considered inadequate for prediction purposes in later stages of the study. A number of equations were subsequently tested in order to improve total R^2 . Several independent variables used previously in the investigation of TIME, PECA, and OECA were analyzed in addition to those originally specified in the cropland model. Equations were computed with observed values, and with log transformations. The final equations differed considerably between the two regions (Table 9).

The best fit for all forty-four observations in Region One was obtained with equation (3). A slight improvement over equation (1) was achieved through log transformation of both CECA and TIME; however, this formulation still left over one-half the variation in LGCECA unexplained. There was noted in the computation of this and preceding equations a large deviation between calculated and observed values of CECA or LGCECA for four counties in Region One. In those counties, (Alcona, Crawford, Luce, Roscommon) observed CECA was equal to zero; that is, no cropland erosion control measures had been applied in FY 1972. A number of equations were computed with observed values and with log transformations after deleting those four observations. This procedure resulted in equation (3), with a significantly higher coefficient of multiple determination than equation (2), as measured by an F-test.

The manpower variable (LGTIME) was highly significant in both equations. The variable representing value of agricultural production (LGVAPS) was the only other one of those originally specified to remain in the final equation. Its sign was negative and was certainly counter

to expectations.⁵³ The variable LGRNFN represents the percentage of non-forested land needing treatment. As such, it is highly related to CPT, CNI, and CNE, with simple correlation coefficients of 0.714, 0.694, and 0.690, respectively, and probably operates as a composite variable. In other equations tested, none of those three individual cropland variables (nor their log transformations) were significant. Equation (3) supported the inference that SCS has indeed organized a cropland erosion control program in Region One. It also provided an acceptable estimator of CECA for later use.

The final formulation in Region Two also had the dependent variable in log form. Equation (2) explained over eighty percent of the variation in LGCECA with two independent variables. Log transformations brought LGTIME and P70 into the equation, even though both were shown not to be significant in the test of hypothesized relationships. An inverse relationship between CECA and total county population is quite reasonable, for a higher total population would imply more urban development and consequently less cropland acreage to be treated. Some interaction of cropland and population variables undoubtedly occurs, for the simple correlation of P70 with CPT was -0.420, which is statistically significant at less than the five percent level. Nevertheless, CPT and LGCPT were not significant in any of the equations tested, both with and without P70. Log transformation of CECA caused DRN to be deleted, although it was the

⁵³ The reasons for this inverse relationship are not clear from cursory examination of observed data, but may relate to high values for VAPS in several counties with fruit and specialty crops in relatively limited cropland areas.

only significant independent variable in equation (1). Several equations were computed with LGDRN, but it was rejected at the ten percent level of significance in each case. Equation (2) revealed a significant relationship between cropland erosion control treatment and SCS technical assistance time in Region Two which was not initially apparent. It is not as strong and direct as might be expected if manpower allocations were in fact based on cropland erosion control needs. Yet it indicates that CECA is sensitive to manpower allocations, and fulfills the need for a predictive equation.

CHAPTER V

ESTIMATING GROSS EROSION REDUCTION

A procedure for estimating average soil loss reductions achieved through installation of various cropland treatment practices was developed. Application of the method described in Chapter III to a twenty-four county area in Southern Michigan revealed substantial differences in gross erosion reduction among counties and also among land treatment practices.

Erosion Reduction by Treatment Type and LCC

The initial step was to compute average soil loss reductions by practice type for each of fourteen land capability classes in each county. The highest annual soil loss in the untreated condition is 42.45 tons per acre, which occurs on class IVe land with a corn-corn-wheat-soybeans rotation. This condition is found in Genesee and Gratiot counties, for example (Appendix Table 1). It will be noted that at this point, the only differentiating factor among counties is the crop rotation. Identical soil loss values occur for a given land capability class in all counties with the same crop rotation. Thus in both Barry and Branch counties, the average soil loss without treatment on class IIe land is 3.11 tons per acre.

These tables clearly indicate a higher erosion hazard on "e" subclass land than on "w" or "s" subclasses. They also indicate that the

payoff in terms of erosion reduction for each of the five land treatment practices is highest on "e" subclass land. Higher levels of protection are evident with the more intensive land treatment practices. For some land capability classes, minimum tillage provides over sixty percent more soil loss reduction than crop residue use, and a change to permanent cover produces at least a four-fold increase.

This first step in the process is limited by several factors. First is the assumption that the chosen crop rotations adequately describe the actual conditions in a particular county. It is important to note that this method is an attempt to estimate average soil loss conditions for an entire county. The results would clearly not apply to a particular acre or even several farms or townships. Crop rotations were selected by an experienced professional based on his knowledge of general farming patterns in the study area (Table 2, page 41). The choice of rotations was further circumscribed by those which had been specified for the original soil loss computations. They represent long term historical patterns and would not reflect the expansion of cultivated acreage and row crop production fostered by the current world food situation.

Assumptions regarding soil loss conditions before and after each type of treatment are a source of error. The initial condition is most difficult to establish, and also the most critical, for all calculations depend upon it. It was assumed here that all land being treated was being farmed up-and-down hill with residue removed. In practice, an acre needing crop residue use may already be cultivated on the contour and need only improved residue management for adequate protection. In such

a case, the method used here would over estimate the amount of erosion reduction. On the other hand, crop residue use is a relatively easy practice for both the farmer and SCS to apply, since it requires only a slight change in tillage procedures. Contouring necessitates engineering surveys for layout, requires special plowing techniques, and generally increases farming time. It seems reasonable that a farmer could be encouraged to apply crop residue use more readily than contouring. This is the situation implied by the initial condition assumed for this analysis.

Actual erosion reduction due to contouring or stripcropping may be somewhat less than estimated if improved residue management is not also practiced as assumed here. This is a corollary to the case outlined above. A farmer would not be likely to apply the more intensive erosion control measures if he has not accepted a basic treatment of crop residue use.

Erosion reduction estimates for a change to permanent cover are the most prone to error. Reportable practices corresponding to this need category could vary widely in their average erosion rates. Conversion to woodland would presumably be the most protective, followed by grassland, then wildlife-recreation land. The latter change might actually increase average erosion rates for limited areas which received heavy recreational use. These problems are complicated by the fact that the available soil loss data did not include estimates for a land use change from cropland to non-cropland use. Use of data corresponding to minimum tillage on terraced land as a surrogate probably understates the erosion reduction actually achieved by land use change.

Finally, several limitations relating to the Universal Soil Loss Equation deserve attention.⁵⁴ Soil loss estimates obtained from the Equation do not have zero variance, although such an assumption was made in this study. Therefore, errors of estimate for soil loss values are larger than implied by the results reported here. A computed soil loss value is an average for the complete rotation. Higher observed losses would be expected in a particular year of row cropping than a year of a meadow crop; and the computed rotation average would lie somewhere between these extremes. Computed values also rest on long term average rainfall probabilities. Observed soil losses in a particular year might vary considerably from the computed average. The equation is also limited to sheet and rill erosion caused by rainfall and runoff. Wind or snowmelt erosion, or localized gullying are excluded from the soil loss estimates used here. Estimates are for gross erosion--the average annual quantity of soil removed from an acre of land. Soil lost from one acre may only move to another acre down the slope, or it may be deposited directly in a watercourse. Characteristics of each watershed area will determine eventual sediment delivery.

The preceding remarks should serve to temper confidence in specific erosion reduction values shown in Appendix Table 1. Nevertheless, these data are still of great merit. Explicitly stated assumptions and uniform application of the methodology make possible valid comparisons among land treatment practices and counties.

⁵⁴Wischmeier and Smith, op. cit., pp. 38-40.

Erosion Reduction Weighted by Treatment Needs

Erosion reduction values computed above were specified for each of fourteen land capability class and subclass (LCCc) groupings. By knowing the LCCc upon which a particular cropland treatment had been applied, one could consult the table for the county of interest and read the estimated erosion reduction. For example, stripcropping on a IIIe soil in Barry County would produce an average soil loss reduction of 6.33 tons per acre.

Unfortunately, the SCS reporting system does not provide this amount of detail. It only reveals the number of acres of stripcropping applied in a county. The distribution of treatment needs among LCCc's was assumed to provide an estimate of the distribution of erosion control measure application (Appendix Table 2). This is an admittedly nebulous assumption. Evidence was cited in Chapter IV that the SCS erosion control program is not necessarily oriented to published estimates of conservation treatment needs. It is unlikely that the acreage of a specific erosion control measure in one year would have been applied across LCCc's according to the identified needs for that practice. Yet over time, the distribution of treatments and needs should tend to coincide. So, although the erosion reduction procedure will be used with data for FY 1972 accomplishments, it should be emphasized that the weighted erosion reduction values may only be interpreted as long-term estimates. In spite of its limitations, this method is an improvement over the alternative of assuming uniform application of treatments across all LCCc groups. It also avoids the task of collecting field data on actual erosion control accomplishments by LCCc, which would refine the data for a particular year, but might not be valid over time.

A weighted reduction value (WERED) for each treatment category was computed by LCCc in each county (Appendix Table 3). When summed over the LCCc's, it provides an estimate of average annual erosion reduction per acre for the five land treatment practices (Table 11). These data show substantial differences among counties in the response to various erosion control measures. As noted earlier, the magnitude of the individual soil loss estimate is not necessarily precise, but valid comparisons may be made among counties. For example, erosion reduction produced by minimum tillage in Clinton County (1.53 tons per acre) is, on the average, nearly double that in Cass County (0.79 tons per acre). Since the crop rotations, and hence the original erosion reduction values, are identical in the two counties, weighting by treatment needs produced these results. They indicate that the CNI identified a need for minimum tillage on a higher proportion of more erosive soils in Clinton County than in Cass County. A zero value, as displayed for contouring in Gratiot and Hillsdale Counties indicates that the CNI acreage was zero for this cropland need category in both counties.

Composite Erosion Reduction Rate

The final step in the process is to combine erosion reduction rates of all five treatment types to obtain a composite value for each county. This requires information on the proportion of total cropland erosion control accomplishments (CECA) represented by each treatment category. Observed FY 1972 values for the component practices represented by CECA were used as the source (Table 12). These show that most cropland erosion control treatment in the twenty-four county study area consists of crop residue use and minimum tillage. Only thirteen counties reported

Table 11.--Total average annual erosion reduction per acre for five cropland treatment categories, by county, Land Resource Area 98.

County	Crop Residue Use	Minimum Tillage	Contouring	Strip- Cropping	Permanent Cover
Tons Per Acre					
Barry	1.14	2.46	2.14	4.41	11.01
Branch	0.34	0.72	1.88	2.41	0.0
Calhoun	0.58	1.24	0.0	3.84	9.92
Cass	0.37	0.79	2.50	2.01	13.25
Clinton	0.79	1.53	0.0	3.66	8.61
Eaton	0.72	1.39	0.0	6.40	8.04
Genesee	1.08	1.80	1.91	0.0	37.93
Gratiot	0.74	1.22	0.0	7.74	19.10
Hillsdale	1.15	2.39	0.0	4.29	8.65
Ingham	0.66	1.20	2.05	3.24	8.33
Ionia	1.38	2.34	7.63	3.33	16.93
Isabella	1.46	2.44	7.04	5.65	17.55
Jackson	0.66	1.24	2.73	4.15	7.87
Kalamazoo	0.28	0.60	0.0	1.40	7.47
Kent	0.72	1.53	2.60	3.35	6.46
Lapeer	1.07	1.81	9.94	7.35	12.60
Lenawee	1.34	2.26	9.49	6.23	30.56
Livingston	0.83	1.69	4.50	5.32	8.62
Montcalm	0.55	1.20	3.43	4.33	2.42
Muskegon	0.32	0.69	1.14	1.85	15.47
Oakland	0.77	1.56	1.88	4.39	8.73
Ottawa	0.43	0.97	1.31	4.14	2.42
St. Joseph	0.41	0.83	0.0	3.97	3.30
Washtenaw	0.91	1.81	3.31	4.04	7.32

Table 12.--Distribution of cropland erosion control accomplishments among component land treatment measures, by county, Land Resource Area 98.

County	Total Accomplish- ments Acres	Crop Residue Use	Minimum Tillage	Contour Farming	Strip- cropping	Permanent Cover
Barry	5948	49	50	0	0	1
Branch	1692	68	30	2	0	0
Calhoun	7478	45	53	1	0	1
Cass	7476	51	42	0	2	4
Clinton	5842	50	47	1	1	1
Eaton	8110	42	55	0	2	1
Genesee	3217	42	43	0	0	15
Gratiot	3837	42	55	0	0	3
Hillsdale	5926	53	41	0	4	2
Ingham	11934	50	49	0	0	1
Ionia	13714	43	54	0	0	3
Isabella	5398	39	51	0	1	9
Jackson	1601	56	37	0	0	7
Kalamazoo	11187	43	53	0	1	3
Kent	1771	60	36	0	2	2
Lapeer	6874	57	37	1	0	5
Lenawee	5186	34	57	0	0	7
Livingston	5931	42	50	0	0	8
Montcalm	7058	44	55	0	0	1
Muskegon	2888	46	50	2	0	1
Oakland	81	67	0	0	0	33
Ottawa	8004	47	47	1	0	5
St. Joseph	7389	51	48	0	0	1
Washtenaw	4364	54	33	0	1	12

contouring or stripcropping, and then in small acreages which amounted to no more than five percent of the total. Somewhat surprising was the fact that a land use change from cropland to permanent cover was reported in all twenty-four counties. In all but four counties, change to permanent cover was reported for a larger area than either contouring or stripcropping. That more erosion control accomplishments consist of the more easily applied practices is not at all surprising. Yet it would seemingly be very difficult to encourage a farmer to convert some land from crop production to permanent cover, for this would usually mean a loss of income. One suspects that the SCS technicians are merely reporting land use changes which result from landowner decisions independent of an erosion control objective. One reason for declining cropland acreage is urban expansion. It is noteworthy that the three counties with the highest proportion of reported change to permanent cover are Genesee (fifteen percent), Oakland (thirty-three percent), and Washtenaw (eleven percent), each of which have large urban growth centers. While the resulting erosion reduction on such areas is no less real than on an acre treated with contouring, their inclusion in the SCS reporting system tends to overstate true program accomplishments.

The synthesis of erosion reduction rates and distribution of cropland treatment by land treatment category yields a value for total erosion reduction per composite acre of cropland treatment (Table 13). Once again there is a wide range of values, from less than one-half ton per acre in Branch County to over seven tons per acre in Genesee. These values represent actual conditions in FY 1972. An estimate of total erosion reduction achieved through the SCS technical assistance program in each county is obtained when multiplied by the observed cropland erosion control

Table 13.--Estimated total erosion reduction per composite acre of cropland treatment, by county, Land Resource Area 98.

County	Tons Per Acre
Barry	1.91
Branch	0.48
Calhoun	1.01
Cass	1.15
Clinton	1.19
Eaton	1.22
Genesee	7.11
Gratiot	1.54
Hillsdale	1.89
Ingham	1.04
Ionia	2.35
Isabella	3.46
Jackson	1.41
Kalamazoo	0.69
Kent	1.16
Lapeer	1.97
Lenawee	3.97
Livingston	1.90
Montcalm	0.95
Muskegon	0.69
Oakland	3.42
Ottawa	0.80
St. Joseph	0.63
Washtenaw	1.98

acreage (Table 14). These data point out a divergence between cropland acreage treatments and gross erosion reduction. While Calhoun and Cass Counties had essentially an equal acreage of cropland treatment, that treatment resulted in over 1,000 tons of additional soil saved in Cass County. The contrast is even more striking between Lenawee and Livingston Counties.

This important issue is examined in some detail in the following chapter. The procedure for estimating gross erosion may be extended from a FY 1972 base to the general case with one additional qualifying assumption:

Table 14.—Observed cropland erosion control accomplishments, computed total erosion reduction, by county, Land Resource Area 98, fiscal year 1972.

County	Cropland Treated ^a (acres)	Erosion Reduction (tons)
Barry	5948	11361
Branch	1692	812
Calhoun	7478	7553
Cass	7476	8597
Clinton	5842	6952
Eaton	8110	9894
Genesee	3216	22866
Gratiot	3837	5909
Hillsdale	5926	11200
Ingham	11934	12411
Ionia	13714	32228
Isabella	5397	18674
Jackson	1601	2257
Kalamazoo	11187	7719
Kent	1771	2054
Lapeer	6874	13542
Lenawee	5186	20588
Livingston	5931	11269
Montcalm	7057	6704
Muskegon	2888	1993
Oakland	81	277
Ottawa	8003	6402
St. Joseph	7389	4655
Washtenaw	4364	8641

^aSource: Computed from Soil Conservation Service Progress Reporting System data.

that the proportions of individual land treatment practices in a county remain as observed in FY 1972. This is necessitated by the predictive equation described in Chapter IV, which relates to total CECA rather than its component practices. Like previous assumptions in the erosion reduction model, this step introduces one more limiting factor which needs attention when interpreting the results. It does, however, enhance the model as a more general analytical tool.

CHAPTER VI

INVESTIGATION OF ALTERNATIVE STAFFING ARRANGEMENTS

One objective of this research was to test the erosion control impacts of adjusting SCS county staffing patterns. Predictive equations developed earlier in the study were to have been utilized in this phase. Lack of success in obtaining workable equations for estimating pastureland and other land erosion control accomplishments was reported in Chapter IV. The analysis in this section was therefore confined to a consideration of cropland alone.

Two aspects of alternative SCS county staffing levels were investigated. The first considered altering observed staff levels in the direction of a higher acreage of cropland erosion treatment. This question was approached for each of the two study regions in Michigan. A second trial dealt with the objective of increasing gross erosion reduction as opposed to treated acreage. This question was explored only in the twenty-four county area for which the erosion control model had been developed.

Increasing Treated Acreage

Region One

Estimates of cropland erosion control acreage were to be computed for various levels of technical assistance (TIME). It was first necessary

to specify minimum and maximum levels which TIME could assume, and required that these levels be within the range of observed values used in building the regression equation.

In Region One, total manpower allocated to the forty-four counties was 123,211 man-hours in FY 1972. County staff levels averaged 2,800 man-hours.

The lowest observation for TIME was ninety-eight man-hours in Keweenaw County, which is located in the northwestern portion of the Upper Peninsula. It has a total land area of 348,160 acres, but only 1,150 acres of cropland, 1,350 acres of other land, and no pastureland. Just over 800 acres of this non-forested area was identified as needing treatment. The county is principally an area of forests and abandoned copper mines which has required and received little SCS technical assistance. Because of these unique circumstances, it was felt that ninety-eight man-hours would not be a reasonable base level for most other counties in Region One.

The next higher TIME observation was 734 man-hours. A base value of 700 man-hours (approximately one-third man-year) was therefore selected. The maximum observed TIME was 6,145 man-hours, and a value of 5,900 man-hours (2.8 man-years) was specified as the upper limit.

A value for CECA was computed for each county while parametrically varying TIME from the minimum to maximum values in increments of 520 man-hours (0.25 man-year). It was assumed that the observed staffing level of ninety-eight man-hours for Keweenaw County was adequate for the scope of identified land treatment needs, and this value was held constant. The estimating equation derived previously was:

$$\begin{aligned} \text{LGCECA} = & -3.2666 + (2.1819) \times \text{LGTIME} \\ & -(0.2410 \times \text{LGVAPS}) + (0.4495 \times \text{LGRNFN}) \end{aligned}$$

with CECA being the antilog of LGCECA.

Four counties had observed FY 1972 zero values for CECA, and had been excluded from the regression analysis.⁵⁵ It was assumed that projected CECA in these counties would remain zero for all staffing levels.⁵⁶

These computations projected a maximum of 5,685 acres of annual cropland erosion control application could be achieved with 6,100 man-hours of technical assistance time in Mecosta County (Table 15). The additional acreage of CECA generated by 520 man-hour increments of TIME was also computed (Table 16). Counties were then ranked from high to low according to the incremental output of CECA (Table 17). Rankings identified those counties with the highest marginal productivity of CECA relative to TIME which would be candidates for additional manpower allocation.

Specification of ninety-eight man-hours to Keweenaw County, and a minimum of 700 to the remaining counties produced a total initial commitment of 30,198 man-hours. A balance of 93,013 man-hours was available for re-allocation. Cropland treatment would be maximized by providing 5,900 man-hours of technical assistance to the seventeen highest ranking counties. The eighteenth ranking county received a total of 5,313 man-hours to exhaust the available supply, while the remaining twenty-six counties had only the specified minimum.

⁵⁵ These counties still received the minimum manpower allocation (700 man-hours) in recognition that technical assistance is provided for purposes other than cropland erosion control.

⁵⁶ An alternate set of computations was made without this assumption. One of these four counties rank first in Region One in terms of total CECA, even at the minimum staffing level. The remaining three were also ranked in the upper one-half.

Table 15.--Total cropland erosion control accomplishments for alternate levels of SCS technical assistance time, by county, Region One.

County	Annual Man-hours Technical Assistance Time										
	700	1220	1740	2260	2780	3300	3820	4340	4860	5380	5900
						Acres					
Alcona	0	0	0	0	0	0	0	0	0	0	0
Alger	12	41	90	159	249	363	499	659	844	1053	1288
Alpena	39	136	285	504	792	1151	1584	2092	2678	3343	4089
Antrim	40	133	289	511	803	1167	1606	2122	2716	3391	4147
Baraga	24	81	175	310	487	708	974	1287	1647	2056	2515
Benzie	22	75	162	287	450	655	901	1190	1523	1902	2326
Charlevoix	44	148	322	569	894	1300	1789	2364	3026	3777	4619
Cheboygan	36	122	264	467	734	1067	1469	1941	2484	3101	3793
Chippewa	24	80	173	307	482	700	964	1273	1630	2035	2488
Clare	38	128	277	490	770	1120	1541	2036	2606	3254	3979
Crawford	0	0	0	0	0	0	0	0	0	0	0
Delta	28	94	204	362	568	826	1136	1501	1922	2399	2934
Dickinson	8	27	59	105	164	239	329	435	556	694	849
Emmet	35	117	254	450	707	1028	1414	1868	2391	2985	3651
Gladwin	36	122	264	467	733	1066	1467	1938	2480	3096	3787
Gogebic	17	58	126	223	350	509	700	925	1184	1478	1808
Gr. Traverse	28	95	206	364	572	831	1144	1511	1934	2414	2953
Houghton	33	111	241	426	669	972	1338	1768	2263	2825	3455
Iosco	36	120	260	461	724	1052	1448	1913	2448	3056	3738
Iron	17	58	126	223	351	510	702	928	1188	1483	1813
Kalkaska	29	99	214	379	595	865	1190	1572	2012	2512	3072
Keweenaw	1	1	1	1	1	1	1	1	1	1	1

Table 15 (cont'd.)

Lake	34	113	245	433	681	990	1363	1800	2304	2876	3518
Leelanau	43	145	315	557	875	1272	1750	2312	2960	3695	4519
Luce	0	0	0	0	0	0	0	0	0	0	0
Mackinac	17	59	128	226	354	515	709	937	1199	1497	1831
Manistee	40	134	290	514	807	1173	1615	2133	2731	3409	4169
Marquette	16	55	120	212	333	484	666	880	1127	1407	1720
Mason	41	139	303	535	841	1223	1683	2223	2845	3552	4344
Mecosta	54	182	396	700	1101	1600	2202	2909	3724	4648	5685
Menominee	29	97	211	374	587	854	1175	1553	1988	2481	3034
Missaukee	31	104	225	397	624	908	1249	1650	2113	2637	3225
Montmorency	30	102	222	392	617	896	1233	1629	2086	2604	3184
Newaygo	41	137	297	526	827	1202	1654	2185	2797	3491	4270
Oceana	42	143	309	547	860	1250	1720	2273	2909	3631	4441
Ogemaw	43	144	311	551	866	1259	1732	2288	2929	3657	4472
Ontonagon	19	64	138	245	384	559	769	1015	1300	1623	1985
Osceola	48	161	348	616	969	1408	1938	2560	3277	4090	5003
Oscoda	27	91	198	351	552	802	1104	1458	1866	2330	2850
Otsego	39	133	288	509	800	1164	1601	2115	2708	3380	4134
Presque Isle	38	128	278	491	772	1122	1544	2040	2611	3259	3986
Roscommon	0	0	0	0	0	0	0	0	0	0	0
Schoolcraft	16	54	116	206	324	471	648	855	1095	1367	1672
Wexford	34	114	248	439	690	1003	1381	1824	2335	2915	3565

Table 16.--Additional cropland erosion control accomplishments generated by 520 man-hour increments of SCS technical assistance time, by county, Region One.

County	Annual Man-hours Technical Assistance Time									
	1220	1740	2260	2780	3300	3820	4340	4860	5380	5900
	Acres									
Alcona	0	0	0	0	0	0	0	0	0	0
Alger	29	48	69	91	113	136	160	185	209	235
Alpena	92	154	219	288	359	433	509	586	665	746
Antrim	94	156	222	292	364	439	516	594	675	756
Baraga	57	94	135	177	221	266	313	360	409	459
Benzie	52	87	125	164	204	246	289	333	378	424
Charlevoix	104	173	247	325	406	489	574	662	751	842
Cheboygan	86	142	203	267	333	402	472	544	617	692
Chippewa	56	93	133	175	219	263	309	357	405	454
Clare	90	149	213	280	350	421	495	570	647	726
Crawford	0	0	0	0	0	0	0	0	0	0
Delta	66	110	157	207	258	311	365	421	477	535
Dickinson	19	32	45	60	75	90	106	122	138	155
Emmet	82	137	196	257	321	387	454	523	594	666
Gladwin	85	142	203	267	333	401	471	543	616	691
Gogebic	41	68	97	127	159	191	225	259	294	330
Gr. Traverse	67	111	158	208	259	313	367	423	480	538
Houghton	78	130	185	243	304	366	430	495	562	630
Iosco	84	140	200	263	328	396	465	536	608	682
Iron	41	68	97	128	159	192	226	260	295	331
Kalkaska	69	115	165	216	270	325	382	440	500	560
Keveensaw	0	0	0	0	0	0	0	0	0	0

Table 16 (cont'd.)

Lake	79	132	188	248	309	372	438	504	572	641
Leelanau	102	170	242	318	397	478	562	648	735	824
Luce	0	0	0	0	0	0	0	0	0	0
Mackinac	41	69	98	129	161	194	228	262	298	334
Manistee	94	157	223	293	366	441	518	597	678	760
Marquette	39	65	92	121	151	182	214	247	280	314
Mason	98	163	233	306	382	460	540	623	707	792
Mecosta	128	213	305	400	499	602	707	815	925	1037
Menominee	68	114	163	214	267	321	377	435	494	553
Missaukee	73	121	173	227	283	341	401	462	525	588
Montmorency	72	120	171	224	280	337	396	456	518	581
Newaygo	96	160	229	301	375	452	531	612	695	779
Oceana	100	167	238	313	390	470	552	636	722	810
Ogemaw	101	168	240	315	393	473	556	641	727	815
Ontonagon	45	75	106	140	174	210	247	284	323	362
Osceola	113	188	268	352	439	530	622	717	814	912
Oscoda	64	107	153	201	250	302	354	408	463	520
Otsego	93	155	221	291	363	438	514	592	672	754
Presque Isle	90	150	214	281	350	422	496	571	648	727
Roscommon	0	0	0	0	0	0	0	0	0	0
Schoolcraft	38	63	90	118	147	177	208	240	272	305
Wexford	80	134	191	251	313	377	443	511	580	650

Table 17.—Ranking of counties by additional acreage of cropland erosion control achieved with 520 man-hour increments of technical assistance time, Region One.

County	Rank ^a	County	Rank
Alcona	b	Lake	20
Alger	38	Leelanau	4
Alpena	12	Luce	b
Antrim	10	Mackinac	33
Baraga	29	Manistee	9
Benzie	31	Marquette	36
Charlevoix	3	Mason	7
Cheboygan	15	Mecosta	1
Chippewa	30	Menominee	25
Clare	14	Missaukee	22
Crawford	b	Montmorency	23
Delta	27	Newaygo	8
Dickinson	39	Oceana	6
Emmet	18	Ogemaw	5
Gladwin	16	Ontonagon	32
Gogebic	35	Osceola	2
Gr. Traverse	26	Oscoda	28
Houghton	21	Otsego	11
Iosco	17	Presque Isle	13
Iron	34	Roscommon	b
Kalkaska	24	Schoolcraft	37
Keweenaw	b	Wexford	19

^aRanking from high to low.

^bExcluded from projections and not ranked.

County estimates of CECA for corresponding levels of TIME were summarized from the preceding array, and one additional value of CECA computed for 5,313 man-hours in Emmet County. Total cropland area treated with erosion control measures was projected to increase from 55,804 acres to 76,576 acres as a result of adjusting county staff levels (Table 18). Although an absolute increase of 20,772 acres was estimated this result was not verified statistically. A t-test of the null hypothesis of no difference between the means of the two values was not significant at the ten percent level (computed t-value equaled 1.668 with 43 d.f.).

Region Two

In Region Two, total manpower allocated to the thirty-nine counties in FY 1972 amounted to 210,367 man-hours, for an average of 5,394 man-hours per county. Values for individual counties ranged from 2,251 to 8,699 man-hours, or 1.08 to 4.18 man-years, respectively.⁵⁷

A value of 2,300 man-hours (1.1 man-years) per county was chosen as the minimum base level from which to begin estimating CECA. The maximum allowable value was set at 8,540 man-hours (4.1 man-years). Both the minimum and maximum were within the range of observed values for TIME used in developing the regression equation.

A value for CECA was computed for each county while parametrically varying TIME from the minimum to maximum values in increments of 520 man-hours (0.25 man-year). The estimating equation, derived as discussed earlier, was:

⁵⁷One man-year is equal to 2,080 man-hours.

Table 18.--Observed and estimated acreage of cropland erosion control for alternative levels of SCS technical assistance time, by county, Region One.

County	Cropland Erosion Control		Technical Assistance	
	Observed	Estimated	Observed	Estimated
Alcona	0	0	2178	700
Alger	562	12	1992	700
Alpena	2720	4089	2729	5900
Antrim	2005	4147	6145	5900
Baraga	37	24	2259	700
Benzie	131	22	1817	700
Charlevoix	581	4619	2438	5900
Cheboygan	1785	3793	3456	5900
Chippewa	5330	24	5966	700
Clare	221	3979	2404	5900
Crawford	0	0	1020	700
Delta	2471	28	4254	700
Dickinson	879	8	3120	700
Emmet	548	2905	1910	5313
Gladwin	4857	3787	3496	5900
Gogebic	71	17	1621	700
Gr. Traverse	412	28	5240	700
Houghton	233	33	4405	700
Iosco	1158	3738	2712	5900
Iron	417	17	2273	700
Kalkaska	114	29	2235	700
Keweenaw	3	1	98	98
Lake	203	34	1138	700
Leelanau	6068	4519	3983	5900
Luce	0	0	293	700
Mackinac	244	17	1615	700
Manistee	1653	4169	3983	5900
Marquette	170	16	2386	700
Mason	2821	4344	4795	5900
Mecosta	5151	5685	5259	5900
Menominee	857	29	5419	700
Missaukee	1232	31	2692	700
Montmorency	1615	30	1670	700
Newaygo	1440	4270	3947	5900
Oceana	20	4441	734	5900
Ogemaw	4629	4472	3538	5900
Ontonagon	74	19	1620	700
Osceola	580	5003	3416	5900
Oscoda	49	27	834	700
Otsego	2161	4134	3342	5900
Presque Isle	1920	3986	3185	5900
Roscommon	0	0	1343	700
Schoolcraft	2	16	1070	700
Wexford	380	34	3181	700
Total	55804	76576	123211	123211
Mean	1268.3	1740.4	2800.2	2800.2

$LGCECA = -1.3076 + (1.3884 \times LGTIME) - (0.000001 \times P70)$
 with CECA equal to the antilog of LGCECA.

This procedure showed that an estimated maximum of 13,799 annual acres of cropland erosion control treatment could be achieved with 8,540 man-hours of technical assistance time in Arenac County (Table 19). The additional acreage of CECA generated by 520 man-hour increments of TIME was also computed (Table 20), and the counties were ranked from high to low according to the incremental output of CECA (Table 21). The rankings were used to identify counties with the highest marginal productivity of CECA relative to TIME which would be candidates for additional manpower allocations.

A minimum specified staffing level of 2,300 man-hours in all counties accounted for 89,700 man-hours out of the total 210,367 available in Region Two. The remaining 120,667 man-hours were thus available for redistribution.

The allocation procedure put a total of 8,540 man-hours in the nineteen counties ranked highest according to marginal productivity of CECA. The twentieth ranking county (Allegan) received 4,407 total man-hours in order to utilize all of the available manpower pool. All other counties received only the minimum level of 2,300 man-hours.

Values of CECA for the appropriate TIME level were extracted from the previous computations, and a new estimate of CECA in Allegan County calculated for 4,407 man-hours. It was found that total estimated cropland erosion control acreage declined slightly with manpower reallocation, from 286,580 acres to 273,040 acres (Table 22).

Table 19.—Total cropland erosion control accomplishments generated by 520 man-hour increments of SCS technical assistance time, by county, Region Two.

County	Annual Man-hours Technical Assistance Time												
	2300	2820	3340	3860	4380	4900	5420	5940	6460	6980	7500	8020	8540
	Acres												
Allegan	1965	2608	3299	4033	4806	5616	6461	7337	8243	9179	10142	11131	12146
Arenac	2233	2963	3748	4582	5460	6381	7340	8336	9366	10428	11523	12646	13799
Barry	2098	2784	3522	4305	5131	5996	6897	7833	8801	9799	10828	11884	12967
Bay	1748	2320	2935	3588	4276	4997	5748	6527	7334	8166	9023	9903	10806
Berrien	1571	2084	2637	3223	3842	4489	5164	5864	6589	7337	8106	8897	9708
Branch	2099	2786	3524	4308	5134	6000	6901	7837	8806	9805	10834	11891	12975
Calhoun	1652	2192	2773	3390	4040	4721	5431	6168	6930	7716	8526	9357	10210
Cass	2073	2751	3480	4255	5071	5925	6816	7741	8697	9684	10700	11744	12814
Clinton	2049	2719	3439	4204	5011	5855	6735	7649	8594	9569	10573	11604	12662
Eaton	1955	2594	3281	4011	4781	5586	6426	7298	8200	9130	10088	11072	12081
Genesee	823	1093	1382	1690	2014	2353	2707	3074	3454	3846	4250	4664	5089
Gratiot	2093	2777	3513	4295	5118	5981	6880	7813	8779	9775	10801	11854	12935
Hillsdale	2103	2791	3530	4315	5143	6010	6913	7851	8821	9822	10852	11911	12997
Huron	2118	2811	3555	4346	5180	6053	6962	7907	8884	9892	10930	11996	13089
Ingham	1256	1667	2108	2577	3071	3589	4129	4689	5268	5866	6481	7113	7762
Ionía	2061	2735	3460	4230	5041	5891	6776	7695	8646	9628	10638	11675	12739
Isabella	2067	2743	3470	4242	5056	5908	6796	7718	8671	9655	10668	11709	12776
Jackson	1647	2186	2765	3380	4028	4707	5415	6149	6909	7693	8500	9328	10180
Kalamazoo	1440	1911	2418	2955	3522	4116	4735	5377	6041	6727	7433	8158	8901
Kent	889	1180	1492	1824	2174	2541	2923	3319	3729	4153	4588	5036	5495

Table 19 (cont'd.)

Lapeer	2031	2695	3409	4167	4967	5804	6676	7582	8519	9485	10480	11503	12551
Lenawee	1898	2519	3186	3895	4643	5425	6241	7087	7963	8867	9797	10752	11733
Livingston	2000	2654	3357	4104	4891	5716	6575	7466	8389	9341	10321	11328	12360
Macomb	543	720	911	1114	1328	1551	1785	2027	2277	2535	2801	3075	3355
Midland	1978	2625	3320	4059	4837	5653	6502	7384	8297	9238	10208	11203	12225
Monroe	1744	2314	2927	3578	4265	4984	5733	6510	7315	8145	8999	9877	10778
Montcalm	2091	2775	3510	4291	5113	5975	6874	7806	8771	9766	10790	11843	12922
Muskegon	1594	2116	2676	3271	3899	4556	5241	5952	6687	7446	8228	9030	9853
Oakland	283	376	475	581	693	809	931	1057	1188	1323	1462	1604	1750
Ottawa	1705	2263	2862	3499	4171	4874	5606	6367	7153	7965	8801	9659	10539
Saginaw	1381	1833	2318	2834	3378	3947	4540	5156	5794	6451	7128	7823	8536
St. Clair	1737	2305	2916	3564	4248	4964	5710	6485	7286	8113	8964	9839	10736
St. Joseph	2054	2726	3448	4215	5023	5870	6752	7668	8616	9593	10600	11634	12694
Sanilac	2114	2805	3548	4338	5170	6041	6949	7892	8867	9874	10910	11974	13065
Shiawassee	1981	2629	3325	4065	4845	5662	6513	7396	8310	9253	10224	11221	12244
Tuscola	2048	2718	3438	4203	5009	5854	6733	7647	8592	9567	10570	11602	12659
VanBuren	2013	2671	3379	4130	4923	5752	6617	7515	8443	9401	10388	11401	12440
Washtenaw	1336	1773	2243	2742	3268	3819	4393	4989	5605	6241	6896	7569	8258
Wayne	5	7	8	10	12	14	16	18	21	23	25	28	30

Table 20.—Additional cropland erosion control accomplishments generated by 520 man-hour increments of SCS technical assistance time, by county, Region Two.

County	Annual Man-hours Technical Assistance Time											
	2820	3340	3860	4380	4900	5420	5940	6460	6980	7500	8020	8540
	Acres											
Allegan	643	691	734	774	810	844	876	907	935	963	989	1015
Arenac	730	785	834	879	920	959	996	1030	1063	1094	1124	1153
Barry	686	737	784	826	865	901	936	968	999	1028	1056	1083
Bay	572	615	653	688	721	751	780	807	832	857	880	903
Berrien	514	552	587	618	647	675	700	725	748	770	791	811
Branch	687	738	784	826	865	902	936	969	999	1029	1057	1084
Calhoun	540	581	617	650	681	710	737	762	786	810	832	853
Cass	678	729	774	816	855	891	925	957	987	1016	1044	1070
Clinton	670	720	765	806	845	880	914	945	975	1004	1031	1058
Eaton	639	687	730	769	806	840	872	902	931	958	984	1009
Genesee	269	289	308	324	339	354	367	380	392	404	415	425
Gratiot	685	736	782	824	863	899	933	966	996	1026	1054	1080
Hillsdale	688	739	785	828	867	903	938	970	1001	1030	1059	1086
Huron	693	744	791	834	873	910	944	977	1008	1038	1066	1093
Ingham	411	441	469	494	518	540	560	579	598	615	632	648
Ionia	674	725	770	811	850	885	919	951	981	1010	1038	1064
Isabella	676	727	772	814	852	888	922	954	984	1013	1041	1067
Jackson	539	579	615	648	679	708	734	760	784	807	829	850
Kalamazoo	471	506	538	567	594	619	642	664	686	706	725	744
Kent	291	313	332	350	366	382	396	410	423	436	448	459

Table 20 (cont'd)

Lapeer	664	714	758	799	837	872	906	937	967	995	1022	1048
Lenawee	621	667	709	747	783	815	847	876	904	930	956	980
Livingston	654	703	747	787	824	859	892	923	952	980	1007	1032
Macomb	178	191	203	214	224	233	242	250	258	266	273	280
Midland	647	695	739	779	815	850	882	913	942	969	996	1021
Monroe	570	613	651	686	719	749	778	805	830	854	878	900
Montcalm	684	735	781	823	862	898	932	965	995	1025	1053	1079
Muskegon	521	560	595	628	657	685	711	736	759	781	803	823
Oakland	93	100	106	111	117	122	126	131	135	139	143	146
Ottawa	558	599	637	671	703	733	760	787	812	836	858	880
Saginaw	452	485	516	544	569	593	616	637	657	677	695	713
St. Clair	568	611	649	684	716	746	775	801	827	851	874	897
St. Joseph	672	722	767	808	847	882	916	948	978	1006	1034	1060
Sanilac	691	743	790	832	871	908	943	975	1006	1036	1064	1091
Shiawassee	648	696	740	780	817	851	883	914	943	971	997	1023
Tuscola	670	720	765	806	844	880	913	945	975	1004	1031	1057
VanBuren	658	708	752	792	830	865	898	929	958	986	1013	1039
Washtenaw	437	470	499	526	551	574	596	616	636	655	673	690
Wayne	2	2	2	2	2	2	2	2	2	2	2	3

Table 21.--Ranking of counties by additional acreage of cropland erosion control achieved with 520 man-hour increments of technical assistance time, Region Two.

County	Rank ^a	County	Rank
Allegan	20	Lapeer	15
Arenac	1	Lenawee	22
Barry	6	Livingston	17
Bay	23	Macomb	37
Berrien	30	Midland	19
Branch	5	Monroe	24
Calhoun	27	Montcalm	8
Cass	9	Muskegon	29
Clinton	13	Oakland	38
Eaton	21	Ottawa	26
Genesee	36	Saginaw	32
Gratiot	7	St. Clair	25
Hillsdale	4	St. Joseph	12
Huron	2	Sanilac	3
Ingham	34	Shiawassee	18
Ionia	11	Tuscola	14
Isabella	10	VanBuren	16
Jackson	28	Washtenaw	33
Kalamazoo	31	Wayne	39
Kent	35		

^aRanking from high to low.

Table 22.--Observed and estimated acreage of cropland erosion control for alternate levels of technical assistance time, by county, Region Two.

County	Cropland Erosion Control		Technical Assistance	
	Observed	Estimated	Observed	Estimated
Allegan	4005	4847	8471	4407
Arenac	7529	13799	3647	8540
Barry	5948	12967	4515	8540
Bay	11285	1748	6753	2300
Berrien	1807	1571	6429	2300
Branch	1692	12975	3309	8540
Calhoun	7478	1652	5782	2300
Cass	7476	12814	4681	8540
Clinton	5842	12662	3838	8540
Eaton	8110	1995	7059	2300
Genesee	3217	823	5914	2300
Gratiot	3837	12935	3968	8540
Hillsdale	5926	12997	5116	8540
Huron	65910	13089	8086	8540
Ingham	11934	1256	5565	2300
Ionia	13714	12739	5090	8540
Isabella	5398	12776	6858	8540
Jackson	1601	1647	4559	2300
Kalamazoo	11187	1440	6706	2300
Kent	1771	889	7149	2300
Lapeer	6874	12551	7161	8540
Lenawee	5186	1898	6247	2300
Livingston	5931	12360	4441	8540
Macomb	4693	543	4394	2300
Midland	2538	12225	3199	8540
Monroe	3711	1774	4450	2300
Montcalm	7058	12922	4486	8540
Muskegon	2888	1594	4149	2300
Oakland	81	283	2278	2300
Ottawa	8004	1705	6330	2300
Saginaw	8774	1381	5878	2300
St. Clair	5691	1737	6860	2300
St. Joseph	7389	12694	4367	8540
Sanilac	8273	13065	6548	8540
Shiawassee	2817	12244	3818	8540
Tuscola	11065	12659	4959	8540
VanBuren	5571	12440	8699	8540
Washtenaw	4365	1336	6357	2300
Wayne	4	5	2251	2300
Total	286580	273040	210367	210367
Mean	7348.2	7000.9	5394.0	5394.0

Examination of individual estimates revealed that the results in one county alone were principally responsible for this unexpected result. In Huron County, observed TIME was 8,086 man-hours. Huron was also one of the counties receiving the maximum manpower allocation of 8,540; but computed CECA was 13,089 acres, compared to an observed value of 65,810 acres.

This outcome is, of course, not inconsistent with multiple regression techniques which use the method of least squares to minimize squared deviations from the mean rather than individual values of the dependent variable.

A t-test was performed to test the null hypothesis of no difference between mean values of CECA for observed and reallocated TIME. The computed t-value of 0.207 (for 38 d.f.) was not significant at the ten percent level. Reallocation of manpower by the procedures used here does not significantly affect application of cropland erosion control measures in Region Two.

Limitations

All evaluation models are abstractions of real events. Compromises necessary to make a problem amenable to quantitative inquiry also limit or at least complicate interpretation of results. The manpower allocation process described above is no exception.

One major shortcoming was the form of the estimating equation. The multiple regression analysis assured that the estimated response in CECA to changes in TIME would at least be linear; in fact, the response was exponential due to log transformation of both dependent and independent variables. A conventional production function, which exhibits declining marginal output over some portion of its range, was forestalled by the choice of a regression estimator.

This situation had its impact on county rankings according to additional CECA for increments of TIME. The values in the array (Tables 16, 20) led to allocation of TIME up to the maximum level in the highest ranking county before additional manpower was distributed to any other county; the second highest ranking county then received a maximum allocation; and so on until available manpower was exhausted. The resulting staffing pattern was not only very skewed, but also failed to satisfy the objective of significantly increasing erosion control accomplishments.

Economies of scale associated with SCS manpower levels were not examined specifically. It is probable that they do occur with respect to certain administrative aspects of staffing and operating a field office. They are considered here only indirectly by using observed minimum county staff levels as a base for revised allocations.

Final regression equations for CECA did not include an independent variable representing cropland treatment needs in either region. One has no assurance, therefore, that the staffing pattern based on these equations is more or less aligned to erosion control needs than was that observed in FY 1972. This is another shortcoming of the multiple regression, for it cannot predict relationships which were not perceived in observed data.

Increasing Gross Erosion Reduction

Data were presented in Chapter V (Table 14) to illustrate that a large acreage of erosion control measures is not always synonymous with a large volume of soil saved. Differences among counties in crop rotations, land treatment needs, and component practices of the cropland erosion control effort can produce wide variations in average soil loss

reduction rates. It is apparent from these data that a higher average payoff in terms of tons of soil saved may be achieved from an acre of cropland treatment in some counties compared to others. Under such conditions, the terms in which an erosion control objective is defined will influence program planning and operation.

The basic objective may be defined as cropland erosion control directed toward maintenance of soil fertility and structure for sustained crop production. Efforts to achieve this goal would presumably emphasize the acreage of cropland treated as the principal measure of accomplishment. An alternative objective would be sediment control with quantity of soil loss as the parameter of prime interest. Not only acres treated, but also the relative erosion hazard and gross erosion reduction potential of various lands would be important factors in program management.

The first approach stems from the fundamental motivations for the soil conservation movement which have long guided SCS efforts. The loss of agricultural land productivity through erosion was the primary problem which stimulated public attention toward soil conservation in the 1930's.⁵⁸ There has even been some shift in emphasis over the years from the soil loss problem alone to total soil management for higher production.⁵⁹

⁵⁸ Morgan, op. cit., pp. 1-13. The author cites evidence that while the Federal erosion control effort was initiated in 1933 fundamentally as an unemployment program, the motivation for individual technicians and farmers was protection of crop production capacity.

⁵⁹ Held and Clawson, op. cit., pp. 69-75.

Most research on the economics of soil erosion control has focused on farm income impacts, as did some examples cited in Chapter II. Only in recent works such as that by Nicol and others at Iowa State University has soil erosion control been approached as a broad environmental policy issue.⁶⁰

It is clear that the U.S. Department of Agriculture and the Soil Conservation Service do recognize sedimentation and other off-site damages created by soil erosion.⁶¹ In its recently prepared Framework Plan, SCS identified a need for a "...massive, countrywide, sediment-control effort, taking into consideration onsite and offsite effects."⁶² To date, however, problem recognition has not led to a reorientation of ongoing erosion control work. This is best illustrated by the SCS Progress Reporting System. As noted earlier, these records refer to acres or other units of various applied treatments with no information as to resulting soil loss reductions. Supplementary information such as initial land management conditions or land capability class for treated areas is not available in the records system. Quantifying erosion reduction rates may only be approached through indirect methods such as described in the preceding chapter. Since the record system is used by SCS as a basis for staffing, personnel promotions, and program planning, emphasis on maximizing acres treated is inherent.

⁶⁰Nicol, Heady, and Madsen, op. cit.

⁶¹See Cecil H. Wadleigh, Wastes in Relation to Agriculture and Forestry, U.S. Department of Agriculture, Miscellaneous Publications No. 1065 (Washington: U.S. Government Printing Office, 1968), pp. 35-57.

⁶²Soil Conservation Service, op. cit., p. 19.

This issue cannot be resolved here, but it is important to recognize the distinction between the two objectives. The soil loss model developed earlier allows some elucidation of alternative program directions when merged with the procedure for reallocating SCS manpower levels.

Estimates of total soil loss reductions were computed for each county in Land Resource Area 98 with alternate staff levels from 2,300 to 8,540 man-hours (Table 23). Total CECA was computed with the regression estimator for Region Two. Soil loss reduction was derived by multiplying each value of CECA by the corresponding erosion reduction rate (Table 13). The additional erosion reduction generated by 520 man-hour increments of technical assistance time was also calculated (Table 24).

Counties were then ranked from high to low according to the additional tons of erosion reduction for incremental TIME inputs. These same twenty-four counties were also ranked according to additional acres of erosion control. Comparison of rankings for these two objectives revealed some major contrasts (Table 25). Branch County, second ranking in terms of erosion control acreage fell to twenty-second position when evaluated on tons of soil saved. Lenawee County shifted in the opposite direction, rising from fourteenth to first position. Genesee also changed dramatically, from number twenty-three based on erosion control acreage to number three based on tons of soil loss reduction. In total, nine counties switched position between the top ten group and the second ten.

Reallocation of SCS manpower to these counties actually involved suboptimization, because only a portion of the total 210,367 man-hours in Region Two could be considered. The twenty-four counties in Land Resource Area 98 had a total observed TIME allocation of 125,925

Table 23.—Total erosion reduction from cropland treatments for alternate levels of SCS manpower inputs, by county,
Land Resource Area 98.

County	Annual Man-Hours Technical Assistance Time												
	2300	2820	3340	3860	4380	4900	5420	5940	6460	6980	7500	8020	8540
	Tons Erosion Reduction												
Barry	4007	5318	6726	8223	9800	11452	13174	14961	16809	18717	20681	22698	24767
Branch	1008	1337	1691	2068	2464	2880	3313	3762	4227	4707	5200	5708	6228
Calhoun	1668	2214	2801	3424	4081	4769	5485	6229	6999	7793	8611	9451	10312
Cass	2384	3164	4002	4893	5831	6814	7838	8902	10002	11137	12305	13505	14736
Clinton	2438	3235	4092	5003	5963	6968	8015	9102	10227	11387	12582	13809	15068
Eaton	2385	3165	4003	4894	5832	6815	7840	8903	10004	11139	12307	13508	14739
Genesee	5855	7770	9828	12014	14319	16732	19247	21858	24559	27346	30215	33162	36185
Gratiot	3223	4277	5410	6614	7882	9211	10595	12033	13519	15054	16633	18255	19919
Hillsdale	3974	5274	6671	8156	9720	11358	13066	14838	16672	18563	20511	22512	24564
Ingham	1306	1733	2192	2680	3194	3733	4294	4876	5479	6100	6740	7398	8072
Ionia	4844	6428	8131	9940	11847	13843	15924	18084	20319	22625	24999	27437	29938
Isabella	7152	9492	12006	14677	17493	20441	23514	26703	30003	33408	36913	40513	44206
Jackson	2322	3082	3898	4766	5680	6637	7635	8670	9742	10847	11985	13154	14353
Kalamazoo	994	1319	1668	2039	2430	2840	3267	3710	4169	4642	5129	5629	6142
Kent	1031	1369	1731	2116	2522	2947	3390	3850	4326	4817	5322	5842	6374
Lapeer	4001	5309	6715	8210	9784	11433	13152	14936	16782	18686	20646	22660	24726
Lenawee	7536	10001	12650	15465	18431	21538	24775	28136	31613	35201	38894	42687	46578
Livingston	3800	5043	6378	7797	9293	10859	12492	14186	15939	17748	19610	21523	23485
Montcalm	1986	2636	3334	4076	4858	5677	6530	7416	8332	9278	10251	11251	12276
Muskegon	1100	1460	1846	2257	2690	3144	3616	4107	4614	5138	5677	6231	6799
Oakland	969	1285	1626	1988	2369	2768	3184	3616	4063	4524	4999	5486	5986
Ottawa	1364	1810	2290	2799	3336	3899	4485	5093	5723	6372	7041	7727	8432
St. Joseph	1294	1717	2172	2655	3165	3698	4254	4831	5428	6044	6678	7329	7997
Washtenaw	2646	3511	4441	5429	6471	7561	8698	9877	11098	12358	13654	14986	16352

Table 24.--Additional erosion reduction from cropland treatment generated by 520 man-hour increments of SCS technical assistance, by county, Land Resource Area 98.

County	Annual Man-hours Technical Assistance Time											
	2820	3340	3860	4380	4900	5420	5940	6460	6980	7500	8020	8540
	Tons Erosion Reduction											
Barry	1311	1409	1497	1577	1652	1721	1787	1849	1908	1964	2017	2069
Branch	330	354	376	397	415	433	449	465	480	494	507	520
Calhoun	546	587	623	657	688	717	744	770	794	818	840	861
Cass	780	838	891	939	983	1024	1063	1100	1135	1168	1200	1231
Clinton	797	857	911	960	1005	1047	1087	1125	1161	1195	1227	1259
Eaton	780	838	891	939	983	1024	1063	1100	1135	1169	1200	1231
Genesee	1915	2058	2187	2304	2413	2515	2611	2701	2787	2869	2947	3023
Gratiot	1054	1133	1204	1269	1329	1385	1437	1487	1534	1579	1622	1664
Hillsdale	1300	1397	1484	1564	1638	1707	1772	1834	1892	1948	2001	2052
Ingham	427	459	488	514	538	561	582	603	622	640	657	674
Ionia	1584	1703	1809	1907	1997	2081	2160	2235	2306	2374	2438	2501
Isabella	2340	2514	2671	2815	2948	3073	3190	3300	3405	3505	3601	3693
Jackson	760	816	867	914	957	998	1036	1071	1106	1138	1169	1199
Kalamazoo	325	349	371	391	410	427	443	458	473	487	500	513
Kent	337	363	385	406	425	443	460	476	491	505	519	532
Lapeer	1309	1406	1494	1575	1649	1719	1784	1846	1904	1960	2014	2065
Lenawee	2465	2649	2815	2966	3107	3238	3361	3477	3588	3693	3794	3891
Livingston	1243	1336	1419	1496	1566	1632	1694	1753	1809	1862	1913	1962
Montcalm	650	698	742	782	819	853	886	916	946	973	1000	1025
Muskegon	360	387	411	433	453	473	491	508	524	539	554	568
Oakland	317	340	362	381	399	416	432	447	461	475	488	500
Ottawa	446	480	510	537	562	586	608	629	649	668	687	704
St. Joseph	423	455	483	509	533	556	577	597	616	634	651	668
Washtenaw	865	930	988	1041	1091	1137	1180	1221	1259	1296	1332	1366

Table 25.--Comparison of county rankings for marginal gross erosion reduction versus marginal acres of erosion control practices, Land Resource Area 98.

County	Ranking from High to Low According to Marginal	
	Gross Erosion Reduction	Acres of Erosion Control
Barry	5	3
Branch	22	2
Calhoun	16	16
Cass	13	6
Clinton	11	10
Eaton	12	13
Genesee	3	23
Gratiot	9	4
Hillsdale	7	1
Ingham	18	21
Ionia	4	8
Isabella	2	7
Jackson	14	17
Kalamazoo	23	19
Kent	21	22
Lapeer	6	11
Lenawee	1	14
Livingston	8	12
Montcalm	15	5
Muskegon	20	18
Oakland	24	24
Ottawa	17	15
St. Joseph	19	9
Washtenaw	10	20

man-hours. Distribution of the total manpower pool in Region Two for the purpose of maximizing erosion control acreage had increased this to 130,080. It was assumed that this change was in the direction of increasing soil loss reductions as well, so the latter value was taken as the new available total. Allocation of this total by the rankings according to additional erosion reduction resulted in distribution of the maximum staff level of 8,540 man-hours to the twelve highest ranking counties, while the remaining twelve received only the minimum of 2,300 man-hours.

Estimated values of total soil loss reduction for each county were summarized from the computed array, in addition to erosion control acreage estimates calculated previously. Composite erosion reduction rates for each county were also applied to observed acreage values and those computed for the maximum acreage alternative for comparison (Table 26).

Manpower shifts to maximize total erosion reduction resulted in an estimated increase of 103,395 tons of soil saved over observed values. A t-test led to rejection of the null hypothesis of no difference between the means at less than the five percent level (computed t-value equal to 2.090 with 23 d.f.). There was also an increase of 60,867 tons of erosion reduction over the amount achieved with a program emphasizing total treated acreage. In this case, however, the null hypothesis was not rejected (computed t-value equal to 1.095 with 23 d.f.).

Comparison of observed erosion reduction values with those estimated for the maximum acreage alternative showed that the total increased from 234,558 tons to 277,086 tons. The means of these estimates were not significantly different at the ten percent level as measured by a t-test

Table 26.--Comparison of cropland erosion control acreage and gross erosion reduction for alternate allocations of SCS technical assistance time, by county, Land Resource Area 98.

County	Observed Allocation ^a		Maximum Acreage Allocation ^b		Maximum Erosion Reduction Allocation ^c	
	Acres	Tons	Acres	Tons	Acres	Tons
Barry	5948	11361	12967	24767	12967	24767
Branch	1692	812	12975	6228	2099	1008
Calhoun	7478	7553	1652	1668	1652	1668
Cass	7476	8597	12814	14736	2073	2384
Clinton	5842	6952	12662	15068	12662	15068
Eaton	8110	9894	1955	2385	12081	14739
Genesee	3216	22866	823	5855	5089	36185
Gratiot	3837	5909	12935	19919	12935	19919
Hillsdale	5926	11200	12997	24564	12997	24564
Ingham	11934	12411	1256	1306	1256	1306
Ionia	13714	32228	12739	29938	12739	29938
Isabella	5397	18674	12776	44206	12776	44206
Jackson	1601	2257	1647	2322	1647	2322
Kalamazoo	11187	7719	1440	994	1440	994
Kent	1771	2054	889	1031	889	1031
Lapeer	6874	13542	12551	24726	12551	24726
Lenawee	5186	20588	1898	7536	11733	46578
Livingston	5931	11269	12360	23485	12360	23485
Montcalm	7057	6704	12922	12276	2091	1986
Muskegon	2888	1993	1594	1100	1594	1100
Oakland	81	277	283	969	283	969
Ottawa	8003	6402	1705	1364	1705	1364
St. Joseph	7389	4655	12694	7997	2054	1294
Washtenaw	4364	8641	1336	2646	8258	16352
Total	142902	234558	169870	277086	157931	337953
Mean	5954.25	9773.25	7077.91	11545.25	6580.46	14081.38

^a Observed FY 1972 acreage and computed gross erosion reduction.

^b Computed value with manpower allocated to maximize annual cropland acreage treated with erosion control practices.

^c Computed value with manpower allocated to maximize annual gross erosion reduction.

(computed t-value equaled 0.855 with 23 d.f.). The increase of 42,528 tons accounted for less than one-half (41.1 percent) of the total estimated change achieved by adjusting manpower for maximum erosion reduction.

These data confirm that erosion control program effects are dependent upon both the manner in which the problem is defined and operational objectives. A manager attempting to increase present quantities of sediment reduction would not significantly improve program performance by merely concentrating on higher treatment acreage. The goal could be attained by consideration of quantitative soil loss data of the type utilized here in order to concentrate technical assistance on the lands and practices with highest relative returns. Although the data are not definitive, there is some indication that this approach would also increase treated acreage somewhat, but not as high as in a specific acreage maximizing program.⁶³

These results are circumscribed by all of the shortcomings of both the soil loss model and the allocation procedure. Little needs to be added to the previous discussions, except to remind the reader that the limitations do exist and have been recognized. Once again, attention should not be drawn to individual computed values. General magnitudes and directions of movement for different parameters serve to illustrate the major point of this section of the study: Fundamental public policy objectives for erosion control do affect the design and operation of land treatment program. A more efficient effort could be organized if the desired outcome were explicitly identified.

⁶³ Comparing means of the three pairs of acreage values produced t-values for each pair which were not significant at the ten percent level.

CHAPTER VII

SUMMARY AND RECOMMENDATIONS

Summary

Increased environmental awareness in recent years has renewed public concern over a timeless natural resource problem: soil erosion. While erosion produces direct damages through loss of soil material and reduced productivity, its off-site effects are often the most dramatic. Sediment is a serious water pollutant which impacts stream flows, fish and wildlife resources, and public health.

A need for continuing erosion control efforts still exists today after nearly forty years of concerted public program action. The Soil Conservation Service of the U.S. Department of Agriculture has been the lead agency in Federal erosion control work. Although SCS has gained additional responsibilities, erosion control is still viewed, by those outside and within the agency, as its primary task.

The Soil Conservation Service has been engaged in erosion control work in Michigan since 1935. From a beginning with one employee in one demonstration project, SCS has grown to a staff of nearly two hundred, with approximately one hundred sixty field technicians serving all parts of the state.

Organization and management of the SCS field staff and its success in meeting erosion control objectives has been the focus of this study. Linkages between physical needs for land treatment and SCS staffing decisions were analyzed. Factors which have influenced the application of erosion control measures were also investigated. A method was developed for estimating gross erosion reduction attributable to certain cropland treatment practices. Alternative county staff levels were then studied to determine their impact on acreage treated and soil loss reductions.

Staff Organization

Analysis of published land treatment needs data and observed FY 1972 staff levels revealed that SCS in Michigan has not organized its county staffing pattern primarily to meet erosion control needs. Multiple regression equations confirmed a highly significant relationship between annual technical assistance time in a county and both the acres of cropland and the years a soil conservation district has been organized. An equation containing just these two independent variables explained a significantly higher proportion of variation in county manpower levels than did the other equations tested. Total acres needing erosion control, cropland acres needing treatment, and cropland acres needing erosion control were each found to be statistically related to SCS technical assistance time, but have received less attention in staffing decisions than total cropland area. A bias in staffing toward longer established soil conservation districts was indicated in all equations tested.

It appears that SCS has followed an incremental and simplistic approach to establishing staff levels for its county offices. Older soil conservation districts, established in an early growth period of the

young agency, have been successful in retaining relatively high levels of technical assistance. Districts organized more recently in an era of restrictive personnel policies have been accorded limited assistance. This tendency has been tempered primarily by consideration of total cropland area rather than attention to the agency's own data on needs for erosion control or total land treatment. The record is ambiguous regarding the issue of whether early soil conservation districts were in fact established in areas of greatest need for erosion control.

Erosion Control Accomplishments

The influences of technical assistance inputs and other factors upon erosion control accomplishments were evaluated by means of multiple regression techniques. Cropland, pastureland, and other land were evaluated in separate analyses in two regions of the state. Results varied substantially by land use type and by region. The objective of developing predictive equations for erosion control acreage was not fully achieved.

Other Land

Analysis of other land was somewhat limited by definitional considerations and treatment data. According to the land use system adopted by SCS, other land consists of non-Federal rural land exclusive of cropland, pastureland, and forest land. It includes farmsteads, non-farm rural residences, investment tracts and miscellaneous areas, and covers just five percent of the total land area of Michigan. Only one erosion control practice--critical area treatment--is generally applicable to other land; but this practice may be used on different land use types as well.

Given the diversity and limited occurrence of other land, perhaps it is not surprising that SCS has not organized a program for its treatment. This was shown by the results for both regions. There was no significant relationship between erosion control accomplishments on other land and SCS manpower levels. Nor was there any indication that treatment has been applied where identified needs are the greatest. There was no evidence showing a consistent effort to encourage treatment of other land in conjunction with measures for cropland protection. Only in Region Two did a pattern emerge to suggest that more treatment of other land occurred in counties experiencing urban development than in largely rural counties. Estimating other land erosion control accomplishments was not feasible with the techniques and data utilized here.

Pastureland

An explicit SCS pastureland erosion control program was not apparent through this evaluation. Application of pastureland treatment measures was found to be largely independent of SCS staff levels, total pastureland acreage, and erosion control needs. Results concerning these variables were essentially the same in both regions.

There was evidence that SCS technical assistance for cropland erosion control results in some pastureland treatment as well. This link was most pronounced in Region One.

Efforts to derive predictive equations were of limited success. Best results were obtained through log transformations of the data, but a uniform and firm relationship to manpower levels was not established. In Region One, the manpower variable was significant; but a better estimator could be obtained by substituting cropland treatment acreage for manpower.

In Region Two, technical assistance time was not significant, but once again cropland erosion control acreage was. These results would have required that predicted values of pastureland erosion control accomplishments be computed using estimated values for cropland treatment acreage which were to be calculated by another regression equation. Such a procedure was rejected, and further study was devoted to cropland acreage estimates.

Cropland

Application of cropland erosion control measures was found to be related to the level of SCS technical assistance. This conclusion was supported by the data for both regions; but the direct link between erosion control treatment and manpower levels was more pronounced in Region One.

Several other independent variables in the hypothesized equation were not significant. Included in this group was the cropland acreage needing erosion control measures. This was consistent with previously cited results regarding treatment needs and manpower levels. Also included was a variable representing presence of a county soil survey. Readily available soils information would eliminate the need for individual surveys for conservation planning. Although this should increase the efficiency of planning and application work, the contribution of a county soil survey is not significant in this context.

There was evidence that the needs for cropland drainage have contributed to erosion control applications in Region Two. It is likely that many farmers who make an initial contact with SCS for drainage

assistance will ultimately be encouraged to apply some erosion control measures as well. This is not surprising, given the magnitude of drainage needs in Region Two and the relatively higher short-term returns on drainage investments.

Satisfactory predictive equations were derived through log transformations of dependent and independent variables. In Region One, SCS manpower, value of agricultural products sold, and non-forest treatment needs were significant, and explained over sixty-five percent of the variation in cropland erosion control accomplishments. Technical assistance time was also significant in Region Two, as was the 1970 county population level. An equation with just these two indicators explained over eighty percent of the variation in the dependent variable.

Erosion Reduction Estimates

A major shortcoming of the present SCS data system is its failure to quantify sediment reduction effects achieved through various land treatment measures. A method was devised to estimate these impacts by merging reported acreage accomplishments with other data sources. This model was illustrated in a twenty-four county sub-area of Region Two.

Data based on the Universal Soil Loss Equation were utilized for computing soil loss reduction rates by land capability class and subclass for five conservation practices. When combined with information on cropland erosion control needs among land capability classes, and the observed distribution of cropland treatment measures, a composite erosion reduction rate per acre was derived. This rate was a measure

of the long run average effectiveness of the SCS erosion control effort in each county, expressed in terms of sediment reduction. The rate varied among counties from less than one ton per acre to over seven tons per acre.

The method was limited by several critical assumptions necessitated by lack of firm data. Interpretation of individual values was therefore somewhat limited; but useful comparisons among counties were made possible by this technique. It also illustrated the contrast between treatment acreage and sediment reduction volume.

Alternate Staff Organization

The initial portion of this study revealed that present SCS county staff levels have not been specifically aligned with erosion control needs. The possibility of increasing program accomplishments through field staff reorganization was explored in the final phase. Analysis of this issue was confined to cropland due to the regression analysis results noted earlier. Impacts upon both total treated acreage and the quantity of soil loss reduction were investigated.

Cropland treatment acreage

Each of the two study regions was evaluated separately. The appropriate regression equation was used to compute total cropland erosion control accomplishments for alternative county staff levels. Counties within each region were ranked and compared according to the additional treated acreage achieved with increments of technical assistance time. The total manpower pool in each region was then redistributed among

counties in the order of the rankings. Estimates of cropland erosion control acreage were computed by the regression equations for each county using the revised staff levels.

Statistical testing of the new acreage estimates failed to confirm a significant increase over observed values in either region. This result emphasized the limitations of the linear regression techniques utilized here. It suggests that more analysis will be needed to clarify production functions for erosion control accomplishments.

Soil loss reduction

The erosion reduction model for the twenty-four county sub-area was joined with the above staff reorganization procedure in order to evaluate manpower adjustments directed at increasing gross erosion reduction. Counties were ranked according to the additional quantity of sediment reduction produced by increments of technical assistance time. Total manpower within this sub-area was reallocated among the counties in correspondence with the rankings. Erosion reduction volumes computed with newly specified manpower levels were summarized and compared to the observed values. The resulting increase in tons of soil saved was shown to be statistically significant.

Estimated erosion reduction volumes produced with staff levels organized for maximum treatment acreage were also compared to observed values. In this case the increase was not significant, and denotes that programs designed for maximum acreage accomplishments do not necessarily optimize sediment reduction. This outcome highlights the importance of clearly defining the ultimate objectives of erosion control policies.

Recommendations for Program Management

This research has touched several aspects of the SCS erosion control effort in Michigan.

This study began with the premise that erosion control is a desirable public policy objective. It has examined several aspects of the SCS erosion control effort in Michigan from a single-purpose approach.

Some of the apparent conflicts between agency operations and that single goal have resulted from deliberate actions in support of other objectives. This would include policies undertaken primarily to bolster political support and ensure continued funding, for these are the ultimate foundation of public programs. But incremental policy and operational decisions which appear to be individually sound may collectively reorient a program to unintended ends.

A major result of a single-purpose program evaluation such as this is to elucidate some of the compromises which have been made in a fundamental objective while accommodating other concerns. The value of program analysis lies in its contribution to decision-making, which in turn impacts upon program operation. Complete analysis therefore includes implementable recommendations for program management.

Improving the Data Base

Reference to data problems has been made repeatedly throughout this discussion. Indeed, a principal motivation for this study was the absence of readily available information on the status of erosion control efforts. Two major data sources with high potential for improvement are discussed.

Conservation Needs Inventory

The 1967 CNI is extremely useful for answering certain questions regarding land use. It is a statistically sound (ignoring some of the questions regarding forest acreage) tabulation of the rural, non-Federal land base. Incorporating the land capability classifications enhances some interpretations of soil productivity and limitations for various uses.

As an indicator of soil erosion conditions, the CNI is seriously deficient. The normative context and broad interpretations of the various treatment needs categories limit its information content. Quantitative estimates of the physical soil loss conditions of an inventoried acre may only be derived through laborious computations such as those described in Chapter V.

These shortcomings could be eliminated by adding just three items to the list of characteristics observed in the field sample: (1) tillage condition (conventional, crop residue use, minimum tillage), (2) mechanical treatment (up-down hill farming, contouring, stripcropping, terracing), (3) usual crop rotation. Identifying these parameters would allow use of the Universal Soil Loss Equation or comparable estimator to compute existing erosion rates. Corresponding factors would need to be identified for pastureland and other land.

Treatment "needs" could be determined on the basis of a uniform physical indicator rather than a judgment factor. The data would also be adaptable to cost-effectiveness studies for evaluating alternative treatment measures individually and combined in resource management systems.

This approach has some inherent problems. Soil management practices and crop rotations are subject to more short-term influences than are land use patterns alone. It might be argued that a new CNI would therefore be outdated in a relatively short time period. But "treatment needs" are also subject to change, so the difference may not be substantial. Inventory procedures and time requirements would be somewhat lengthened, particularly for determining crop rotations. On balance, the added information content would outweigh these concerns.

Progress Reporting System

Data elements in existing SCS progress reports do not relate to program effectiveness. They essentially measure acres and other units of inputs comprising a land treatment system. Outputs of the system are acres of land adequately treated and the quantity of gross erosion reduction, for which no information is recorded.

Resolving this deficiency would be accomplished by adding four characteristics of the area being treated to the report form: (1) tillage condition, (2) mechanical practice, (3) usual crop rotation, (4) land capability class and sub-class. Conditions after treatment would be implied by the mix of practices being reported at the time. As suggested above, these parameters would be used with a soil loss equation to quantify treatment effects. Such information, combined with expanded CNI data, would permit evaluation of soil conservation progress over time. It would also provide a means of measuring the sediment reduction effects of erosion control measure applications.

Reconsidering Staffing Patterns

Investigation of criteria for staffing decisions ultimately revolves around the question of program objectives. If SCS in Michigan has had the goal of providing technical assistance to every cropland acre, regardless of its need for conservation treatment, and to give preference to older soil conservation districts while doing so, the present distribution of manpower resources among counties is well suited. If this has not been, or is not now, the conscious objective, then some adjustments are warranted.

It is not the purpose of this study to settle upon the appropriate erosion control objective. That is a basic policy question, and fundamentally a political one. Highlighting and quantifying some attributes of the present program should contribute to a more thorough consideration of future alternatives.

A new factor in the decision process is the recently enacted state sediment control act.⁶⁴ New demands for technical assistance have already developed and will undoubtedly grow. This legislation is clear in its intent to approach erosion control as a sediment reduction device rather than a cropland management tool. As noted in Chapter VI, such an operational goal will call for a different strategy than one designed to emphasize acreage accomplishments.

⁶⁴Soil Erosion and Sedimentation Control Act of 1972, Act 347, Public Acts of 1972.

Expansion of the soil loss model to other land use types and to all counties in the state is recommended. This will quantify comparative erosion hazards and expected treatment impacts. Such data could be utilized to guide coordinated Federal, state, and local management decisions.

Such legislation may drastically alter the effectiveness and productivity of SCS manpower. It changes erosion control from a voluntary program to one of forced participation. The problem of "selling" a landowner on a particular practice will be transformed into a question of choosing among several requests for assistance. Quantitative information on the relative payoff from alternative practices will become even more desirable.

Recommendations for Further Research

Opportunities for additional analysis in several areas have been suggested by this study. Some relate to unresolved problems, and others involve extensions of methodology.

Technical Assistance and Accomplishments

Development of workable production functions for erosion control accomplishments is critical to an expanded evaluation of alternative land treatment programs. Highly refined production curves are not required, for merely identification of the point of zero marginal return to technical assistance time would be a major contribution to existing knowledge. A successful approach might include selected socio-economic characteristics of client groups in addition to resource base data as were employed here. Intensive analysis of data from selected counties, stratified by farm enterprise types or economic class of farm is suggested as an alternative to the broader approach of this study.

The influence of other government programs on erosion control accomplishments should be considered in addition to the role of SCS manpower. The present study could be extended by evaluating the impact of cost-sharing and education programs, and by estimating the relative returns to public funds allocated to these activities and to technical assistance programs. Although more difficult to quantify, the leadership and influence of local soil conservation districts in erosion control efforts warrants additional investigation.

It is recognized that Michigan has only moderate erosion problems when compared to the loess soil area of western Iowa, or portions of the southern Great Plains Region which are subject to severe wind erosion. Since the hazards are greater in such areas, one might expect a different landowner response to technical assistance than was observed in Michigan. Evaluation of data from other states is recommended in order to clarify relationships between manpower levels and land treatment accomplishments. Research in states which have implemented mandatory sediment controls on agricultural land would provide information on the probable impact of the agricultural phase of Act 347 which will take effect in 1979.

Multiple Objective Planning

Comprehensive program planning for land resource management requires attention to other problems in addition to erosion control. An analytical system is needed to provide information for decision making on multiple objective programs. The concepts employed for the investigation of alternative staffing levels should be extended to additional purposes.

Research to identify production functions for technical assistance outputs other than erosion control is an initial requirement. Linear programming or other appropriate techniques should be tested as an aid to allocating manpower and other agency resources to two or more program areas.

Evaluation of the National Program

The lack of correspondence between SCS staffing levels and land treatment needs among counties in one state leads to the question of how well the national program is organized to meet identified needs. SCS expanded its nationwide effort slowly over the years as landowners in the various states organized local soil conservation districts. One suspects that this relatively unplanned incremental growth has produced some misallocation of resources. A national study of this issue is needed to provide information for long-range planning. The initial phase of such an evaluation might utilize only state totals for the pertinent variables. Sample county data could be analyzed for additional refinements and detailed planning.

Application to Water Resources Planning

The soil loss model described in Chapter V has application beyond the scope of this study. Watershed and river basin planning efforts are somewhat limited by a lack of quantitative estimates of sediment reduction achieved with land treatment programs. The problem is less severe in small watershed planning. There the size of the study area is often small enough that soil loss estimates may be computed directly with the Universal Soil Loss Equation. Such computations are not feasible for

river basin studies which typically cover several million acres. The soil loss model is adapted to providing erosion reduction estimates for any multi-county region. Reliability of the model for use in this manner would be improved by additional studies within a particular river basin to verify two key sets of assumptions: (1) county crop rotations, and (2) distribution of land treatment accomplishments among land capability classes. Sample surveys to provide this information could easily be added to the extensive data collection efforts which are now a part of all river basin investigations. The soil loss model with these refinements will contribute to a better evaluation of the sediment control impacts of land management alternatives.

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APPENDICES

APPENDIX A

**DEFINITIONS OF LAND USE
AND
TREATMENT NEEDS CATEGORIES
OF THE
CONSERVATION NEEDS INVENTORY**

APPENDIX A

DEFINITIONS OF LAND USE AND TREATMENT NEEDS CATEGORIES OF THE CONSERVATION NEEDS INVENTORY

Land Use and Area

Total land area. Land area given is from Bureau of the Census Area Measurement Reports and the 1964 Census of Agriculture adjusted to exclude areas inundated by new reservoirs, lakes, and ponds larger than 40 acres constructed since April 1, 1960.

Federal land. Federally owned land except cropland operated under lease or permit; primarily the federally owned land outside towns and cities. Indian land under trusteeship but owned by individuals or tribes is not included.

Urban and built-up areas. Cities, villages, and built-up areas of more than 10 acres; industrial sites (except strip mines, borrow and gravel pits); railroad yards; cemeteries; airports; golf courses; shooting ranges; institutional and public administration sites; and similar

Source: U.S. Department of Agriculture, Basic Statistics-National Inventory of Soil and Water Conservation Needs, 1967, Statistical Bulletin No. 461 (Washington: U.S. Government Printing Office, 1971), pp. 209-210.

kinds of areas. Road and railroad acreage is included, and intermingled federal acreages may be included. Farmland acreage inside city and village limits is not included.

Water areas. Ponds and lakes of more than 2 acres and not more than 40 acres and rivers and streams that are less than 1/8 mile wide.

Total inventory acreage. Acreage after federal land, urban and built-up areas, and water areas have been deducted from the total land area.

Cropland. Land used primarily for the production of adapted cultivated close-grown, fruit, or nut crops for harvest, alone or in association with sod crops, and open land formerly in such uses.

Pastureland. Land producing forage plants, principally introduced species, for animal consumption. Management practices usually include one or more treatments such as reseeding, renovating, mowing, liming, or fertilizing. "Native pasture" that because of location or soil limitation is treated like rangeland is included.

Forest land. Land at least 10 percent stocked by forest trees of any size and capable of producing timber or other wood products or capable of influencing the water regime; land formerly at least 10 percent stocked by forest trees of any size and not currently developed for other uses; afforested (planted) areas; and chaparral areas.

Commercial. Land producing crops of industrial wood, generally capable of producing at least 20 cubic feet of annual growth per acre; cutover areas on which timber species have not been reestablished and

that have not been developed for nonforest use; and land not withdrawn from timber use by status of administrative regulation.

Non-Commercial. Land incapable of producing industrial wood products because of adverse site conditions and forest land withdrawn from commercial timber use by status or administrative regulation.

Other land. Nonfederal rural land that is not classified as cropland, pastureland, rangeland, or forest (includes strip mines, borrow and gravel pits, and miscellaneous areas).

In farms. Other land considered a part of a farm, such as farmsteads, farm roads, feedlots, and fences and hedge rows.

Not in farms. Other nonfederal rural land that is not part of a farm, such as rural nonfarm residences, investment tracts, coastal dunes, and marshes not used for grazing.

Treatment Needs

Cropland

Residue and annual cover. Cropland on which only crop residues, annual cover crops, or other locally used annually recurring measures, including stand improvement on hayland, are needed to meet the conservation problems.

Sod in rotation. Cropland on which a sod crop is needed in the rotation to meet the conservation problems and hayland needing reestablishment.

Contouring. Cropland on which contouring is needed to control erosion.

Stripping, terracing, diversions. Cropland on which stripcropping, terraces, or diversions are needed to treat and protect the land in addition to measures that may be used to supplement these practices. Acreages needing a system of sod waterways or windbreaks are included.

Permanent cover. Cropland on which a permanent cover of grass or trees is needed. The land is unsuited to growing row or grain crops and should be taken out of cultivation.

Drainage system. Cropland on which an adequate drainage system is needed to remove excess surface or internal water.

Pastureland

Change in land use. Pasture that needs to be converted to forest.

Protection only. Pasture that is overgrazed but will reseed naturally and recover with proper livestock management. Installation of watering facilities and fences to improve grazing distribution may be needed.

Improvement only. Pasture on which the desired kind of vegetation is present but the stand is thin. To get a satisfactory stand, practices such as fertilizing, weed control, and mechanical measures in addition to proper grazing management are needed for improvement.

Improvement and brush control. Pasture on which brush control measures are needed in addition to forage stand improvement.

Reestablishment only. Pasture in such poor condition that it needs complete reestablishment but brush is not a problem. The desired vegetation must be protected against grazing until it is established.

Reestablishment and brush control. Pasture on which brush control measures are needed in addition to reestablishment.

Forest Land

Timber stand establishment or reinforcement. For commercial forest, land producing below its potential because of inadequate stocking. It can be satisfactorily stocked by planting or by natural or artificial seeding with or without site preparation. The treatment is physically possible but may not be economical. The density or degree of stocking indicates the extent to which growing space is occupied. Increases in stocking of trees will ameliorate fundamental soil and water conservation problems and contribute to future timber supplies.

For noncommercial forest, all non-stocked and poorly stocked land on which increases in tree stocking will improve the nontimber benefits both onsite and off.

Timber stand improvement. For commercial forest only, the acreage on which timber stand improvement is biologically feasible. The acreage that can benefit from timber stand improvement even though it may not be practicable because of costs and the variability of management objectives. Timber stand improvement includes cutting to release crop trees or potential crop trees for increased growth or quality of the remaining trees, or both.

Other Land

Treatment needed. Land needing conservation treatment to protect it against erosion and deterioration and to keep it from damaging adjacent land and on which treatment is economically and physically feasible.

APPENDIX B

DEFINITIONS OF SELECTED SOIL CONSERVATION SERVICE PROGRESS REPORT ITEMS AND CONSERVATION PRACTICES

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DEFINITIONS OF SELECTED SOIL CONSERVATION SERVICE PROGRESS REPORT ITEMS AND CONSERVATION PRACTICES

Progress Report Items

Conservation plan. A document containing material relative to the conservation use and treatment of soil and water resources of an entire individual land unit, including but not limited to appropriate soil, water and plant inventories, with needed interpretations, maps, statements about critical conservation problems, record of decisions for the conservation and development of soil and water resources as made, and alternatives for sound land use(s) and conservation treatment when conservation decisions have not been made. The plan should eventually contain all major conservation decisions to assure that the entire unit of land will be used and treated to achieve the conservation objectives.

District cooperator. An individual, group of people, or representative of a unit of government who has entered into an understanding, working arrangement or cooperative agreement with a conservation district to

Source: USDA, Soil Conservation Service, Fieldbook of Timekeeping and Progress System Codes (Washington, 1973); and USDA, Soil Conservation Service, National Handbook of Conservation Practices (Washington, 1971).

work together in planning and carrying out soil and water resources use, development, and conservation on a specific land area.

Operating units. Those units of land where the primary objective of the operation is to manage the land and related natural resources to produce income from plants, animals or related outdoor recreation, or wildlife. Included are units operated as farms, ranches, tree farms, hunting preserves, game lands, forest lands used to produce salable timber, prison farms, mining lands, etc.

Other land units. Those units where the land and related natural resources primarily provide physical support and open space for residential or industrial use, transportation, public facilities, institutions, etc., and to those entities having restricted use or rights-of-way over lands owned or controlled by others, where the primary objective is not to produce income from plants, animals, or agriculturally related outdoor recreation.

Units of government and their agencies. An estimate of the number of local or state units of government or their planning and development commissions, councils, or agencies who may request technical assistance for resource planning and implementation for areas for which they have planning or implementation responsibility but which they do not own or directly control.

Conservation Practices

Conservation cropping system. Growing crops in combination with needed cultural and management measures. Cropping systems include rotations that contain grasses and legumes as well as rotations in which the

desired benefits are achieved without the use of such crops. Purpose: To improve or maintain good physical condition of the soil; protect the soil during periods when erosion usually occurs; help control weeds, insects, and diseases; and meet the need and desire of farmers for an economic return. Applicable: On all cropland and on certain recreation and wildlife land.

Contour farming. Farming sloping cultivated land in such a way that plowing, repairing land, planting, and cultivating are done on the contour. (This includes following established grades of terraces, diversions, or contour strips.) Purpose: To reduce erosion and control water. Applicable: On sloping cropland and on recreation and wildlife land where other cultural and management practices in a cropping system do not control soil and water loss.

Critical area planting. Planting vegetation such as trees, shrubs, vines, grasses, or legumes on critical areas. (Does not include tree planting mainly for wood products.) Purpose: To stabilize the soil; reduce damage from sediment and runoff to downstream areas; improve wildlife habitat; and enhance natural beauty. Applicable: On sediment-producing, highly erodible or severely eroded areas, such as dams, dikes, mine spoil, levees, cuts, fills, surface-mined areas, and denuded or gullied areas where vegetation is difficult to establish with usual seeding or planting methods.

Crop residue use. Using plant residues to protect cultivated fields during critical erosion periods. Purpose: To conserve moisture; increase infiltration; reduce soil loss; and improve soil tilth. Applicable: On land where adequate crop residues are produced.

Field windbreak. A strip or belt of trees or shrubs established within or adjacent to a field. Purpose: To reduce soil blowing; control snow deposition; conserve moisture; protect crops, orchards, livestock, and wildlife; or increase the natural beauty of an area. Applicable: In or around open fields which need protection against wind damage to soils, crops, or livestock; where the deposition of snow for moisture conservation can best be accomplished by windbreaks; or where strips of trees or shrubs increase the natural beauty of an area or provide food and cover for wildlife.

Grade stabilization structure. A structure to stabilize the grade or to control head cutting in natural or artificial channels. (Does not include straight pipe overfill structures used in drainage and irrigation systems for structures for water control.) Purpose: To stabilize the grade in natural or artificial channels, prevent the formation or advance of gullies, and reduce environmental and pollution hazards. Applicable: Where the concentration and flow velocity of water are such that structures are required to stabilize the grade in channels or to control gully erosion. Special attention will be given to maintaining or improving habitat for fish and wildlife, where applicable.

Grassed waterway or outlet. A natural or constructed waterway or outlet shaped or graded and established in vegetation suitable to safely dispose runoff from a field, diversion, terrace, or other structure.

Minimum tillage. Limiting the number of cultural operations to those that are properly timed and essential to produce a crop and prevent soil damage. Purpose: To retard deterioration of soil structure; reduce soil

compaction and formation of tillage pans; and to improve soil aeration, permeability, and tilth. Applicable: On all cropland and on certain recreation and wildlife land.

Pasture and hayland management. Proper treatment and use of pastureland or hayland. Purpose: To prolong life of desirable forage species; to maintain or improve the quality and quantity of forage; and to protect the soil, and reduce water loss. Applicable: On all pastureland or hayland.

Pasture and hayland planting. Establishing long-term stands of adapted species of perennial, biennial, or reseeding forage plants on land converted to pasture or hayland from other uses. (Does not include a grassed waterway or outlet on cropland.) Purpose: To adjust land use; produce high quality forage; and reduce erosion. Applicable: On land that is converted from other uses on which a species remains indefinitely before it is reestablished.

Stripcropping, contour. Growing crops in a systematic arrangement of strips or bands on the contour to reduce water erosion. The crops are arranged so that a strip of grass or close-growing crop is alternated with a strip of clean-tilled crop or fallow or a strip of grass is alternated with a close-growing crop. Purpose: To reduce erosion and control water. Applicable: On sloping cropland and certain recreation and wildlife land where the topography is uniform enough that tilling and harvesting can be done practically; and where it is an essential part of a cropping system to effectively reduce soil and water losses.

Stripcropping, field. Growing crops in a systematic arrangement of strips or bands across the general slope (not on the contour) to reduce water erosion. The crops are arranged so that a strip of grass or close-growing crop is alternated with a clean-tilled crop or fallow. Purpose: To help control erosion and runoff on sloping cropland where contour strip-cropping is not practical. Applicable: On sloping cropland and certain recreation and wildlife land.

Stripcropping, wind. Growing wind-resisting crops in strips alternating with row crops or fallow and arranged at angles to offset adverse wind effects. Purpose: To reduce wind velocity at the soil surface, thereby reducing soil blowing and damage to crops. Applicable: On cropland subject to soil blowing and where needed as part of a cropping system.

Terrace, basin. A form of level terrace with closed ends constructed on non-cropland with permeable soils and designed to impound a given amount of runoff from the drainage area above it. Purpose: To retain gully runoff from non-cropland areas, check erosion on the lower slopes, prevent gully development, reduce flooding, increase infiltration opportunity and reduce pollution from sediment and runoff. Applicable: (1) Where runoff from higher lying areas will damage crop or pastureland; conservation roads, buildings, or other cultural features. (2) Where the soil is deep and capable of absorbing and storing extra water.

Terrace, gradient. An earth embankment or a ridge and channel constructed across the slope at a suitable spacing and with an acceptable grade. Purpose: To reduce erosion damage and pollution by intercepting surface runoff and conducting it to a stable outlet at a nonerosive

velocity. Applicable: Normally are limited to cropland having a water erosion problem. They shall not be constructed on deep sands or on soils that are too stony, steep, or shallow to permit practical and economical installation and maintenance. The topography must be such that farmable terraces can be constructed. Gradient terraces may be used only where suitable outlets are or will be made available.

Terrace, level. An earth embankment or a ridge and channel constructed across the slope at a suitable spacing with no grade. Purpose: To conserve moisture, to control erosion, and reduce pollution. Applicable: Only on deep soils that are capable of absorbing and storing extra water without appreciable crop damage and in areas where the rainfall pattern is such that storage of rainfall in the soil, rather than removal, is practical and desirable. In cultivated areas the topography must be such that farmable terraces can be constructed.

Terrace, parallel. An earth embankment or a ridge and channel in parallel constructed across the slope at a suitable spacing and with an acceptable grade. Purpose: To reduce erosion and pollution, conserve moisture, and provide a more farmable terrace system. Applicable: Normally limited to cropland having water erosion problem. Gradient terraces may be used only where suitable outlets are or will be made available. Level terraces are capable of absorbing and storing extra water without appreciable crop damage and in areas where the rainfall pattern is such that storage of rainfall in the soil, rather than removal is practical and desirable. The topography must be such that farmable terraces can be constructed.

Tree planting. Planting tree seedlings or cuttings. Purpose: To establish or reinforce a stand of trees to conserve soil and moisture; beautify an area; protect a watershed; or produce wood crops. Applicable: In open fields, in understocked woodland, beneath less desirable tree species, or on other areas suitable for producing wood crops; where erosion control or watershed protection is needed; where greater natural beauty is wanted; or where a combination of these is desired.

Land Use Conversions

Cropland to grassland. A change in use from cropland to hayland, pastureland, or rangeland. Reported when the acreage is planted, seeded or otherwise converted to grassland.

Cropland to woodland. A change in use from cropland to woodland. Reported when the acreage is planted or seeded for use as woodland.

Cropland to wildlife-recreation. A change from cropland to wildlife-recreation land exclusively, and to multiple-use land where the primary use is wildlife-recreation. Reported when the acreage is protected, planted, developed, or otherwise established for wildlife-recreation.

APPENDIX C

DESCRIPTION OF VARIABLES USED IN REGRESSION EQUATIONS

APPENDIX C

DESCRIPTION OF VARIABLES USED IN REGRESSION EQUATIONS

<u>Label</u>	<u>Description</u>
CECA	Cropland Erosion Control Accomplishments: Sum of SCS reported acreage for (1) crop residue use, (2) minimum tillage, (3) contour farming, (4) stripcropping (all types), and (5) land use conversion of cropland to grassland, woodland, or wildlife-recreation. <u>1/</u>
CNE	Cropland Needing Erosion Control Treatment: Sum of cropland acreage in tillage rotation needing (1) residue and annual cover, (2) sod in rotation, (3) contouring, (4) stripcropping, terracing, diversions, and (5) permanent cover. <u>2/</u>
CNT	Cropland Needing All Treatments: Sum of cropland acres needing drainage improvement and CNE. <u>2/</u>
COAR	County Area: Total land area of the county in acres. <u>2/</u>
COOP	Cooperators: Cumulative number of soil conservation district cooperators, to June 30, 1972. <u>1/</u>
CPT	Cropland: Total county cropland acreage. <u>2/</u>
DRN	Drainage Needs: Cropland acreage needing improved drainage systems. <u>2/</u>
ENT	Erosion Needs, Total: Sum of erosion control needs for cropland, pastureland, and other land. <u>2/</u>
GOVTU	Government Units: Cumulative number of units of government and their agencies, to June 30, 1972. <u>1/</u>

LG...	Log (base 10) of corresponding variable.
OECA	Other Land Erosion Control Accomplishments: SCS reported acreage of critical area treatment. <u>2/</u>
ONT	Other Land Needing Treatment: Acreage of other land needing conservation treatment. <u>2/</u>
OT	Other Land: Total county acreage of other land. <u>2/</u>
PCH	Population Change: Numerical change in total county population, 1960 to 1970. <u>3/</u>
PECA	Pastureland Erosion Control Accomplishments: Sum of SCS reported acreage for (1) pasture and hayland management, and (2) pasture and hayland planting. <u>1/</u>
PLANS	Plans: Cumulative number of conservation plans prepared in the county, to June 30, 1972. <u>1/</u>
PNT	Pastureland Needing Treatment: Sum of pastureland acreage needing (1) protection only, (2) improvement only, (3) improvement and brush control, (4) reestablishment only, (5) reestablishment and brush control. <u>2/</u>
P70	Population, 1970: Total county population, 1970. <u>3/</u>
PR70	Population, Rural, 1970: County population classified as rural, 1970. <u>3/</u>
PT	Pastureland: Total county acreage of pastureland. <u>2/</u>
RNFN	Ratio of Non-Forest Land Needs: Sum of CNT, PNT, and ONT divided by COAR. <u>2/</u>
RTN	Ratio of Total Needs: Value of TNT divided by COAR. <u>2/</u>
SS	Soil Survey: Dummy variable to indicate presence or absence of a detailed soil survey in the county. SS was set equal to one if only the field survey had been completed, as well as if the completed report had been published. <u>4/</u>
TIME	Time: Total man-hours of SCS technical assistance time charged to the county for planning and application of conservation measures (SCS financial project CO-01). <u>1/</u>

TNT Total Acreage Needing Treatment: Sum of CNT, PNT, ONT and forest land acreage needing treatment. 2/

UBT Urban and Built-up Area: Total county acreage of urban and built-up land. 2/

VAPS Value of Agricultural Products Sold: County average per farm market value of all agricultural products sold, 1969. 5/

1/ Annual Summary of Time and Progress Reports, 1972 Fiscal Year (unpublished data in files of the Soil Conservation Service, East Lansing, Michigan).

2/ Michigan State Conservation Needs Inventory Committee, Michigan Conservation Needs Inventory (East Lansing, 1970).

3/ Michigan State University, Graduate School of Business Administration, Division of Research, Michigan Statistical Abstract (East Lansing, 1972), Table I-7, pages 38-41.

4/ Status of Soil Surveys in Michigan (unpublished data in files of the Soil Conservation Service, East Lansing, Michigan).

5/ U.S. Bureau of the Census, Census of Agriculture, 1969, Volume 1, Area Reports, Part 13, Michigan Section 2, County Data (Washington: U.S. Government Printing Office, 1972), Table 4.

APPENDIX D

**EROSION REDUCTION TABLES
FOR SELECTED COUNTIES
IN LAND RESOURCE AREA 98**

APPENDIX TABLE 1.--ESTIMATED AVERAGE ANNUAL SOIL LOSS AND EROSION REDUCTION PER ACRE FOR FIVE CROPLAND TREATMENT CATEGORIES, BY LAND CAPABILITY CLASS, BY COUNTY, LAND RESOURCE AREA 90

CROPLAND TREATMENT CATEGORY																
CROP RESIDUE USE				MINIMUM TILLAGE			CONTOURING			STRIPCRIPPING			PERMANENT COVER			
SOIL LOSS CONDITION 1/																
COUNTY	LCC	NT	WT	FRED	NT	WT	FRED	NT	WT	FRED	NT	WT	FRED	NT	WT	FRED
BARRY		TONS PER ACRE														
	I	1.03	0.82	0.21	1.03	0.57	0.46	1.03	0.41	0.62	0.0	0.0	0.0	0.0	0.0	0.0
	II E	3.11	2.46	0.65	3.11	1.73	1.38	3.11	1.23	1.88	3.11	0.61	2.50	3.11	0.17	2.94
	II W	1.26	1.00	0.26	1.26	0.70	0.56	1.26	0.50	0.76	1.26	0.25	1.01	1.26	0.07	1.19
	II S	1.27	1.00	0.27	1.27	0.70	0.57	1.27	0.50	0.77	1.27	0.25	1.02	1.27	0.07	1.20
	III E	8.30	6.57	1.73	8.30	4.63	3.67	8.30	3.94	4.36	8.30	1.97	6.33	8.30	0.55	7.75
	III W	2.01	1.59	0.42	2.01	1.12	0.89	2.01	0.79	1.22	2.01	0.39	1.62	2.01	0.11	1.90
	III S	1.27	1.00	0.27	1.27	0.70	0.57	1.27	0.50	0.77	1.27	0.25	1.02	1.27	0.07	1.20
	IV E	16.98	13.44	3.54	16.98	9.48	7.50	16.98	10.75	6.23	16.98	5.37	11.61	16.98	1.51	15.47
	IV W	1.59	1.26	0.33	1.59	0.89	0.70	1.59	0.63	0.96	1.59	0.31	1.28	1.59	0.08	1.51
	IV S	1.27	1.00	0.27	1.27	0.70	0.57	1.27	0.50	0.77	1.27	0.25	1.02	1.27	0.07	1.20
	V E	5.89	5.43	0.46	5.89	3.81	2.08	5.89	4.34	1.55	5.89	2.17	3.72	5.89	0.61	5.28
	V S	0.67	0.62	0.05	0.67	0.43	0.24	0.67	0.31	0.36	0.67	0.16	0.51	0.67	0.04	0.63
	VI E	11.23	10.35	0.88	11.23	7.26	3.97	11.23	9.31	1.92	11.23	4.66	6.57	11.23	1.31	9.92
	VI S	2.70	2.49	0.21	2.70	1.75	0.95	2.70	1.99	0.71	2.70	1.00	1.70	2.70	0.28	2.42

SEE FOOTNOTES AT END OF TABLE

APPENDIX TABLE 1.—CONTINUED

		CROPLAND TREATMENT CATEGORY														
		CRCP RESIDUE USE			MINIMUM TILLAGE			CONTOURING			STRIP-CROPPING			PERMANENT COVER		
		SOIL LOSS CONDITION 1/														
COUNTY	LCC	NT	WT	ERED	NT	WT	ERED	NT	WT	ERED	NT	WT	ERED	NT	WT	ERED
BRANCH	TONS PER ACRE															
	I	4.49	3.37	1.12	4.49	2.24	2.25	4.49	1.68	2.81	0.0	0.0	0.0	0.0	0.0	0.0
	II E	3.11	2.46	0.65	3.11	1.73	1.38	3.11	1.23	1.88	3.11	0.61	2.50	3.11	0.17	2.94
	II W	1.26	1.00	0.26	1.26	0.70	0.56	1.26	0.50	0.76	1.26	0.25	1.01	1.26	0.07	1.19
	II S	1.27	1.00	0.27	1.27	0.70	0.57	1.27	0.50	0.77	1.27	0.25	1.02	1.27	0.07	1.20
	III E	8.30	6.57	1.73	8.30	4.63	3.67	8.30	3.94	4.36	8.30	1.97	6.33	8.30	0.55	7.75
	III W	2.01	1.59	0.42	2.01	1.12	0.89	2.01	0.79	1.22	2.01	0.39	1.62	2.01	0.11	1.90
	III S	1.27	1.00	0.27	1.27	0.70	0.57	1.27	0.50	0.77	1.27	0.25	1.02	1.27	0.07	1.20
	IV E	16.98	13.44	3.54	16.98	9.48	7.50	16.98	10.75	6.23	16.98	5.37	11.61	16.98	1.51	15.47
	IV W	1.59	1.26	0.33	1.59	0.89	0.70	1.59	0.63	0.96	1.59	0.31	1.28	1.59	0.08	1.51
	IV S	1.27	1.00	0.27	1.27	0.70	0.57	1.27	0.50	0.77	1.27	0.25	1.02	1.27	0.07	1.20
	V E	5.89	5.43	0.46	5.89	3.81	2.08	5.89	4.34	1.55	5.89	2.17	3.72	5.89	0.61	5.28
	V S	0.67	0.62	0.05	0.67	0.43	0.24	0.67	0.31	0.36	0.67	0.16	0.51	0.67	0.04	0.63
	VI E	11.23	10.35	0.88	11.23	7.26	3.97	11.23	9.31	1.92	11.23	4.66	6.57	11.23	1.31	9.92
	VI S	2.70	2.49	0.21	2.70	1.75	0.95	2.70	1.99	0.71	2.70	1.00	1.70	2.70	0.28	2.42

SEE FOOTNOTES AT END OF TABLE

APPENDIX TABLE 1.—CONTINUED

		CROPLAND TREATMENT CATEGORY														
		CROP RESIDUE USE			MINIMUM TILLAGE			CONTOURING			STRIPCRIPPING			PERMANENT COVER		
		SOIL LOSS CONDITION 1/														
COUNTY	LCC	NT	WT	ERED	NT	WT	ERED	NT	WT	ERED	NT	WT	ERED	NT	WT	ERED
GENESEE		TONS PER ACRE														
	I	4.49	3.37	1.12	4.49	2.24	2.25	4.49	1.68	2.81	0.0	0.0	0.0	0.0	0.0	0.0
	II E	7.78	6.22	1.56	7.78	5.18	2.60	7.78	3.11	4.67	7.78	1.55	6.23	7.78	0.51	7.27
	II W	3.17	2.53	0.64	3.17	2.11	1.06	3.17	1.26	1.91	3.17	0.63	2.54	3.17	0.21	2.96
	II S	1.27	1.00	0.27	1.27	0.70	0.57	1.27	0.50	0.77	1.27	0.25	1.02	1.27	0.07	1.20
	III E	20.76	16.61	4.15	20.76	13.84	6.92	20.76	9.96	10.80	20.76	4.98	15.78	20.76	1.66	19.10
	III W	5.04	4.03	1.01	5.04	3.36	1.68	5.04	2.01	3.03	5.04	1.00	4.04	5.04	0.33	4.71
	III S	1.27	1.00	0.27	1.27	0.70	0.57	1.27	0.50	0.77	1.27	0.25	1.02	1.27	0.07	1.20
	IV E	42.45	33.96	8.49	42.45	28.30	14.15	42.45	27.17	15.28	42.45	13.58	28.87	42.45	4.52	37.93
	IV W	3.99	3.19	0.80	3.99	2.66	1.33	3.99	1.59	2.40	3.99	0.79	3.20	3.99	0.26	3.73
	IV S	1.27	1.00	0.27	1.27	0.70	0.57	1.27	0.50	0.77	1.27	0.25	1.02	1.27	0.07	1.20
	V E	5.89	5.43	0.46	5.89	3.81	2.08	5.89	4.34	1.55	5.89	2.17	3.72	5.89	0.61	5.28
	V S	0.67	0.62	0.05	0.67	0.43	0.24	0.67	0.31	0.36	0.67	0.16	0.51	0.67	0.04	0.63
	VII E	11.23	10.35	0.88	11.23	7.26	3.97	11.23	9.31	1.92	11.23	4.66	6.57	11.23	1.31	9.92
	VII S	2.70	2.49	0.21	2.70	1.75	0.95	2.70	1.99	0.71	2.70	1.00	1.70	2.70	0.28	2.42

SEE FOOTNOTES AT END OF TABLE

APPENDIX TABLE 1A--CONTINUED

		CROPLAND TREATMENT CATEGORY														
		CROP RESIDUE USE			MINIMUM TILLAGE			CONTOURING			STRIPCRIPPING			PERMANENT COVER		
		SOIL LOSS CONDITION 1/														
COUNTY	LCC	NT	WT	EBED	NT	WT	EBED	NT	WT	EBED	NT	WT	EBED	NT	WT	EBED
COUNTY		TONS PER ACRE														
	I	4.49	3.37	1.12	4.49	2.24	2.25	4.49	1.68	2.81	0.0	0.0	0.0	0.0	0.0	0.0
	IIE	7.78	6.22	1.56	7.78	5.18	2.60	7.78	3.11	4.67	7.78	1.55	6.23	7.78	0.51	7.27
	IIM	3.17	2.53	0.64	3.17	2.11	1.06	3.17	1.26	1.91	3.17	0.63	2.54	3.17	0.21	2.96
	IIS	1.27	1.00	0.27	1.27	0.70	0.57	1.27	0.50	0.77	1.27	0.25	1.02	1.27	0.07	1.20
	IIIE	20.76	16.61	4.15	20.76	13.84	6.92	20.76	9.96	10.80	20.76	4.98	15.78	20.76	1.66	19.10
	IIIM	5.04	4.03	1.01	5.04	3.36	1.68	5.04	2.01	3.03	5.04	1.00	4.04	5.04	0.33	4.71
	IIIS	1.27	1.00	0.27	1.27	0.70	0.57	1.27	0.50	0.77	1.27	0.25	1.02	1.27	0.07	1.20
	IIE	42.45	33.96	8.49	42.45	28.30	14.15	42.45	27.17	15.28	42.45	13.59	28.87	42.45	4.52	37.93
	IIM	3.99	3.19	0.80	3.99	2.66	1.33	3.99	1.59	2.40	3.99	0.79	3.20	3.99	0.26	3.73
	IIS	1.27	1.00	0.27	1.27	0.70	0.57	1.27	0.50	0.77	1.27	0.25	1.02	1.27	0.07	1.20
	VE	5.89	5.43	0.46	5.89	3.81	2.08	5.89	4.34	1.55	5.89	2.17	3.72	5.89	0.61	5.28
	VIS	0.67	0.62	0.05	0.67	0.43	0.24	0.67	0.31	0.36	0.67	0.16	0.51	0.67	0.04	0.63
	VE	11.23	10.35	0.88	11.23	7.26	3.97	11.23	9.31	1.92	11.23	4.66	6.57	11.23	1.31	9.92
	VIS	2.70	2.49	0.21	2.70	1.75	0.95	2.70	1.99	0.71	2.70	1.00	1.70	2.70	0.28	2.42

SEE FOOTNOTES AT END OF TABLE

APPENDIX TABLE 1.--CONTINUED

		CROPLAND TREATMENT CATEGORY														
		CROP RESIDUE USE			MINIMUM TILLAGE			CONTOURING			STRIPCROPPING			PERMANENT COVER		
		SOIL LOSS CONDITION 1/														
COUNTY	LCC	NT	WT	ERED	NT	WT	ERED	NT	WT	ERED	NT	WT	ERED	NT	WT	ERED
WASHTENAW		TONS PER ACRE														
	I	4.49	3.37	1.12	4.49	2.24	2.25	4.49	1.68	2.81	0.0	0.0	0.0	0.0	0.0	0.0
	II E	3.11	2.46	0.65	3.11	1.73	1.38	3.11	1.23	1.88	3.11	0.61	2.50	3.11	0.17	2.94
	II W	3.17	2.53	0.64	3.17	2.11	1.06	3.17	1.26	1.91	3.17	0.63	2.54	3.17	0.21	2.96
	II S	1.27	1.00	0.27	1.27	0.70	0.57	1.27	0.50	0.77	1.27	0.25	1.02	1.27	0.07	1.20
	III E	8.30	6.57	1.73	8.30	4.63	3.67	8.30	3.94	4.36	8.30	1.97	6.33	8.30	0.55	7.75
	III W	5.04	4.03	1.01	5.04	3.36	1.68	5.04	2.01	3.03	5.04	1.00	4.04	5.04	0.33	4.71
	III S	1.27	1.00	0.27	1.27	0.70	0.57	1.27	0.50	0.77	1.27	0.25	1.02	1.27	0.07	1.20
	IV E	16.98	13.44	3.54	16.98	9.48	7.50	16.98	10.75	6.23	16.98	5.37	11.61	16.98	1.51	15.47
	IV W	3.99	3.19	0.80	3.99	2.66	1.33	3.99	1.59	2.40	3.99	0.79	3.20	3.99	0.26	3.73
	IV S	1.27	1.00	0.27	1.27	0.70	0.57	1.27	0.50	0.77	1.27	0.25	1.02	1.27	0.07	1.20
	V E	5.89	5.43	0.46	5.89	3.81	2.08	5.89	4.34	1.55	5.89	2.17	3.72	5.89	0.61	5.28
	V S	0.67	0.62	0.05	0.67	0.43	0.24	0.67	0.31	0.36	0.67	0.16	0.51	0.67	0.04	0.63
	VI E	11.23	10.35	0.88	11.23	7.26	3.97	11.23	9.31	1.92	11.23	4.66	6.57	11.23	1.31	9.92
	VI S	2.70	2.49	0.21	2.70	1.75	0.95	2.70	1.99	0.71	2.70	1.00	1.70	2.70	0.28	2.42

1/ NT: NO TREATMENT; WT: WITH TREATMENT; ERED: EROSION REDUCTION DUE TO TREATMENT. SOIL LOSS ESTIMATES FOR STRIPCROPPING OR PERMANENT COVER ON CLASS I LAND WERE NOT INCLUDED IN THE DATA.

SOURCE: COMPUTED FROM UNPUBLISHED DATA PROVIDED BY THE SOIL CONSERVATION SERVICE.

APPENDIX TABLE 2.--DISTRIBUTION OF CROPLAND EROSION CONTROL NEEDS AMONG LAND CAPABILITY CLASSES, BY TREATMENT NEED CATEGORY, BY COUNTY, LAND RESOURCE AREA 98

COUNTY	LCC	TREATMENT NEED CATEGORY							
		RESIDUE AND ANNUAL COVER 1/		CONTOURING		STRIP-CROPPING		PERMANENT COVER	
		ACRES	PERCENT	ACRES	PERCENT	ACRES	PERCENT	ACRES	PERCENT
BARRY	I	0.	0.0	0.	0.0	0.	0.0	0.	0.0
	II E	17955.	32.96	2623.	61.91	404.	50.00	0.	0.0
	II W	10896.	20.00	0.	0.0	0.	0.0	0.	0.0
	II S	605.	1.11	0.	0.0	0.	0.0	0.	0.0
	III E	10655.	19.63	807.	19.05	404.	50.00	0.	0.0
	III W	1210.	2.22	0.	0.0	0.	0.0	0.	0.0
	III S	3027.	5.56	807.	19.05	0.	0.0	0.	0.0
	IV E	7466.	13.70	0.	0.0	0.	0.0	2421.	44.43
	IV W	0.	0.0	0.	0.0	0.	0.0	0.	0.0
	IV S	807.	1.48	0.	0.0	0.	0.0	0.	0.0
	V E	1211.	2.22	0.	0.0	0.	0.0	1615.	29.64
	V S	202.	0.37	0.	0.0	0.	0.0	0.	0.0
	VII E	404.	0.74	0.	0.0	0.	0.0	1413.	25.93
	VII S	0.	0.0	0.	0.0	0.	0.0	0.	0.0
	TOTAL	54482.	100.00	4237.	100.00	808.	100.00	5449.	100.00

SEE FOOTNOTES AT END OF TABLE

APPENDIX TABLE 2.--CONTINUED

		TREATMENT NEED CATEGORY							
COUNTY	LCC	RESIDUE AND ANNUAL COVER 1/		CONTOURING		STRIPCRIPPING		PERMANENT COVER	
BRANCH		ACRES	PERCENT	ACRES	PERCENT	ACRES	PERCENT	ACRES	PERCENT
I		0.	0.0	0.	0.0	0.	0.0	0.	0.0
IIF		8769.	14.18	438.	100.00	2192.	24.39	0.	0.0
IIW		16442.	26.60	0.	0.0	5042.	56.10	0.	0.0
IIS		24334.	39.36	0.	0.0	0.	0.0	0.	0.0
IIIE		0.	0.0	0.	0.0	1754.	19.51	0.	0.0
IIIW		6358.	10.28	0.	0.0	0.	0.0	0.	0.0
IIIS		5919.	9.57	0.	0.0	0.	0.0	0.	0.0
IVE		0.	0.0	0.	0.0	0.	0.0	0.	0.0
IVW		0.	0.0	0.	0.0	0.	0.0	0.	0.0
IVS		0.	0.0	0.	0.0	0.	0.0	0.	0.0
VIF		0.	0.0	0.	0.0	0.	0.0	0.	0.0
VIS		0.	0.0	0.	0.0	0.	0.0	0.	0.0
VIIE		0.	0.0	0.	0.0	0.	0.0	0.	0.0
VIIS		0.	0.0	0.	0.0	0.	0.0	0.	0.0
TOTAL		61822.	100.00	438.	100.00	8988.	100.00	0.	0.0

SEE FOOTNOTES AT END OF TABLE

APPENDIX TABLE 2.--CONTINUED

COUNTY	LCC	TREATMENT NEED CATEGORY							
		RESIDUE AND ANNUAL COVER 1/		CONTOURING		STRIPCRIPPING		PERMANENT COVER	
GENESEE		ACRES	PERCENT	ACRES	PERCENT	ACRES	PERCENT	ACRES	PERCENT
	I	0.	0.0	0.	0.0	0.	0.0	0.	0.0
	IIE	9760.	28.57	0.	0.0	0.	0.0	0.	0.0
	IIW	15483.	45.33	152.	100.00	0.	0.0	0.	0.0
	IIS	0.	0.0	0.	0.0	0.	0.0	0.	0.0
	IIIE	1022.	2.99	0.	0.0	0.	0.0	0.	0.0
	IIW	3249.	9.51	0.	0.0	0.	0.0	0.	0.0
	IIIS	1128.	3.30	0.	0.0	0.	0.0	0.	0.0
	IVE	323.	0.95	0.	0.0	0.	0.0	108.	100.00
	IVW	431.	1.26	0.	0.0	0.	0.0	0.	0.0
	IVS	2410.	7.06	0.	0.0	0.	0.0	0.	0.0
	VIE	0.	0.0	0.	0.0	0.	0.0	0.	0.0
	VIS	351.	1.03	0.	0.0	0.	0.0	0.	0.0
	VIIE	0.	0.0	0.	0.0	0.	0.0	0.	0.0
	VIIS	0.	0.0	0.	0.0	0.	0.0	0.	0.0
	TOTAL	34156.	100.00	152.	100.00	0.	0.0	108.	100.00

SEE FOOTNOTES AT END OF TABLE

APPENDIX TABLE 2--CONTINUED

		TREATMENT NEED CATEGORY							
COUNTY	LCC	RESIDUE AND ANNUAL COVER 1/		CONTOURING		STRIPCRIPPING		PERMANENT COVER	
GRATIOT		ACRES	PERCENT	ACRES	PERCENT	ACRES	PERCENT	ACRES	PERCENT
	I	0.	0.0	0.	0.0	0.	0.0	0.	0.0
	IIF	3059.	2.99	0.	0.0	204.	7.15	0.	0.0
	IIW	76657.	75.05	0.	0.0	0.	0.0	0.	0.0
	IIS	0.	0.0	0.	0.0	0.	0.0	0.	0.0
	IIIE	0.	0.0	0.	0.0	0.	0.0	204.	100.00
	IIIW	18961.	18.56	0.	0.0	2243.	78.56	0.	0.0
	IIIS	0.	0.0	0.	0.0	0.	0.0	0.	0.0
	IVF	0.	0.0	0.	0.0	408.	14.29	0.	0.0
	IVW	2447.	2.40	0.	0.0	0.	0.0	0.	0.0
	IVS	1020.	1.00	0.	0.0	0.	0.0	0.	0.0
	VIF	0.	0.0	0.	0.0	0.	0.0	0.	0.0
	VIS	0.	0.0	0.	0.0	0.	0.0	0.	0.0
	VIIE	0.	0.0	0.	0.0	0.	0.0	0.	0.0
	VIIS	0.	0.0	0.	0.0	0.	0.0	0.	0.0
	TOTAL	102143.	100.00	0.	0.0	2855.	100.00	204.	100.00

SEE FOOTNOTES AT END OF TABLE

APPENDIX TABLE 2.--CONTINUED

COUNTY	LCC	TREATMENT NEED CATEGORY							
		RESIDUE AND ANNUAL COVER 1/		CONTOURING		STRIPCRIPPING		PERMANENT COVER	
		ACRES	PERCENT	ACRES	PERCENT	ACRES	PERCENT	ACRES	PERCENT
WASHTENAW	I	0.	0.0	0.	0.0	0.	0.0	0.	0.0
	IIF	20504.	33.70	0.	0.0	1799.	40.00	0.	0.0
	IIW	9890.	15.94	0.	0.0	450.	10.01	0.	0.0
	IIS	450.	0.73	0.	0.0	225.	5.00	0.	0.0
	IIIE	8541.	13.77	675.	42.86	1798.	39.98	0.	0.0
	IIIW	8317.	13.41	0.	0.0	225.	5.00	0.	0.0
	IIIS	7642.	12.32	225.	14.29	0.	0.0	0.	0.0
	IVE	2473.	3.99	225.	14.29	0.	0.0	225.	20.02
	IVW	1799.	2.93	0.	0.0	0.	0.0	0.	0.0
	IVS	1349.	2.17	0.	0.0	0.	0.0	0.	0.0
	VIE	674.	1.09	450.	28.57	0.	0.0	899.	79.98
	VIS	0.	0.0	0.	0.0	0.	0.0	0.	0.0
	VIIE	0.	0.0	0.	0.0	0.	0.0	0.	0.0
	VIIS	0.	0.0	0.	0.0	0.	0.0	0.	0.0
	TOTAL	62038.	100.00	1575.	100.00	4497.	100.00	1124.	100.00

1/ CORRESPONDS TO BOTH CROP RESIDUE USE AND MINIMUM TILLAGE PRACTICES.

SOURCE: COMPUTED FROM MICHIGAN CONSERVATION NEEDS INVENTORY, 1967, TABLE 5, PP. 57-73.

APPENDIX TABLE 3.--WEIGHTED AVERAGE ANNUAL EROSION REDUCTION PER ACRE FOR FIVE CROPLAND TREATMENT CATEGORIES, BY LAND CAPABILITY CLASS, BY COUNTY, LAND RESOURCE AREA 9B

COUNTY	LCC	CROPLAND TREATMENT CATEGORY				
		CROP RESIDUE USE	MINIMUM TILLAGE	CONTOURING	STRIP- CROPPING	PERMENENT COVER
BARRY				TONS PER ACRE		
	I	0.0	0.0	0.0	0.0	0.0
	IIE	0.21	0.45	1.16	1.25	0.0
	IIW	0.05	0.11	0.0	0.0	0.0
	IIS	0.00	0.01	0.0	0.0	0.0
	IIIE	0.34	0.72	0.83	3.16	0.0
	IIIW	0.01	0.02	0.0	0.0	0.0
	IIIS	0.02	0.03	0.15	0.0	0.0
	IVE	0.48	1.03	0.0	0.0	6.87
	IVW	0.0	0.0	0.0	0.0	0.0
	IVS	0.00	0.01	0.0	0.0	0.0
	VIE	0.01	0.05	0.0	0.0	1.56
	VIS	0.00	0.00	0.0	0.0	0.0
	VIIE	0.01	0.03	0.0	0.0	2.57
	VIIS	0.0	0.0	0.0	0.0	0.0
	TOTAL	1.14	2.46	2.14	4.41	11.01

APPENDIX TABLE 3.--CONTINUED

COUNTY	CROPLAND TREATMENT CATEGORY					PERMENENT COVER
	LCC	CROP RESIDUE USE	MINIMUM TILLAGE	CONTOURING	STRIP- CROPPING	
BRANCH	TONS PER ACRE					
I		0.0	0.0	0.0	0.0	0.0
IIE		0.09	0.20	1.88	0.61	0.0
IIW		0.07	0.15	0.0	0.57	0.0
IIS		0.11	0.22	0.0	0.0	0.0
IIIE		0.0	0.0	0.0	1.23	0.0
IIIW		0.04	0.09	0.0	0.0	0.0
IIIS		0.03	0.05	0.0	0.0	0.0
IVE		0.0	0.0	0.0	0.0	0.0
IVW		0.0	0.0	0.0	0.0	0.0
IVS		0.0	0.0	0.0	0.0	0.0
VIIE		0.0	0.0	0.0	0.0	0.0
VIS		0.0	0.0	0.0	0.0	0.0
VIIE		0.0	0.0	0.0	0.0	0.0
VIIS		0.0	0.0	0.0	0.0	0.0
TOTAL		0.34	0.72	1.88	2.41	0.0

APPENDIX TABLE 3.--CONTINUED

CROPLAND TREATMENT CATEGORY						
COUNTY	LCC	CROP RESIDUE USE	MINIMUM TILLAGE	CONTOURING	STRIP- CROPPING	PERMENENT COVER
GENESEE		TONS PER ACRE				
	I	0.0	0.0	0.0	0.0	0.0
	IIE	0.45	0.74	0.0	0.0	0.0
	IIW	0.29	0.48	1.91	0.0	0.0
	IIS	0.0	0.0	0.0	0.0	0.0
	IIIE	0.12	0.21	0.0	0.0	0.0
	IIIW	0.10	0.16	0.0	0.0	0.0
	IIIS	0.01	0.02	0.0	0.0	0.0
	IVE	0.08	0.13	0.0	0.0	37.93
	IVW	0.01	0.02	0.0	0.0	0.0
	IVS	0.02	0.04	0.0	0.0	0.0
	VIE	0.0	0.0	0.0	0.0	0.0
	VIS	0.00	0.00	0.0	0.0	0.0
	VIIIE	0.0	0.0	0.0	0.0	0.0
	VIIIS	0.0	0.0	0.0	0.0	0.0
TOTAL		1.08	1.80	1.91	0.0	37.93

APPENDIX TABLE 3.--CONTINUED

COUNTY	LCC	CROPLAND TREATMENT CATEGORY				
		CROP RESIDUE USE	MINIMUM TILLAGE	CONTOURING	STRIP- CROPPING	PERMENENT COVER
GRATIOT				TONS PER ACRE		
	I	0.0	0.0	0.0	0.0	0.0
	II E	0.05	0.08	0.0	0.45	0.0
	II W	0.48	0.80	0.0	0.0	0.0
	II S	0.0	0.0	0.0	0.0	0.0
	III E	0.0	0.0	0.0	0.0	19.10
	III W	0.19	0.31	0.0	3.17	0.0
	III S	0.0	0.0	0.0	0.0	0.0
	IV E	0.0	0.0	0.0	4.13	0.0
	IV W	0.02	0.03	0.0	0.0	0.0
	IV S	0.00	0.01	0.0	0.0	0.0
	V E	0.0	0.0	0.0	0.0	0.0
	V S	0.0	0.0	0.0	0.0	0.0
	VI E	0.0	0.0	0.0	0.0	0.0
	VI S	0.0	0.0	0.0	0.0	0.0
	VII E	0.0	0.0	0.0	0.0	0.0
	VII S	0.0	0.0	0.0	0.0	0.0
	TOTAL	0.74	1.22	0.0	7.74	19.10

APPENDIX TABLE 3.--CONTINUED

CROPLAND TREATMENT CATEGORY						
COUNTY	LCC	CROP RESIDUE USE	MINIMUM TILLAGE	CONTOURING	STRIP- CROPPING	PERMENENT COVER
WASHTENAW		TONS PER ACRE				
	I	0.0	0.0	0.0	0.0	0.0
	IIE	0.22	0.47	0.0	1.00	0.0
	IIW	0.10	0.17	0.0	0.25	0.0
	IIS	0.00	0.00	0.0	0.05	0.0
	IIIE	0.24	0.51	1.87	2.53	0.0
	IIIW	0.14	0.23	0.0	0.20	0.0
	IIIS	0.03	0.07	0.11	0.0	0.0
	IVE	0.14	0.30	0.89	0.0	3.10
	IVW	0.02	0.04	0.0	0.0	0.0
	IVS	0.01	0.01	0.0	0.0	0.0
	VIE	0.01	0.02	0.44	0.0	4.22
	VIS	0.0	0.0	0.0	0.0	0.0
	VIEE	0.0	0.0	0.0	0.0	0.0
	VIIIS	0.0	0.0	0.0	0.0	0.0
TOTAL		0.91	1.81	3.31	4.04	7.32