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ABSTRACT

A CASE STUDY OF THE ECONOMIC IMPACTS OF FARM SOIL LOSS CONTROLS

By

Richard W. Carkner

This study investigates the economic impacts of imposing soil loss controls on a case study farm. These controls represent an attempt to regulate environmental quality through legislation. Controls are a response to the concern for improving the quality of our natural environment.

Previous studies dealt with the economics of soil conservation from the standpoint of maintaining agricultural productivity. More current research on soil loss control adds an environmental quality dimension. These studies include conceptual models and large area studies, however, detail is insufficient to accurately assess economic impacts for land users.

Sediment and erosion control literature and legal tools available to improve the environment (including recently passed soil loss legislation) are reviewed.

The economic impacts of soil loss controls were evaluated within a theoretical setting, and then modeled using a profit maximizing linear programming model. The crop production and soil loss model was based on the detailed

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characteristics of a case study farm. A case study was used because soil loss legislation applies to individual land users with all their subtle differences in enterprises, location, and scale of operation.

Results for the case study farm indicate that soil loss constraints specified in the Iowa Conservancy Legislation do not significantly reduce farm profits. This could imply that a wider application of soil loss controls is economically feasible. However, cautions should be considered before generalizing. Soil loss controls are likely to have different impacts on land users depending on their location, soil type and enterprise combinations. For example, soil loss controls eliminate row crop production on steeply sloping land regardless of the tillage system used. Less intensive land use (sod crops) would result in reduced farm income. Additional research is necessary to study a broader range of physical and economic circumstances under which soil loss controls might be imposed.

Any of the six combinations of tillage systems and conservation practices can meet the Iowa soil loss limits for the case study farm. Important in reducing soil loss, regardless of the tillage practices used is to match land management systems with soil characteristics and slope. Further research on the economics of alternative crop production soil loss controlling technology is needed.

A CASE STUDY OF THE ECONOMIC IMPACTS
OF FARM SOIL LOSS CONTROLS

By

Richard W. Carkner

A THESIS

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CHAPTER I

INTRODUCTION

Concern for the quality of the natural environment has become widespread and is expressed at all levels of government. President Nixon in a 1970 address to Congress stated "....this represents the first time in the history of nations that a people has paused, consciously and systematically, to take comprehensive stock of the quality of its surroundings."¹ This concern has led to the establishment of improving environmental quality as a national policy goal.

Agriculture has been identified as a major source of water pollution. Sediment (soil particles washed into streams) in the magnitude of 4 billion tons, are deposited in U.S. streams annually.² This is the largest single stream pollutant. And more than half of these deposits are estimated to come from agricultural lands.³

Some degree of progress has been reported in reducing sediment. However, the nutrient problem (fertilizers carried by soil particles) is getting worse.⁴ It is suggested that the problem might best be solved by better watershed management (holding soil in place) than by curtailing fertilizer applications. Voluntary compliance with soil management practices that reduce soil loss has been inadequate to achieve the degree of control desired. Hence,

response to the concern over sediment pollution is manifested in recently passed legislation. Examples include the Iowa Conservancy Law (May 1971), a revision to existing Wisconsin statutes (May 1972), and at the Federal level, a Bill to revise the Federal Water Pollution Control Act (S2770) to specifically include nonpoint (sediment) sources of water pollution.

The Problem

Environmental quality legislation is often passed without a complete assessment of the economic implications. These circumstances are common to many types of regulatory legislation. Expediency simply does not allow waiting until all information is available. The Iowa Conservancy Law was chosen for study because it is currently being implemented and it represents a pioneer effort in conservancy legislation. The Law's objective is to preserve and protect the public interest in the soil and water resources of Iowa. This objective will be pursued by an administrative body with authority to impose limits on soil loss.

The purpose of this study is to evaluate the impact of the Iowa Conservancy Law on a case study farm. It is hypothesized that legislated soil loss controls will increase crop production costs and in turn, increase the cost of meeting feed requirement needs of livestock enterprises. The magnitude of the impact will depend on the nature and level of soil loss controls, soil types and feed requirements

relative to soil productivity and size of farm. In sum, this study is an attempt to evaluate the impact of imposing soil loss limits on a given system of enterprise organization.

Research Objectives

Objectives of this study include:

- (1) Review the literature on physical and economic aspects of controlling erosion and sedimentation.
- (2) Review environmental law, in particular soil loss legislation as it applies to a case study farm.
- (3) Determine the economic impact of soil loss regulations on a case study farm.

Meeting these objectives will provide needed information for policy makers and farmers on the impact of imposing soil loss regulations on farms.

Method and Procedure

Study Area

The case chosen for study is a dairy farm in South Eastern Wisconsin. Dairy enterprises are predominant in the region and hence a logical choice for analysis.⁵ The region was chosen because an erosion problem exists and because of the technical assistance from a geologist and personnel employed by the Soil Conservation Service, USDA, in Madison. The particular farm was chosen for a number of reasons. The operator participates in the Production Credit Association's AGRIFAX program and hence has up-to-date, detailed farm records. Secondly, recent airphotos and soils maps are available for the farm. Thirdly, the farm itself

is an economically viable operation, and reasonably representative of other farms in the area. Lastly and importantly, the operator chose to cooperate and has answered numerous requests for additional data.

Research Method

A case study has been selected as opposed to a synthetic firm approach because soil loss legislation applies to individual land users with all their subtle differences in enterprises, location and scale of operation. Soil loss is sensitive to differences in the types and distribution of soils as well as crop management practices employed. Hence, soil loss assessment must be made in a case-by-case basis. Another reason for a case study analysis is the large quantity of primary data necessary to assess soil loss accurately. Detailed land use information is required by soil type, slope, and other variables for each field farmed.

The analytical model used is a profit maximizing linear programming model. A linear programming model has been chosen over simple budgeting procedures because it facilitates the evaluation of a large number of alternatives and allows the consideration of approximations to real world constraints such as limits on the availability of land, labor and other resources.

Procedure

The objectives were achieved by the following procedure. The first objective was accomplished by making a review of selected literature on the physical and economic aspects of

soil loss control. The purpose is to provide background on efforts to control soil loss.

The second objective was fulfilled by a review of environmental law and in particular, legislation to control soil loss. Legislation is increasingly being used in an attempt to curtail environmental degradation. The basis for this legislation and the Iowa Conservation Law are outlined.

Satisfying the first two objectives is necessary to provide a frame of reference for the third objective, evaluating the impact of soil loss controls - the primary focus of this study. The first step is to analyze the imposition of soil loss controls within a theoretical setting.

The second step is to design a profit maximizing model for crop production. The impact of ranged soil loss control levels are evaluated in terms of labor and average costs of production required to produce specified outputs. Soil loss control levels evaluated include those established by the Iowa Conservancy Law.

Only the crop production enterprises of the farm are modeled. Soil loss is generally not a direct function of livestock enterprises except as they dictate the types and mix of crops necessary to support these operations. A profit maximizing crop production model tied to the feed requirements of the dairy operation simplifies modeling and yet meets the objectives of the study.

The feed requirements or demands to be met in the crop

production model are estimated for the dairy herd using a least-cost dairy ration program developed at Michigan State University. Rations for three levels of milk production are balanced using feeds currently being grown and fed.

For each of two soil conservation systems, the model determines the appropriate crop rotation subject to ranged soil loss limits under three tillage systems. The systems are conventional, minimum and no tillage.

To be consistent with profit maximization crop selling transfer activities are included. Also crop purchasing activities are incorporated. This is to prevent infeasibilities in the event the land being farmed is insufficient to produce dairy feed requirements.

The analysis is presented as follows: Chapter II discusses the status of physical and economic research on erosion and sedimentation; Chapter III develops the theoretical basis for environmental quality controls and firm adjustments to controls; Chapter IV reviews environmental legislation and legislation designed to control soil loss, its basis and in particular, the Iowa Conservancy Law; Chapter V describes the linear programming crop production and soil loss model; Chapter VI presents empirical results of the analysis; and Chapter VII provides a summary, conclusions and discusses the studies limitations, implications and needed further research.

CHAPTER I. FOOTNOTES

1. Council on Environmental Quality. Environmental Quality. The First Annual Report of the Council on Environmental Quality Transmittal to Congress, Washington, D.C., U.S. Government Printing Office, Aug. 1970.
2. Wadleigh, Cecil, H. Wastes in Relation to Agriculture and Forestry. U.S.D.A. Misc. Pub. 1065, 1968.
3. Robinson, A. R. "Sediment is Still the Largest Single Pollutant of Water." Farm Journal, p. G4, April 1971.
4. Wall Street Journal. "Environmental Outlays Rising to \$287 Billion in 10 Years Through 1980, U.S. Panel Says," Aug. 8, 1972.
5. Wisconsin Farm Business Summary, 1970 Data Cooperative Extension Programs - University Extension Department of Agricultural Economics; Madison, Wisconsin, 1971.

CHAPTER II

REVIEW OF SELECTED LITERATURE ON EROSION AND SEDIMENTATION

Introduction

One of the questions pertinent to American agriculture is soil conservation. As early as the 1800's George Perkins Marsh, a forerunner of the conservationist movement, in his book Man and Nature, warned that continued disregard for resource management would curtail the progress which seemed inevitable to early American pioneers. Despite this early warning, conservation was not made public policy until President Franklin Delano Roosevelt created the Soil Conservation Service in 1935.¹ Since that time a considerable body of literature has been amassed pertaining to erosion and sedimentation research.

The problems created by erosion and sedimentation cannot be ignored. These two elements reduce the productive power of the land while they mar its aesthetic and physical qualities. They are said to be a multi-edged sword in the deterioration of the environment.² While this chapter will not attempt to review or to expand the information now available, it will endeavor to present a characterization of more recent physical research on sedimentation and a review of

soil conservation and of the economics of soil loss as it relates to environmental quality.

Physical Research on Sedimentation

Sedimentation is a process which includes erosion, transportation, and deposition of sediment.³ It exists as a separate field of study and incorporates soil physics and chemistry as well as the fluid dynamics associated with movement of eroded particles. Published research on soil loss since Hugh Bennett's, "The National Menace of Soil Erosion", has been continuous.⁴ Examples of more recent research can be found in the 1963 Proceedings of The Federal Inter-Agency Sedimentation Conference.⁵ The publication is a collection of papers on land erosion and control and sediment in streams, estuaries and reservoirs.

Some of this physical research has led to the development of a soil loss estimating technique used by agencies planning conservation systems. This method, referred to as the "Universal Soil Loss Equation" represents a synthesis of empirical and theoretical research since 1930 on factors causing soil loss.⁶ In the equation all pertinent research is incorporated to provide design data for conservation plans, and it can be easily revised to incorporate new research findings. The soil loss equation can be used to estimate erosion. However, if sediment yields are to be predicted, a sediment delivery ratio is required. This presents somewhat of an intractable problem because there

are many variables to consider between the initial detachment of soil particles and their ultimate deposition. Crude techniques have been developed to estimate delivery ratios which are based on the size of the drainage area, average stream volume, or length.⁷

Attempts to incorporate more of the relevant variables for estimating sediment yields have led to the development of hydrology simulation models. A model developed by Stanford University is a representation of the hydrological cycle in a watershed.⁸ Streamflow hydrographs are produced using daily evapo-transpiration and hourly precipitation data. Simulation models have been used to estimate the effects of alternative watershed conditions on streamflow characteristics. For example, attempts have been made through simulation to estimate water yields after forest fires.⁹

Mathematical models have been developed to assist in agricultural watershed engineering.¹⁰ Here watershed hydrology is reduced to a pattern of physical probabilities. On a smaller scale, simulation models have been built of the erosion process itself.¹¹ Four subprocesses - soil detachment by rainfall, transport by rainfall, detachment by runoff and transport by runoff - describe soil movement.

A major problem in developing sedimentation simulation models is in assembling the required data. The accuracy of existing suspended sediment data is a source of considerable uncertainty.¹² Under conditions of rapidly fluctuating

discharge sediment concentrations may be continuously changing. With present sampling techniques the actual amount of sediment passing a gage may be measured only by chance. Other problems in developing hydrological simulation models are that many of the physical relationships have not been theoretically developed. Further, probability distributions of weather and other data must be estimated. As the number of unknowns estimated outside the model increases, its validity decreases.

In an attempt to utilize some of the large amounts of physical research on various aspects of sedimentation, a conference was held by the Economic Research and the Agricultural Research Services, USDA in which papers dealing with the entire continuum of sedimentation problems were presented.¹³ The consensus seemed to be that sediment control benefits are a public good. Therefore, social and public interest benefits from sedimentation control should be studied. Approximately half of the papers discussed particularly sedimentation problems, some of which appear to be amenable to measurement. For example, sediment damages to reservoirs, to navigation as part of flood damages, as a factor in increasing flood frequency, and to fish propagation and production, appear reasonably measurable. However, the content of the remaining papers requires further research before a quantitative evaluation can be made. Areas where more research is necessary are : the impact of sediment borne nutrients on water quality, recreation values, and aesthetic considerations. No comprehensive attempt was made at the Conference to quantify or to

specify all damages enumerated for a specific location. This would be a logical starting point in assessing social benefits from erosion control and is an area with potential for research.

Besides taking a piecemeal approach to sediment damages, no attempt was made to focus attention on that portion of sedimentation subject to management versus total sedimentation. A certain amount of sedimentation is a function of dissipating the energy of moving water. The Missouri River was filled with sediment before the first pioneer touched a plow to its drainage basin and was called the "Big Muddy" for this reason. This is what can be called natural sedimentation. Damage estimation relative to erosion control efforts should focus on man induced erosion, i.e., agriculture, construction, etc. Damages from natural erosion should be treated separately. The purpose of making this distinction is to allow the relationship between the costs of erosion control practices, and damages prevented, or benefits, to be properly assessed.

The Economics of Soil Conservation From the Standpoint of Maintaining Soil Productivity

Soil conservation is concerned with maintaining soil productivity into perpetuity. Generally, allowable rates of annual soil loss are a function of soil depth and the rate of soil formation. So-called allowable soil losses have been established for all major soil types.

Soil conservation has been national policy for decades and yet the extent of adoption is less than desired. A number

of studies have been made of factors preventing more widespread adoption of soil conservation practices. Surveys of land users were made by Held and Timmons¹⁴ in 1958 and by Blase and Timmons¹⁵ in 1961. They reported that major problems preventing wider adoption of soil conservation practices were (1) tenure uncertainty of non-owner operators, (2) lack of confidence in recommended practices, and (3) lack of adequate finances and the need for immediate income. In a summary, Held¹⁶ cited economic considerations, customs, and legal arrangements as important variables explaining adoption of soil conservation practices. Farmers failed to see the need to adopt soil conserving practices during a period when yields per acre were rapidly increasing. Low cost fertilizers easily replaced nutrients lost in soil runoff. Currently, larger farms have additional reasons for not adhering strictly to soil conservation practices.¹⁷ Timeliness has been found to be increasingly important and farm operators consider terraces and other conservation measures as obstacles delaying field operations.¹⁸

It was recognized that for voluntary compliance to occur, adoption of conservation practices must not have an adverse affect on farm income. This generated interest in the economics of conservation systems. The Soil Conservation Service prepared a handbook on the economics of conservation.¹⁹ It outlined crop budgeting techniques and the use of discount tables to determine present values. Unfortunately, no concrete examples were included to assist in application. A number of

other studies, using budgeting techniques, have been completed. In an Iowa study, Ball²⁰ was unable to establish an accurate relative measure of soil saved per dollar invested, but at least he outlined a tentative ordering. Coutu²¹ in North Carolina noted after analyzing alternative conservation systems that there is no single answer to the question "Does conservation pay?" because conditions vary so widely. In Kansas, Michael²² found that terraces, grade stabilization, and waterways were uneconomic on most soils. In a report from Tennessee, Atkins states that high levels of conservation (approximately 5 tons/acre/year erosion on most soils) were found not economically justified over time.²³

As if the research techniques used might be partially responsible for the results, additional studies were carried out by other researchers using linear and dynamic programming. Using recursive linear programming Smith and Heady studied the impact of alternative conservation systems over time.²⁴ No conclusions were reached about whether conservation yields a positive economic return. However, they did outline important considerations relating to profitability. They found that conservation plans should be tailored to each farm enterprise situation and adjusted over time. In a study using conventional linear programming Langren concluded that an annual soil loss of 5 tons per acre was consistent with his profit maximizing solution.²⁵ When soil losses were reduced to less than 5 tons per acre, however, profitability was rapidly reduced. Research reported by Anderson concluded

that net profit could be increased and still achieve Soil Conservation Service soil loss recommendations.²⁶

Perhaps variability in study circumstances can account for some of the differences in study results both for budgeting and programming techniques. For example, the studies reviewed were carried out at different points in time and at different locations. Cost and price assumptions obviously affect profitability and vary over time. Differences in the profitability of conservation practices due to location include the distribution and type of soils and the mix of crop and livestock enterprises indigenous to the area. For level, well-drained soils, rainfall erosion is minimal and hence only limited conservation practices are necessary in order to achieve Soil Conservation Service soil loss goals. With steeper sloped, highly erosive soils, more expensive conservation practices (e.g. terraces) are necessary to allow intensive cropping consistent with soil loss limits.

From the studies reviewed it appears that soil conservation from the standpoint of maintaining agricultural productivity is not profitable in some circumstances. This is an important reason for the limited success of voluntarily adopted soil conservation programs. There are, however, differences of opinion. For example, one researcher explains: "Experience has shown that land treatment measures (conservation practices) usually result in high benefit-cost ratios so that this ratio need not be computed for justification of watershed protection projects."²⁷

*Parenthesis mine.

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The Economics of Soil Conservation From
the Standpoint of Environmental Quality

Soil conservation research reviewed in the previous section was focused on maintaining the crop producing potential of the nation's soils. The current interest in soil loss has taken on the added dimension of environmental quality. This represents a broader perspective than earlier work and involves man's relationship with his total environment. Frequent reference can be found to sedimentation as an environmental quality problem.²⁸

When discussing sediment as a pollutant the properties of sediment must be considered. Sediment is a complicated substance with physical, chemical, and biological properties; all of which influence the environment.

The erosion, transport and deposition processes are selective since coarse sediment moves differently than fine sediment. Fine sediment is composed of silts, clays, and organic materials which may have chemically active properties. It may sorb ions from solution or release ions to solution depending on the chemical environment. Reactions between chemicals and colloidal sediment determine the relative concentration of pollutants in solution and suspension. In general, coarse sediment tends to buffer the dissolved and suspended chemical load. It is primarily coarse sediment that is more readily controlled with available technology. We do not know yet how to control the amounts of clay and colloidal fractions which constitute the bulk of our sediment problems. This is true of both at the sediment source and in the final disposition of the material.

In its role as a scavenger, sediment may sorb chemicals from solution and then deposit them in stream channels or reservoirs. The deposited pollutants may or may not stay in place. They may desorb or react to re-enter the stream in another form. Reactions between chemicals and colloidal

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sediment may determine the relative concentration of other pollutants that remain in solution or suspension.²⁹

Eroded soil particles carry plant nutrients and contribute to the enrichment of the water-courses they enter. The problems caused by this enrichment may be reduced by limiting soil erosion or reducing fertilizer applications on agricultural lands. The economic impact of restricting nitrogen fertilizer in Illinois has recently been estimated.³⁰ Using Iowa State University's national linear programming model, nitrogen applications were limited to 50 lbs. per acre. Given these limits the comparative advantage of soybean production increased with respect to corn in Illinois. Illinois farm income was reduced whereas national farm income increased. (National farm product price increases from three to five per cent resulted from imposing these limits in Illinois).

Other studies have examined the economic implications of imposing soil loss controls. Several conceptual models have been developed and will be outlined. A least cost linear programming model for a hypothetical river basin was developed at Iowa State University. Using this model, Seay³¹ studied the impact of parametrically ranging sediment constraints. The sediment constraints were related to water quality and achieved by selecting from alternative crop rotations and soil conservation systems. In a slightly different application of the same model, Jacobs³² studied the phosphorous content of eroded soil and the water quality

implications. The studies satisfied the objective of building a conceptual model but were acknowledged to be severely lacking in reality. Data limitations and the lack of understanding about sediment delivery were cited as major difficulties. The cropping pattern that emerged as consistent with limited soil loss and agriculture income objectives was continuous row crops using minimum tillage.

Swanson and Narayanan³³ evaluated the impact on private farm income of improving water quality in a reservoir. Using a linear programming model, crop rotations and tillage systems were related to farm income and soil loss. More detail was added over previous studies. The sediment delivery estimation method considered the distance to the reservoir from agricultural plots. Also a wider variety of soils information was used as opposed to a single representative soil found in earlier work.

Another river basin linear programming study of sediment and erosion is underway by Rosenberry at Iowa State University.³⁴ This model will attempt to further refine estimation of a delivery ratio, provide additional detail concerning soils, and include a wider range of soil conservation practices than existing studies. The effect of soil loss limits will be evaluated with respect to (1) farm profits and the need for subsidies, (2) food prices, and (3) benefits to society from reducing sedimentation.

The studies outlined so far represent a progression from the abstract conceptual model developed by Seay to added

realism incorporated in Rosenberry's proposal. Further, the studies reviewed cover multi-county areas and hence are macro in scope. Some work has also been proposed at the farm firm level. Swanson is collecting data on representative farms to study microeconomic impacts of soil loss controls.³⁵ His objectives include evaluating the impact on individual producers, evaluating alternative incentive systems and also estimating sediment damages.

Research to support the study of the farm firm level impact of soil loss controls is needed. For example, it has been recognized for some time that limited tillage planting methods reduce soil loss. A recent study of no-till planting concluded that its potential for reducing soil erosion warrants continued study.³⁶ Many technical relationships need to be established between tillage systems, crop yields, soils, planting and harvest dates, and climate.

Before this section is concluded, urban sediment and erosion problems will be discussed briefly. Sediment damage from denuded construction sites has long been a source of concern. However, only limited economic analysis of alternative control systems has been completed. A notable exception is a study recently completed by the Dow Chemical Company.³⁷ Using cost-effectiveness techniques, it studied alternative erosion and sediment control systems for construction sites. They found that conventional systems, controlling approximately 91 per cent of the erosion, would

cost about \$1,125 an acre. Damages from uncontrolled erosion could reach a potential of \$1,500 per acre. However, major problems exist in estimating damages. The most important problem cited by the study was the uncertainty surrounding estimation of sediment delivery and transport ratios. These ratios determine the distribution of damages along a water course and are critical to damage estimation.

Many areas have enacted erosion control ordinances in the absence of economic analysis.³⁸ In a study of urban soil erosion and sediment control sponsored by the Federal Water Quality Administration the lack of economic analysis was recognized.

Insufficient consideration has been given to the economics involved in sedimentation control. On one hand, not enough information is available by which to determine, on a sound basis, the actual costs which stem from soil erosion and sediment problems. On the other hand, little substantive research has been conducted which would provide criteria by which to judge the economic benefits which are derived from sedimentation control. Many such benefits are aesthetic in nature...³⁹

Following urban controls, states are proceeding with uniform sediment and erosion control laws focusing primarily on agriculture.⁴⁰ Unfortunately, this too can be supported by only limited research on the economic implications of proposed controls.

Research Needs

Both physical and economic research is necessary to put current efforts to legislate sedimentation controls in perspective.⁴¹ ⁴² On the physical side, a more careful

evaluation of the technical relationships between tillage systems, crop yields, soils, planting, and harvest dates is necessary to facilitate more specific evaluation of the costs of soil loss controls. Other areas of physical research that currently preclude relating costs of control to preventable damages are (1) measurement of sediment delivery and transport between the points of initial detachment and final deposition and (2) separation of man-induced from natural or geologic erosion.

Developing legislation alone to reduce sedimentation may not achieve the desired results - that of reducing soil loss to within acceptable levels. It is necessary to study the legal, social and political constraints involved in adopting controls. Also the evaluation of alternative incentive systems to generate expanded use of soil conservation practices could assist in developing soil loss controls that would be effective. An idea that may result in greater compliance with soil loss controls on commercial agriculture is to combine soil conservation and pollution control programs with existing farm programs, particularly crop production controls.⁴³

CHAPTER II. FOOTNOTES

1. Udall, Stewart L., The Quiet Crisis, Holt, Rinehart and Winston.
2. "A National Program of Research for Soil and Land Use," prepared by a Joint Task Force of the U.S. Department of Agriculture, the State Universities and Land Grant Colleges, April 1969.
3. Water, 1955 Yearbook of Agriculture, U.S. Department of Agriculture, U.S. Government Printing Office, p. 137.
4. Proceedings, Federal Inter-Agency Sedimentation Conference, Miscellaneous Publication No. 970, U.S. Department of Agriculture, Agricultural Research Service, 1963, p. 4.
5. Ibid.
6. Wischmeier, Walter H. and Smith, Dwight D., "Predicting Rainfall-Erosion Losses from Cropland East of the Rocky Mountains," Agricultural Handbook No. 282, U.S. Department of Agriculture, Agricultural Research Service, U.S. Government Printing Office, May 1965.
7. Roehl, John W., "Sediment Source Areas, Delivery Ratios and Influencing Morphological Factors," presented at the Symposium on Land Erosion, October, 1962.
8. Negev, Moshe, "A Sediment Model on a Digital Computer," Technical Report No. 76, Department of Civil Engineering, Stanford University, March 1967.
9. Fleming, George, "Hydrologic Simulation Procedures as Applied to Vegetation Management, Hydrocomp International, Palo Alto, California, 1971.
10. U.S. Department of Agriculture, USDA H.L.-70 Model of Watershed Hydrology," Agricultural Research Service draft, 1971.
11. Meyer, L. D. and Wischmeier, Walter H., "Mathematical Simulation of the Process of Soil Erosion by Water," Transactions of A.S.E.A., Volume 12, No. 6, 1969.
12. Roehl, op. cit., p. 2.

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13. ERS - ARS Conference on Sediment Research, ARS Sedimentation Laboratory, Oxford, Mississippi, May 18-19, 1971.
14. Held, Burnell R. and Timmons, John F., "Soil Erosion Control in Process in Western Iowa," Research Bulletin 460, Agricultural and Home Economics Experiment Station, Iowa State College, August 1958.
15. Blase, Melvin G. and Timmons, John F., "Soil Erosion Control in Western Iowa: Progress and Problems," Research Bulletin 498, Agriculture and Home Economics Experiment Station, Iowa State University of Science and Technology, October 1961.
16. Held, Burnell R., et. al., "Soil Erosion and Some Means for its Control," Special Report No. 29, Agricultural and Home Economics Experiment Station, Iowa State University of Science and Technology, August 1962.
17. The rate of soil conservation practice adoption may vary with farm size. Marginal farms may be less willing to adopt soil conserving practices that yield low short run economic returns.
18. Rosenberry, Paul E. and Moldenhauer, W. C., "Economic Implications of Soil Conservation" Journal of Soil and Water Conservation, November-December 1971, pp. 221-224.
19. "Economic Evaluation of Conservation" prepared by the Engineering and Watershed Planning Unit, Soil Conservation Service, Portland, Oregon, January 1958.
20. Ball, Gordon, et. al., "Economic Evaluation of Use of Soil Conservation and Improvement Practices in Western Iowa," Technical Bulletin No. 1162, U.S. Department of Agriculture, U.S. Government Printing Office, June 1957.
21. Coutu, Aurthur J., "Methods for an Economic Evaluation of Soil Conservation Practices," Technical Bulletin 137, North Carolina Agricultural Experiment Station, January 1959.
22. Michael, Charles C. & Nauheim, Charles W., "Economics of Soil Conservation in Northeastern Kansas," Agricultural Economics Report No. 101, Kansas State University, December 1961.
23. Atkins, S. W., "Economic Appraisal of Conservation Farming in the Grenada-Loring-Memphis Soil Area of West Tennessee," Agricultural Experiment Station Bulletin No. 369, University of Tennessee, October 1963.

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24. Smith, Wesley G. & Heady, Earl O., "Use of a Dynamic Model in Programming Optimum Conservation Farm Plans on Ida-Monona Soils," Research Bulletin 475, Agricultural and Home Economics Experiment Station, Iowa State University of Science and Technology, February 1960.
25. Langren, Norman E. & Andersen Jay C. "A Method for Evaluating Erosion Control in Farm Planning," Agricultural Economics Research, U.S. Department of Agriculture, Vol. XIV No. 2, April 1962.
26. Andersen, Jay C. et. al., "Profit-Maximizing Plans for Soil Conserving Farming in the Spring-Valley Creek Watershed in Southwest Iowa," Research Bulletin 519, Agricultural and Home Economics Experiment Station, Iowa State University of Science and Technology, July 1963.
27. Gottschalk, L. C., "Effects of Watershed Protection Measures on Reduction of Erosion and Sediment Damages in the United States," Extract of Publication No. 59 of the I.A.S.H. Commission of Land Erosion, n.d.
28. A National Program of Research, op. cit. and Rosenberry, op. cit.
29. Robinson, A. R., "A Primer on Sediment," Journal of Soil and Water Conservation, March-April 1971, p. 61.
30. Swanson, Earl R., "Environmental Aspects of Fertilizer Use," Paper presented in the Department of Agricultural Economics, Michigan State University, East Lansing, Michigan, September 28, 1972.
31. Seay, Edmond Eggleston, Jr., "Minimizing Abatement Cost of Water Pollutants from Agriculture: A Parametric Linear Programming Approach," Unpublished Ph.D. Dissertation, Iowa State University, Department of Economics, Ames, Iowa, 1970.
32. Jacobs, James J., "Economics of Water Quality Management: Exemplified by Specified Pollutants in Agricultural Runoff," Unpublished Ph.D. Dissertation, Iowa State University, Department of Economics, Ames, Iowa, 1972.
33. Swanson, Earl R. and Narayanan, A.V.S., "Evaluation of the Effect of Alternative Agricultural Systems on Water Quality: A Linear Programming Approach," Unpublished, Iowa State University, Ames, Iowa, 1972.

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34. Rosenberry, Paul E., "Evaluating Soil Management Practices to Reduce Erosion and Sediment in a River Basin," Project underway, Economic Research Service, U. S. Department of Agriculture located at Iowa State University, Ames, Iowa, 1973.
35. Swanson, Earl R., "Soil Loss from Illinois Farms: Economic Analysis of Productivity Loss and Sedimentation Damage," Project proposal, Department of Agricultural Economics, University of Illinois, 1972.
36. Doster, D. Howard, "Economics of No-tillage," Presented at the National No-tillage Systems Symposium, Ohio State University, Columbus, Ohio, February 21, 1972.
37. "An Economic Analysis of Erosion and Sediment Control Methods for Watersheds Undergoing Urbanization," A Dow Chemical Company Report, Midland, Michigan, February 1972.
38. Examples are:
 - 1) Soil Erosion Ordinance of Ann Arbor, Michigan, Chapter 63, Title V of the Code of the City of Ann Arbor, Michigan passed March 1970.
 - 2) Maryland Erosion Control Law applying to non-agricultural development in the State, Chapter 245, Maryland Laws of 1970.
39. "Urban Soil Erosion and Sediment Control," by the National Association of Counties Research Foundation, 1001 Connecticut Avenue, N.W., Washington, D.C. 20036, May 1970, p. 22.
40. State and Federal erosion and sediment control will be considered in some detail in Chapter IV.
41. See "A National Program of Research," op. cit., p. 55 for a list of research needs.
42. See "Urban Soil Erosion and Sediment Control," op.cit. p. 34 for a list of economic research needs on urban sedimentation.
43. See Rosenberry, Paul E. and Moldenhauer, W. C., op. cit., p. 224.

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CHAPTER III
THEORETICAL BASIS
FOR ENVIRONMENTAL QUALITY CONTROLS

Introduction

The purpose of this chapter is to provide a theoretical setting for a case study of the effects of erosion controls on a farm firm. The first question is why pollution (environmental degradation) exists and what alternatives are available for its amelioration. The relevant theory encompasses the "new welfare theory" as it relates to rights of the individual in private property.¹ The second question is what are the economic alternatives to reduce pollution.

These alternatives range from affluent charges to regulatory legislation. At the micro level, the economic impact of controls can be evaluated with firm theory.² The third question is then, what economic adjustments are relevant to a firm subject to controls.

Why Pollution Exists

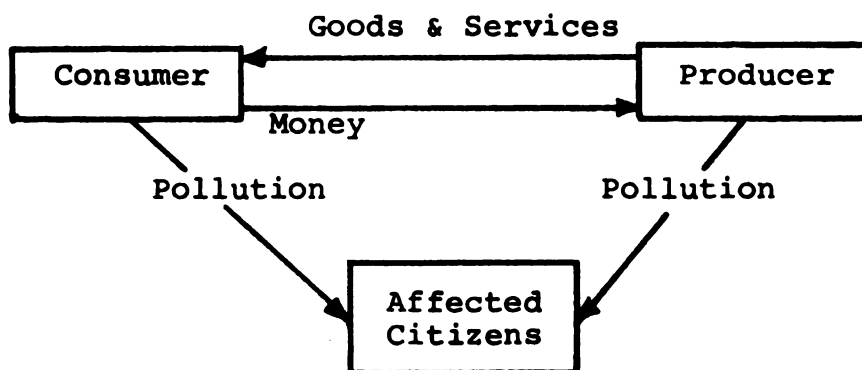
Commercial agriculture has been described as distorting the environment in favor of man.³ Food crops have replaced weeds and modern livestock have replaced their wild ancestors. Agriculture, according to this description, means radical

intervention in the ecosystem. Social organizations can be viewed in an analogous way. Similar to the farmer distorting the ecosystem, social organizations attempt to distort the social system in favor of ideals consistent with human welfare. An example is the market system. It is a social organization designed to facilitate specialization and the exchange of goods and services and hopefully minimize the "bads" like crime, poverty and pollution. The market system is a highly specialized social organization. "Some functions it performs well, some not so well, and some not at all. Unfortunately, matters of environmental quality fall mainly into the latter two categories."⁴ That is, problems concerning environmental quality arise from market failure. In traditional economic theory these market failures are labeled externalities. More precisely called nonpecuniary external diseconomies, they are direct effects, not priced in the market, imposed on one decision maker by another.

Where the market system is performing well, consumers are expected to pay the full cost of goods purchased and receive full claim to their use. Unfortunately, those who pay do not always receive all the benefits and payments made may not cover all production costs. As an example from agriculture, intensive crop production has typically been accompanied by soil erosion. Upon entering water courses, these eroded soil particles pollute the water. Pollution is defined as a reduction in environmental quality caused by the disposal of residuals (soil particles). This pollution

is a cost not covered in the production of agricultural commodities. These costs are opportunity costs, i.e., the value of environmental services foregone by using water courses as a soil receptor.

Common to many environmental quality problems are external effects such as sediment. These external effects have two important properties.⁵ The first is interdependency, i.e., individual behavior imposes costs and benefits on others. Secondly, there is no compensation; those creating costs are not made to pay nor are those providing benefits adequately rewarded. Compensation can also be thought of as a way to deal with an externality but may not remove its presence. The interaction of buyers and sellers in the market place serves to regulate both parties to the exchange. But in addition, others not users of products exchanged, are also affected. This demonstrates interdependency. Further, there is no way for those not consuming products to influence producers, i.e., lack of compensation. These concepts are illustrated in the diagram below.



Externalities are one of the most elusive concepts facing economists.⁶ What is beneficial to one individual may be harmful to others depending on factors not considered or valued in the market, i.e., time, location, etc. The market system fails to account for many environmental problems. The pervasiveness of externalities can be illustrated by considering the residuals approach.⁷

The materials residual approach is based on the concept of conservation of mass. It follows that residual from consumption and production must be equivalent to the raw materials used in the process. Hence, externalities will exist unless "(1) all inputs are fully converted to outputs, with no unwanted material residuals along the way, and all final outputs are utterly destroyed in the process of consumption, or (2) property rights are so arranged that all relevant environmental attributes are in private ownership and these rights are exchanged in competitive markets."⁸ This discussion equates residuals with externalities and helps to explain why they exist.

Up to this point, it has been suggested that externalities exist as part of a market economy and that they are pervasive. They exist because of transaction costs, legal restrictions and gaps in information and property rights. These are some of the same reasons Pareto optimality is difficult to achieve. Pareto optimality is an efficient position where no one can be made better off without making someone else worse off. It represents a theoretical base

against which actual achievement can be compared.

Theoretical discussions of the competitive model and Pareto optimality assume full knowledge. Transmission of information is costly and it is not likely that enough will be produced. Improving the quality and availability of information would assist those affected by externalities to bargain for a resolution. Since knowledge is scarce and costly, it is important to know what to be efficient about. In a market economy, information is generated to facilitate efficient production, consumption and distribution. Increasingly, it is becoming apparent that we must also generate information, hence be efficient about ameliorating adverse environmental effects of production on the environment.⁹ Reversible and irreversible environmental effects should be considered in allocating information gathering resources. Resource decisions that result in reversible environmental effects pose limited problems. However, when there are irreversible, care should be taken to maintain options for the future.

Transactions costs are another facet of externalities. Transactions costs include, but are not limited to, the costs of generating, recording and communicating information and the actual physical movement of goods and services necessary to bring about a mutually beneficial transaction. In some instances, transaction costs may exceed the net individual benefits to be gained from a transaction. Infinitely high transactions costs may result from legal restraints on the

use and exchange of resources.

Lastly, the existence of environmental problems can be traced to the system of economic incentives based on use rights in property. The structure of property rights in the United States is determined by the Constitution. Concepts incorporated in this document are that property is both a natural right and a defense against the State. Pursuit of self interest, as consistent with general welfare is also present. The rationale for this is well expressed by a quote from de Tocqueville, "If you do not succeed in connecting the notion of right with personal interest, which is the only immutable point in the human heart, what means will you have of governing except by fear." The Constitution, then is based on private property and individual freedom to pursue self interest within a framework of laws.

Separation of powers in the Constitution provides individual protection from the State. The courts have traditionally protected individuals against government action to attenuate private use rights without compensation. The current concern is in the state's ability to deal with private property rights.¹⁰ It has become increasingly clear that private decisions do not always lead to desirable social results. Hence, concern has shifted to protecting the majority from individual action or inaction.

The functions of property are to..."distribute claims to, and liabilities for, the benefits and burdens of property interests..."¹¹ This definition makes it clear that property

rights have distributive effects. They indicate who may use resources and who will gain or lose from decisions to use resources. The welfare implications of granting property rights should not be taken lightly. Headley raises questions about how granting property rights will influence the economy's performance and that the impact on the economy should be the criterion for granting property rights.¹² These questions are concerned with whether granted property rights are consistent with social goals, their relative impact on various social groups, and how markets will be affected.

Explicit awareness of the interconnectedness of ownership rights, incentives and economic behavior has recently initiated an effort to expand economic theory to specifically incorporate property rights. A few basic ideas taken from a recent review article of property rights and economic theory will help illuminate these relationships.¹³ First, property rights are defined as "the sanctioned behavioral relations among men that arise from the existence of things and pertain to their use." It is explained that this means property rights define economic and social relations with respect to resource use. Second, profit maximization behavior is rejected as descriptive of the economic man. A shift is made to utility maximization as the central theme in economic behavior. This might seem like a step backward to some economic theorists. However, conceptually, it provides a broader base from which to study economic behavior.

It may also be an admission of the limited applicability and realism of profit motivated behavior. A third important idea is that different property rights systems lead to different behavior.¹⁴ Property rights define what choices are permissible as well as the system of penalties and rewards. The contribution of property rights in economics is to show how alternative assignments of property rights affects the economic outcomes of resource use and allocation. Taken to the extreme, economics might be considered as the study of property rights and subsequent resource use. Limitations of traditional theory might be traced to glossing over the role of property rights in determining economic behavior.

Techniques for Control

The costs of agricultural commodities are understated when residuals disposal reduces environmental quality. Agricultural commodities are produced and distributed as desirable outcomes within a marketing framework. However, the concomitant pollution is not desirable and must be dealt with outside normal market channels.¹⁵

One of the problems in developing environmental controls to supplement the market system is to determine an acceptable amount of pollution.¹⁶ What pollution control levels will equate marginal social benefits and costs? This amounts to determining what degree of pollution people are willing to live with. Another important question is how should costs

of pollution be distributed.¹⁷ The answer to the latter question is not strictly monetary.

Alternative techniques for control are outlined and their relative impacts discussed. Pollution control methods discussed in the literature include both technical alternatives and social instruments. Technical alternatives for pollution control outlined by Freeman, et. al. are discussed below.¹⁹ They define pollution as reduced environmental quality from residuals disposal. The first alternative is to reduce the throughput of materials and energy. The term throughput is offered as a replacement for the terms inputs and outputs used in traditional discussions of the production process. This term encompasses the environment within which the circular flow of goods and services between producing and household sectors takes place. An example of reduced throughput would be to curtail intensive crop production on erosive soils thereby reducing erosion.

Secondly, residuals could be treated to reduce their negative environmental impact. Suspended sediment from eroded soil could be treated to remove plant nutrients or pesticides and the water returned to the watercourse.

The third technical alternative is to carefully select the time and place of residuals discharge such that harmful effects are minimized. For example, a fast moving stream could accommodate a higher biological oxygen demand (B.O.D.) imposed on it by nutrient carrying soil particles than a slow moving stream.

The last alternative is to invest in the assimilative capacity of environment. The capacity of a stream to handle the B.O.D. from plant nutrients, carried by eroded soil particles, could be augmented by mechanically aerating the water.

As indicated, the above are technical alternatives to reduce pollution and their implementation would require a system of incentives. Various social instruments to provide incentives include environmental legal action initiated by individuals or by those not personally damaged, systems of effluent charges, taxes or subsidies, and systems of enforced standards or regulation.²⁰ Both of the latter systems require government intervention.

These systems represent various ways to internalize external costs. The principle is to force or provide incentives for firms to make pollution one of their management decision variables.

Effluent charges are suggested as a control technique for those who think polluters should bear the costs.¹⁸ The concept is economically efficient since costs would be reflected in products reaching consumers. Effluent charges increase production costs, and in the long run could shift supply curves left and thereby reduce output and increase product price. Equity is achieved since payment is made for use of the environment for waste disposal. Effluent charges have the advantage of yielding revenue that could be used to centrally treat waste discharges, provide information, etc.

Taxes, if levied on the same basis, would have an effect on producers similar to effluent charges. Taxes could be imposed on polluters and the revenue used to reduce harmful effects or force some firms to cease operations and/or relocate. If taxes were too low the firm would pay the tax and continue to pollute. Both effluent charges and taxes have been called, "licenses to pollute" by the "man on the street."

Subsidies are another alternative to control pollution. In this case the polluter is paid not to pollute. Subsidies will offset pollution abatement costs of the firm. However, there is no incentive for the firm to seek the most efficient abatement technology. Further, there is no economic incentive for the firm to reduce pollution below the subsidized level. Subsidies are not an economically efficient solution because pollution abatement costs are not reflected in products reaching the consumer. Firm costs and output are unchanged. Hence, products will be priced too low and too many of them will be produced. The implication of subsidies for taxpaying consumers is that they are paying for protection.

Taxes, subsidies, and appropriate effluent charges require collective government action and a good deal of information to achieve desired results. A balance must be reached between the costs of obtaining this information and the undesirable effects to be reduced.

Not satisfied with these alternatives some theorists

argue in favor of establishing standards and then using taxes or subsidies to achieve them.²¹ Baumol attempts to show that with public goods externalities neither taxation nor compensation is compatible with optimal resource allocation. He suggests that standards, such as a four per cent unemployment rate, have a number of advantages. For example, they require less information, do not use police or the courts, pose no state financial burden and promise at least in principle to reduce pollution.

Another means of internalizing externalities is through voluntary action.²² If bribes were used either by the person causing or bearing the external cost they would have to equal the cost of reducing the externality to the former or equal the benefits foregone to the latter. If perfect bargaining could be achieved a Pareto optimum could result. However, many barriers exist to achieving such a solution. These difficulties include valuing the externality and excluding free riders.

Merging parties to an externality is another form of voluntary control. For this to be possible, as with bribes, the number of parties must be few. A potential problem if the resulting firm is large is inordinate market control or monopoly.

For controls to be economically efficient marginal social costs must equal marginal social benefits. Within this framework the "right amount of pollution" can be determined.

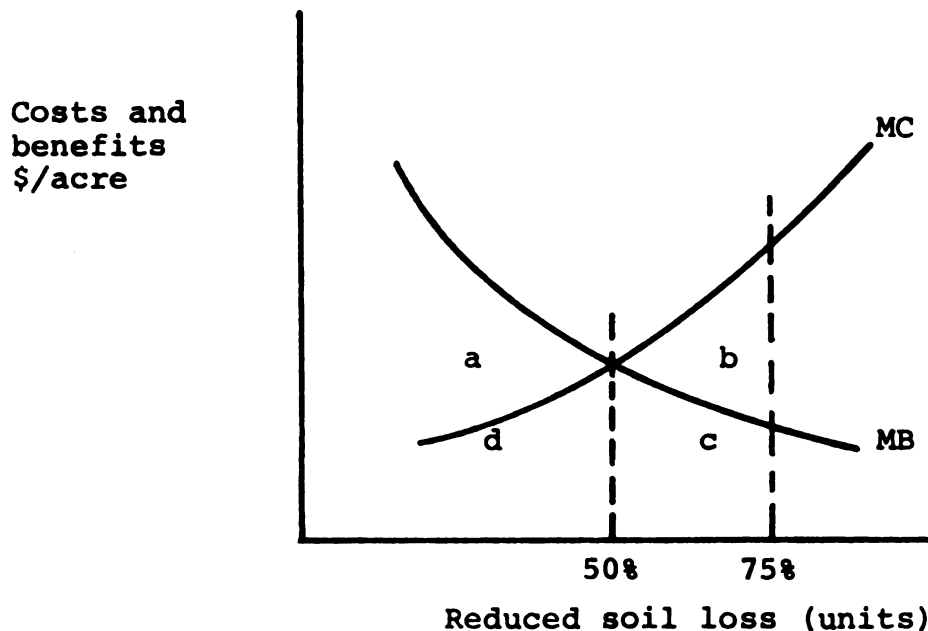


Figure 1. The Right Amount of Pollution

From Figure 1 the optimum or efficient level of soil loss is 50 per cent of existing levels. Benefits include areas $a + d$ and the costs are represented by area d and, of course, marginal benefits equal costs at the intersection of these two curves. Additional soil loss control equal to 75 per cent of current levels can be achieved and the incremental benefits are represented by area c . The incremental costs, however, equal $c + b$. Hence, control beyond 50 per cent is economically inefficient since marginal costs exceed marginal benefits.

Up to this point we have briefly discussed effluent charges, taxes, subsidies and voluntary action to control externalities. One of the most widely used techniques for

pollution control is legal restriction.²³ As with other controls, the optimum level is where the marginal costs of control equal the marginal benefits from control. It is possible, for a particular firm size, that regulations be imposed such that marginal benefits equal marginal costs. Regulations are generally an educated guess and not completely arbitrary. However, the optimum level of pollution from regulation is less likely to be achieved than with tax subsidies or effluent charges. The reasoning is that regulation is an inflexible solution. Because individual firms have different cost curves for pollution control, they should treat different amounts. Each firm, under a tax, could find its optimum adjustment. Firms with lower cost structures would treat more and pay less tax and the reverse would be true for firms with high cost structures. The effect is to allocate pollution control to the most efficient firms. This result does not follow from regulation. While not economically efficient, regulation does have definite advantages.²⁴ The first is that regulation may simply be easier to institute. Public revenue problems associated with tax collection and allocation are absent. A second point is that regulation could be self policing if provisions for private suits against violators were included. This is especially true if provisions for sharing court costs are available. Regulations reducing allowable soil loss represent an attenuation or restriction of the use rights in property and are a means of forcing control costs

to be internalized.

Soil erosion and subsequent sedimentation is a nonpoint source of pollution. Land users collectively discharge soil materials in a dispersed manner such that no individual discharge can be identified. Bargaining positions individually or collectively are ill-defined, hence it is difficult to determine the right level of soil loss. In lieu of this conceptual optimum, regulated levels have been imposed to provide some degree of soil loss control. Admittedly, this is a satisficing rather than optimizing position.

In order to achieve the least disruption of competitive positions, regulation of polluting firms must be universally applied. If applied in a piecemeal fashion, losses would be incurred by some firms which would result in an improved competitive position for others with similar cost structures. If all firms are affected uniformly costs to each would rise; and assuming a market effect supply curves would shift left and a new equilibrium achieved at a higher price. Another alternative is for efficient firms to acquire inefficient firms and there may be no market effect.

The imposition of controls would have the least disruptive effect on the economy if they were phased in over a period of time. This would allow time for resource adjustment. An example is the auto exhaust emission standards set for 1975.

Firm Response to Controls

Soil loss controls set standards and allow the land user to select the most efficient means to meet them. The economic impact of controls can be minimized since the optimum combination of resources in response to controls is possible.

Tracing firm response to soil loss controls necessitates a look at alternative means to control soil loss. Ultimately control methods are limited by crop production technology since soil loss is a joint product of crop production. Soil loss from agronomic practices due to wind and water erosion can be reduced by limiting tillage and increasing crop residue management, using less intensive row crop rotations and in general by adopting soil conserving practices.

Investments in durable assets such as tillage equipment are reflected in the fixed costs of the firm. The fixed costs of these tillage tool investments do not change with production. Variable costs of production are effected when the use of fixed resources is changed. For example, reduced tillage tools require fewer machine operating hours (variable costs) per unit of crop yield.

In practice, how an individual land user's economic position will be affected by soil loss controls will vary with the type and mix of current enterprises, soil type, existing land preparation methods and his financial position.

The following theoretical discussion focuses on a few of these variables as an example of firm response.

Several assumptions are necessary to theoretically analyze firm response to soil loss controls. The first is that the crop production function can be represented in the following way:

$$Y = F (X \dots X_a/X_{a+1} \dots X_b/X_{b+1} \dots X_n)$$

where

Y = crop production

$X_1 \dots X_a$ = variable factors of production

$X_{a+1} \dots X_b$ = factors fixed for the firm but variable between enterprises

$X_{b+1} \dots X_n$ = factors fixed for the firm and enterprise

The factors $(X_1 \dots X_a)$ are combined such that $\frac{MVP_{Xi}}{P_{Xi}} = 1$
for $i = 1 \dots a$

or that these inputs are combined in a least cost fashion.

The factors $X_{a+1} \dots X_b$ are fixed for the firm because the value of these factors in production is less than acquisition price but greater than salvage value ($\infty > P_{x_i}^{acq} > MVP_{x_i} > P_{x_i}^{sal} \geq 0$ for $i=a+1 \dots b$). These factors are variable between enterprises but are expected to be allocated to equate marginal returns between uses.

($MVP_{X_{ij}}$ are equal for all $i=a+1 \dots b$ for all j)

Examples include family labor and tractors. Some adjustment in the use of these factors can be expected as product prices, input costs or the productivity of inputs change the relationship between MVP's and acquisition and

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salvage prices.

Factors fixed for the farm ($X_{b+1} \dots X_n$ where $MVP_{x_i} > 0$) but not variable between enterprises ($X_{a+1} \dots X_b$). Examples include terraces, drainage systems and tillage tools.

Assuming a normally shaped production function, cost curves can be drawn as indicated below.

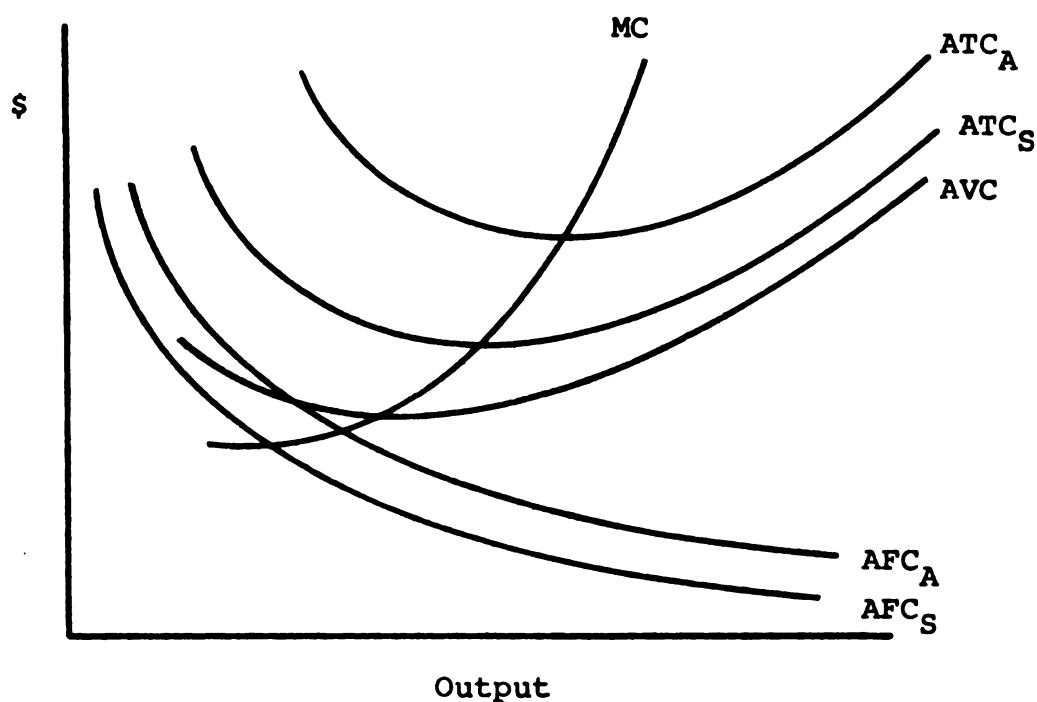


Figure 2. Cost Functions for Crop Production

Figure 2 shows both acquisition and salvage values for fixed factors. Salvage values represent the opportunity cost of factors of production. At some level of soil loss control it can be expected that the productive value of certain factors will be reduced to the point where they will no longer be used in specific types of crop production.

For example, under soil loss controls sloping land may no longer be used for grain production.

Further assumptions are that input and crop prices are constant, that the latter prices are above ATC_s and that firms are profit maximizers. Crop prices must be above ATC_s and below ATC_a to be consistent with fixed asset theory. If prices were below ATC_s fixed factors would be diverted to other uses. If crop prices were above ATC_a more of these factors would be purchased or diverted from other uses to crop production. In essence, these factors are worth more in production than their cost, i.e., additional units would be profitable. The assumption that firms are profit maximizers ensures that production is within stage II of the production function.

A likely adjustment to soil loss controls is to adopt reduced tillage systems. A change to reduced tillage tools affects the productivity of other factors of production and a crop yield response would be anticipated. Whether the yield response will be positive or negative varies with soil type. Variation across soil types for the same tillage system is greater than between tillage systems. Hence, yield variation depends more on the distribution of soils than on the tillage system used. For purposes of illustration it is assumed that there is no yield response to reduced tillage systems. An input affected by reduced tillage is labor, (fixed for the firm but variable between enterprises) its marginal product will be increased. The magnitude of the

change will determine whether the new marginal value product of labor exceeds its acquisition price and in turn whether some labor will be transferred to other enterprises. The marginal product of variable factors of production, in the aggregate will be reduced, i.e., more will be required to maintain the previous yield levels.

The reduced tillage response to soil loss controls will result in a new set of cost curves for the firm. Those are illustrated in Figure 3. In general, average fixed costs (tillage equipment plus labor) will be reduced.

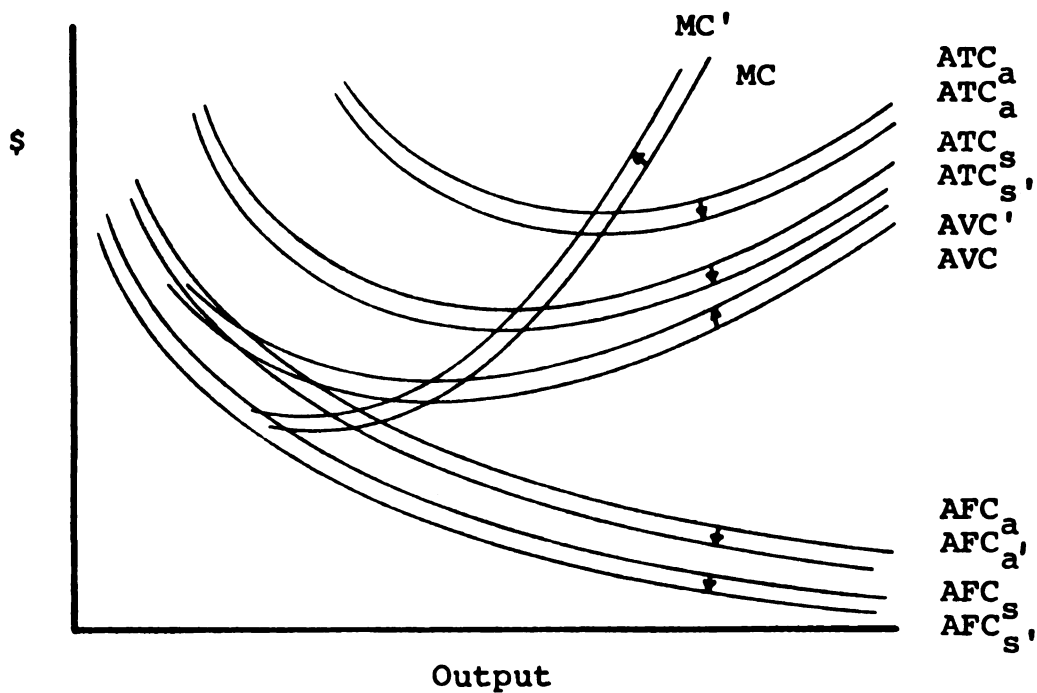


Figure 3. Crop Production Costs

After acquisition the cost of reduced tillage equipment

becomes fixed for the firm and not variable between enterprises. Labor requirements, fixed for the firm but variable between enterprises, are reduced and may more than offset the increased fixed cost of tillage equipment. If this is true the net effect will be a reduction in fixed costs for the firm.

Again, in general, variable costs will be increased. To maintain crop yields reduced tillage must be accompanied by increased seed, fertilizer, and herbicide applications. These costs may more than offset the reduced costs associated with fewer passes over the land. Assuming the reduction in fixed costs more than offsets the increase in variable costs average total costs will be reduced. These changes are represented by an increase of AVC to AVC' and a decrease in ATC_a and ATC_s to ATC'_a and ATC'_s . The marginal cost curve will shift up and to the left.

If the new ATC_a curve is below the crop prices, the optimum adjustment for firm would be to acquire more assets for crop production. On the balance the case for reduced tillage from the standpoint of the land users may rest with saving labor. The importance of saving labor will depend on the opportunity cost of labor and can be expected to vary between land users.

Another response to soil loss regulation is to adopt less intensive row crop rotations. This means substituting forage production for corn, small grains or other higher valued crops. This implies no change in production functions

for respective crops except that timing of production will be changed. However, there will be a change in the distribution of production between row crops and forage crops. The economic effect is to reduce the total value of crops produced over the life of a rotation. This in turn may influence total production of these respective crops by region, and assuming a market effect, crop prices may change. If there is a change in crop supplies by regions and a consequent change in prices, firm adjustments can be expected accordingly. For example, if the price of hay drops below the ATCs the optimum adjustment for the firm would be to discontinue hay production.

Yet another response to soil loss controls is the adoption of soil conservation practices such as contour tillage or contour strip cropping. These practices increase land preparation and harvesting (variable) costs. The conservation practices themselves may have only a limited impact on crop yield.

In practice firm response to controls will involve some combination of tillage systems, crop rotations and soil conservation practices. And a priori it is difficult to anticipate the combinations of these variables and hence the net response of the firm. Empirical results of the linear programming model will shed more light on this.

The previous discussion outlines, in theory, specific firm adjustments to soil loss controls. However, there are a number of variables that could constrain this adjustment.

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Where will funds come from to implement soil loss regulations? Private capital is an important source; however, credit, tax regulations and cost sharing assistance are also significant.

The Rural Environmental Assistance Program (REAP) that provided the majority of cost sharing funds for permanent conservation practices (terraces, etc) was terminated for 1973. A REAP appropriation bill was passed for fiscal 1974 but program details are not yet available. Cost sharing assistance is currently limited to tax regulations allowing rapid amortization and investment credit. If rapid amortization is chosen, the investment credit will not be allowed.²¹ However, it is possible to combine 20 per cent first year depreciation with investment credit.

The primary criteria for credit-worthiness is the ability to repay according to a specified schedule. Specific uses for credit are a less important criteria. Assuming controls do not significantly impair a land user's overall net returns, credit should be available for soil conserving systems. Those most affected would be marginal operators or those made marginal through the implementation of controls. Whether land users would be willing to borrow and pay from current earnings for a non-income generating investment is another question. Their willingness may not be in question, however, if mandatory controls are instituted.

Often cited impediments to the adoption of pollution abatement practices are discussed by Van Arsdall and Johnson.

Some of these are outlined below.²² The first and perhaps the most important is uncertainty and lack of knowledge. Two problems face those adopting soil conserving practices. First, the cost and effectiveness of various control systems will not be fully known until further research is completed. Lack of technical assistance is a related problem. There are nearly unlimited combinations of tillage systems, crop rotations, residue management and other soil management practices. Each combination results in different crop yields, soil loss and production costs. Second, the control level ultimately demanded by society is unknown. Rational behavior for land users, attempting to avoid being left with obsolete systems and the inability to recapture investments is to delay adoption of soil conserving systems.

Another reason for reduced response to controls is the absence of economic incentives. In the long run there is no incentive for land users to reduce soil loss below the natural rate of soil formation. Further control that may be desired for environmental purposes is beyond the decision frame of the profit motivated firm. In the short run it may not even be in the interests of land users to reduce soil loss to the rate of soil formation. An important reason is the age and tenancy status of the land user. The age of the land user determines his planning horizon. Typically, older men are reluctant to make investments when the returns extend beyond their planning horizon.

The tenure status of the land user is also important.

Agreements on sharing returns to land improvements may preclude adoption of soil conserving systems. Incentives must be provided to tenants before additional conservation land treatment efforts can be expected.

CHAPTER III. FOOTNOTES

1. The "new welfare theory" in contrast to the "old" focuses on a general equilibrium rather than a market by market equilibrium and assumes utility is ordinal and not measurable.
2. No attempts will be made to evaluate off-farm costs and benefits from controls.
3. Boulding, Kenneth, Economics as a Science, McGraw-Hill, 1970, p. 50.
4. Barkley, Paul W. and Seckler, David W., Economic Growth and Environmental Decay: The Solution Becomes the Problem. Harcourt Brace, 1972, p. 99.
5. Ibid, p. 101.
6. Biniek, Joseph P., "Economics of Water Pollution Control Measures," paper presented at a meeting, Fort Collins, August 1-13, 1969, p. 7.
7. Kneese, Allen V., "Environmental Pollution: Economics and Policy", AER, Vol. LXI, No. 2, p. 153 and Ayres, Robert U. and Kneese, Allen V.; Production, Consumption and Externalities, RFF Reprint No. 76, July 1969, p. 282.
8. Ibid., p. 283.
9. It should be pointed out efficiency and economic analysis is a sound base from which to deal with environmental problems. The focus must change from what is technically efficient to what is socially efficient, i.e., attempt to broaden our focus to internalize externalities.
10. Wunderlick, Gene, "Emerging Views of Property in Land," in Issues in Natural Resource Use and Development, Report No. 1, North Central Regional Strategy. Committee on Natural Resource Development, edit., Dan Bromley & Loyd Fischer, October 1971, p. 7.
11. Ibid., p. 4.

12. Headley, J. Charles, "Agricultural Productivity, Technology and Environmental Quality," AAEA Seminar Papers, August 21, 1972 presented at the University of Florida, p. 10.
13. Furubotn, Eirik, and Pejovich, Svetozar; "Property Rights and Economic Theory: A Survey of Recent Literature," Journal of Economic Literature, December 1972, Vol. X, No. 4, pp. 1137-1162.
14. In a recent article, A. Allan Schmid explores the question of what differences do alternative institutions have for human behavior. He suggests four institutional alternatives and researchable hypotheses. A. Allen Schmid, "Analytical Institutional Economics: Challenging Problems in the Economics of Resources for a New Environment", Am. J. Ag. Econ. 54:893-901, Dec. 1972.
15. In a recent article Randall discusses conditions necessary for viable market solutions to environmental quality externalities. He explains that institutional change is necessary to reduce the crucial variable, transactions costs. See Randall, Alan, "Market Solutions to Externality Problems: Theory and Practice," Am. J. Ag. Econ. 54:175-183, May 1972.
16. Connor, Larry, and Hoglund, C. R., "An Economic Appraisal of Farm Pollution and Waste Management," Ag. Econ. Misc. 1970-4, Michigan State University, Department of Agricultural Economics, p. 4.
17. Schmid A. Allen, "Impact of Pollution Controls on Agriculture," paper presented at a meeting January 7, 1970, p. 15.
18. Kneese Allen V., "Protecting Our Environment and Natural Resources in the 1970s", RFF Reprint # 88, p.196.

There is a tendency to identify polluters as villains when in reality it is difficult to determine who or if such a person or group exists. See: Connor L. J., Environmental Pollution - Causes, Costs, Controls, and Tradeoffs," Ag. Econ. Misc. 1971-8, Michigan State University, Department of Agricultural Economics, July 1971, p. 5.
19. Freeman A., Myrick III; Havaman, Robert A. and Kneese, Allen V., "The Economics of Environmental Policy," John Wiley and Sons Inc., New York, 1973.
20. See Chapter IV for a discussion of environmental law.

21. Baumol, William J., "On Taxation and the Control of Externalities," AER, Vol. LXII, No. 3, p. 307 and Biniek Joseph P., "Economics of Water Pollution Control Measures," paper presented at a meeting Ft. Collins, August 10-13, 1969, p. 7.
22. Davis, Otto, A. and Kamien, Morton I., "Externalities, Information and Alternative Collective Action," in the Analysis and Evaluation of Public Expenditures: The PPB. System a compendium of papers submitted to the Joint Economic Committee 91st Congress p. 77 and Johnson, James, and Connor, Larry J. "Origins and Implications of Environmental Quality Standards for Animal Production," reprint from Proceedings of the International Symposium of Livestock Wastes, St. Joseph, Michigan.
23. Barkley, Paul op. cit., p. 107 and Connor, Larry, J., "Environmental Pollution - Causes, Costs, Controls, and Tradeoffs," Ag. Econ. Misc. 1971-8, Michigan State University, Dept. of Ag. Economics, July 1971, p. 6.
24. Barkley and Seckler, op. cit., p. 108.

CHAPTER IV
ENVIRONMENTAL LAW AND SOIL LOSS LEGISLATION

Introduction

As the last chapter indicated, environmental problems can often be traced to gaps in property rights and the results are called externalities. Property rights can be viewed as legal policy guidelines for relationships between people as individuals and groups, and their resources. Also, rules, custom and law become the fabric of social controls and agreements - they provide the framework within which economic systems operate.

The rules men devise to order access to their resources has been called the "hallmark of economic development."¹ However, a counterpart of economic development has been environmental degradation. The amount of pollution created has grown to such enormous proportions and is increasing at such a rapid rate that controls are necessary to prevent the demise of mankind.² Further, the technical capacity to inflict irreversible environmental insults has reached a danger point. These developments have generated the need for environmental regulation. Environmental regulation is accomplished through environmental law.

This chapter contains a brief review of environmental

law followed by a few comments on the limitations of environmental legal solutions. The last section outlines recent nonpoint pollution control (soil loss) legislation, specifically, the Iowa Conservancy legislation. The latter will be treated in some detail and contrasted with similar legislation in Wisconsin and Michigan.

Environmental Law

A brief review of environmental law will assist in understanding the degree of erosion control that can be expected from legal solutions. Legal concepts can be grouped into procedural considerations, common law, statutory law and constitutional law. Procedural considerations are conditions that must be met before suits can be brought to court.³ The procedures include standing to sue, class actions and burden of proof. Before "standing" is granted the individual or individuals bringing suit must be harmed or have harm threatened in the future by those conducting the pollution emitting activity. Until recently this has meant nearly a complete bar to private law suits challenging actions of the federal government. A 1968 case, Flast versus Cohen, decided by the United States Supreme Court, has greatly increased the possibility of private individuals obtaining standing to sue against the federal government.⁴

Standing to sue against local governments is founded on an individual's status as a taxpayer and is granted in most jurisdictions. Increasingly the trend is to allow action

against state governments on the same basis. This more liberal interpretation of standing to sue will allow citizens to bring action forcing government officials to justify their lack of action on, for example, nonpoint pollution laws.

Class action is a procedural device that allows courts to provide remedy for an individual who has a small stake in an environmental problem. There are several desirable features of class actions. They allow potentially prohibitive costs of a suit to be shared. The larger claims sought may attract better legal talent. And, perhaps as important, it focuses public and judicial attention on environmental problems.

The burden of proof rule requires that the party alleging damages must demonstrate that certain activities cause specific harm. This is typically not easy. Further, the party alleging damages must counter arguments by the polluter that his conduct is legally justified.

A more relaxed burden of proof rule is necessary to prevent legal action from being terminated before the courtroom is reached. Recent court cases reduce the burden of proof to showing actual or potential environmental damages. The burden of proof is then shifted to the defendant to demonstrate the reasonableness of his actions. In all three procedural rules discussed above there has been a gradual relaxation in the attitude of the courts, generating greater potential for successful environmental law suits.

Common law elements often used in environmental suits include nuisance, trespass, liability and negligence.⁵ Common law is based on judicial decisions, formed largely by transforming customs into rules of law.

A nuisance can be defined as an unreasonable interference in an individual's right to use or enjoy his property.⁶ A nuisance represents a restriction in the use of property and can be classed as either public or private. A public nuisance affects the rights to which all people are entitled. A private nuisance applies to individuals in the enjoyment of some private right not common to the public. Courts, in handling nuisance cases, must balance the rights of both parties, a so-called "balancing equities." Past decisions have given the greatest weight to economic damages without carefully considering the natural environment.

Trespass is an actionable invasion of interests in the exclusive possession of land. In the past it has applied to only physical invasion, but now applies to visible or invisible intrusion upon an individual's protected interests. Advantages of trespass over nuisance action are that proof of actual injury is not required and the plaintiff is entitled to damages. Problems with trespass are that if it has occurred over a long period the trespasser may have acquired prescriptive rights to continue and that the courts may apply the balancing equities test.

Liability may be used in conjunction with nuisance or trespass action and damages recovered. However, the absence

of a substantial body of case law limits its use in environmental problems.

Negligence action requires that the plaintiff show that the defendant was negligent and a causal relationship exists between the defendant's action and his injury. The major problem in proving negligence in environmental quality cases is that there are no recognized standards to apply.

Statutory law, enactments of Congress and state legislatures, and local laws or ordinances provide another basis for individual or group action to prevent environmental damages. The Uniform Declaratory Judgment Act adopted by 35 states provides courts with the power to declare the rights of parties. A suit under this act would request the court to determine the validity of agency actions and whether the environment was being adequately considered. Another statute, the River and Harbor Act of 1899, prohibits discharging refuse in navigable waters or their tributaries. Fines range from \$500 to \$2,500 per day of violation with half the fine going to the individual leading to the conviction. This provision, where the informer shares in the statutory penalty, could provide a strong deterrent against polluters if it were more widely used.

A recent statute with potential for improving the environment is the National Environmental Policy Act of 1969 (NEPA). The purpose of this Act is to protect the environment. Among its important provisions are the establishment of a Council on Environmental Quality, the requirement that all

federal actions provide for consideration of the environment, and that all federal or federally assisted projects must be accompanied by an environmental impact statement. The impact statement must consider adverse effects, alternatives to the proposed action and any irreversibilities or irretrievable resource commitments. NEPA has been given much acclaim; however, its substance for improving the environment has been questioned.⁷ The Act has been interpreted to mean that agencies consider environmental effects in good faith but judgment rests with the agency. Environmentalists' opinion can not be substituted and in the absence of "bad faith" the courts will not require that alternatives be used.

A few states (Wisconsin and Florida) have statutes permitting private suits to enjoin a public nuisance.⁸ However, the burden of proof rests with the plaintiff and few actions have been taken because of the prohibitive expense. The State of Michigan used a different approach in their Natural Resources Conservation and Environmental Act of 1970. All the plaintiff must do is make a prima facie case and then the burden of proof shifts to the defendant. The Act also gives citizens the right to enjoin a polluter even though no special individual damage can be shown.

State and Federal Constitutions provide potential environmental remedies under law. It is contended that a pollution-free environment is guaranteed by the unenumerated rights of the Federal Constitution (9th Amendment).⁹ It is

further contended that the due process clause of the 5th Amendment prevents the Federal Government from interfering with these rights and that the 14th Amendment extends these rights to the states.

The State of New York amended its constitution in 1969 to, in essence, guarantee the right to enjoy a healthy and safe environment. The Michigan Constitution has had a similar provision since 1963, but neither has been used in environmental litigation. They do, however, offer considerable potential for abating environmental degradation.

The public trust doctrine, recognized as early as 1892 by the U.S. Supreme Court, could become a basis for environmental lawsuits. This trust is a precondition assumed by the Government in its statutory right to govern. Further, it is implicit in the beneficiary-trustee relationship between the public and the Government. The public trust concept provides a substantive basis for developing a comprehensive legal approach to environmental problems.¹⁰ Unfortunately, a large number of courts do not believe that they are the appropriate forum to examine actions dealing with resources in public trust.¹¹ Currently the public trust concept applies primarily to specific public lands.

Defining water and air resources as commodities held in the public trust would, in essence, assign property rights to these resources and allow legal action to protect these rights. Perhaps the time is approaching to modify our concept of property rights in the direction of a public trust.

For a century and a half we have been slowly retreating from a concept of relatively complete private property rights to a more society-oriented view. We are shifting from the view of property as the despotic domain of individual owners to a concept of property as a public trust--as rights that people may hold in land and other objects that must be exercised in the public interest and subject to public direction and guidance.¹²

Before discussing the limitations of legal solutions it might be worth emphasizing the trend in environmental law. There is a definite shift toward a more liberal interpretation of existing laws in favor of environmental cases. Examples are easing of the requirements to obtain standing to sue, a broader definition of actional trespass, and the courts' recognition of class action suits. Also, there has been a shift from the courts to the state legislatures in environmental management. There has been a good deal of environmental legislative activity at the Federal level also. The emphasis in this legislation is toward laws that will protect the individual plaintiff and the public as well.

More fundamental is a rethinking of who should represent the public in environmental cases. In the past law has tended to minimize the role of private citizens and create regulatory agents to speak for the public. This role is beginning to change in favor of private citizens. Basically, it represents a reversion to a more participatory democratic system and has considerable potential for dealing with environmental problems.¹³

Limitations of Legal Solutions

Changes in environmental law provide potential for reducing the degradation of common property resources; however, the approach is piecemeal. Collectively, common law remedies suffer from a number of shortcomings for dealing with environmental quality problems.¹⁴ They are concerned with the rights of individuals and are not readily adaptable to protecting the public interest. More importantly, they provide no means to prevent pollution, irreversible acts, or provide any general approach. They only supply remedies for past acts and, possibly under injunction, prevent specific future occurrences.

Individual legal actions to control pollution are said to be relatively ineffective for a number of reasons.¹⁵ First, there are many difficulties in the pleading and proof of agricultural pollution cases. Secondly, the courts do not approach agricultural pollution cases with an enlightened attitude. And, thirdly, court action is too unpredictable to base a pollution control program. In addition the adversary element in the courtroom may not result in comprehensive and sound plans for environmental management.¹⁶

There is also some question about whether private legal efforts can be sustained. If a more comprehensive approach is to be taken more resources (dollars) will be required. Current citizen efforts are sporadic because they are dependent on philanthropic financial sources. One alternative

is to expand the use of sharing fines imposed on polluters when citizens bring action. This is a provision of the Rivers and Harbors Act of 1899.

In sum, current environmental legal efforts are both fragmented and inadequately funded. Lohrmann concludes that "given the nature of the pollution problem, anything short of a massive legislative effort at all levels of government will probably not provide an effective and lasting solution."¹⁷ In the interim, private environmental litigation in addition to providing some temporary relief, can be used to develop a body of case law useful in drafting future legislation and provides a means of keeping public and private officials alert to environmental problems.

Current Nonpoint (Soil Loss) Pollution

Compared with other environmental problems, little attention has been given to nonpoint pollution from land runoff.¹⁸ Soil erosion has only recently been thought of as a pollution problem. Historically, the focus has been on reducing erosion to maintain soil productivity for agriculture. Substantial government efforts have been made to promote voluntary control of erosion over the last 35 years.¹⁹ The general conclusion is that voluntary efforts have been inadequate to achieve the level of soil loss desired.

The creation of watershed management units with authority to set and enforce standards for water and land resource use has received considerable attention recently.

The following discussion outlines the provisions of recent legislation in Iowa and then contrasts this with similar laws in Wisconsin and Michigan.

Iowa Conservancy Legislation

The Iowa Conservancy Legislation represents a first in the area of agricultural soil loss legislation.²⁰ Since its passage in July of 1971 many other states have followed. The immediate reason for establishing authority to enforce soil loss limits was the expressed need to control siltation of Iowa's lakes and streams.²¹ Major provisions of the Iowa law will be outlined below followed by a few comments.

The objective of the Iowa Conservancy Act is to preserve and protect the public interest in soil and water resources of the State. To accomplish this, the State is divided into six conservancy districts each of which are political subdivisions of the State. Each conservancy district is governed by the State Soil Conservation Committee and the Chairman of the State Soil Conservation Committee will be the Chairman of each conservancy district. Each district conservation committee (Commissioners) supervises the water resources of the district and has the authority to sue and be sued in the name of the district.

The basis for action by commissioners is that soil erosion is declared a nuisance if it results in damage to any conservancy district improvement to property other than that of the owner or occupant of the land on which the erosion is occurring. The Commissioners may require

abatement of such nuisances under provisions of the Conservancy law.

To determine when a violation has occurred, the Commissioners of each soil conservation district will establish and adopt a set of "reasonable" soil loss limits. The limits will be based on topography, soil characteristics, current land use and other factors affecting erosion. Limits will be established for agricultural, nonagricultural lands and construction sites. Prior to adopting the soil loss limits, public hearings will be held to give those affected by the regulations an opportunity to express their concerns. Actual soil loss limits adopted for agricultural lands vary from one to five tons per acre per year.

Before any action is undertaken by the Commissions, a written complaint must be filed with the soil conservation district indicating damages from excessive erosion. The Commissioners are required to investigate complaints the burden of proof resting with them.²² The results of the investigation will be given to the alleged violator with a request for voluntary abatement. The Commissioners are required to issue an administrative order to the violators advising them of action required. The Commissioners must also determine if cost-share assistance is available. The Conservancy Law states that cost-sharing funds of at least 75 per cent must be available for permanent conservation practices and committed to an alleged violator before a court order requiring compliance can be issued.

An important question is to determine to what extent the cost-sharing provision of the conservancy legislation will limit its implementation. The primary source of cost-sharing funds was to come from the Rural Environmental Assistance Program (REAP) administered by the Agricultural Stabilization and Conservation Service (ASCS). The REAP program has been cancelled for 1973; however, a REAP appropriation bill was passed for fiscal 1974. Program details are not yet available. For certain conservation practices, ASCS would cost-share, supporting the conservancy legislation to the extent that funds are available. The Iowa REAP specialist²³ explained that each ASCS county committee decides how to allocate its budget for conservation work and that they have indicated a general willingness to support the legislation. The REAP specialist pointed out, however, that the counties had no trouble exhausting their budgets prior to the conservancy legislation. Additional conservation work initiated under the conservancy law would represent another demand on funds currently exhaustible with existing programs.

In addition to the fact that REAP funds were fully extended prior to the conservancy legislation, another possible difficulty exists because the REAP Act specifies a maximum payment allowable to any one land owner or user. The law states that for each program year, funds for approved practices shall not exceed the sum of \$2,500 to any person.²⁴ This provision would constrain the rate of compliance with

the conservancy legislation. The impact would be related to the size of land holdings under a single ownership or control. A land user with extensive acreage may be required to make only relatively minor reductions in annual soil loss because of the cost-sharing limitation.

Funding for cost-sharing has been a problem for the legislation from the beginning. An attempt was made to incorporate Iowa State cost-sharing funds into the legislation when it was being drafted. This was met with sufficient opposition to get the provision removed from the Act. No funds are now available from the state. Attempts are currently being made to obtain cost-sharing from the Iowa State Legislature.²⁵ A bill has been introduced requesting a million and a half dollars for the first year of operation.

The conservancy legislation was amended to allow non-public funds to be used for cost-sharing. This will enable a damaged person or other groups to provide cost-sharing funds. The practical effect of this amendment can only be guessed at this time. The legislation does enable private citizens to file complaints and the amendment ensures compliance with administrative orders if cost-sharing funds are supplied. If used to supplement REAP cost-sharing funds, assuming they become available, the rate of compliance with administrative orders could be accelerated.

Another possible source of cost-sharing funds is from the Iowa State Conservation Commission. This agency

administers recreation and wildlife programs and they may be willing to cost-share on watersheds above their improvements.

The practical effect of the conservancy legislation remains to be determined. Complaints have been filed with the Conservancy District Commissioners, but are pending the availability of cost-sharing funds. Of the limitations affecting the reduction in soil loss and water pollution from the conservancy law cost-sharing is the most important.

Another factor affecting progress toward the objectives of the conservancy legislation is the general reluctance of neighbors to act against each other. Perhaps, because of the existence of the law, increased voluntary compliance will result, independent of legal proceedings. To a certain extent, this will be influenced by the effectiveness of the Department of Soil Conservation's education function.

Wisconsin Soil Loss Legislation

The purposes of Wisconsin law are to provide for the conservation of soil resources, control soil erosion and provide for floodwater and sediment damage prevention, and, in general, to promote the health, safety and welfare of the people of Wisconsin.²⁶ Provisions to provide remedies for excess soil loss are in an amendment to the Standard State Soil Conservation District Law of 1936.

The law allows but does not require that soil conservation districts be established to set standards for soil loss. In contrast with the Iowa law, conservation districts are not required to set standards nor are standards subject to

review and approval by a supervisory state government unit. Once soil conservation districts establish standards the law is potentially stronger than the Iowa law. First, the Wisconsin law provides that if compliance is not accomplished within a reasonable time, the conservation district supervisors may perform the work and recover costs and expenses from the land occupier. The Iowa law simply provides for contempt of court order. Secondly, the Wisconsin law provides for 50 per cent cost-sharing funds from state sources for permanent conservation practices. There is no provision for state appropriated funds to support the Iowa law.

Michigan Soil Loss Legislation

The purposes of the Michigan law are to control soil erosion and protect state waters from sedimentation.²⁷ This will be accomplished by prescribing powers, duties and functions of state and local agencies and by developing rules and providing for remedies and penalties. Standards and specifications for sediment and erosion control have been developed and will be provided to each enforcing agency.²⁸ These standards along with technical assistance can be obtained from the local Soil Conservation Districts.

The Michigan law, in contrast to either the Wisconsin or Iowa laws, does not make any provision for cost-sharing. Evidently, all costs must be borne by the land user or developer. Similar to the Iowa law, the Michigan law will be enforced with court injunctions or other processes to

prevent violations. The enforcement and administrative responsibilities have been given to local government by the Act. The Michigan law does not allow for these enforcement agencies (counties) to perform corrective action and collect expenses from the violator.

Another point at variance with Iowa and Wisconsin laws is that the Michigan law specifically excepts from jurisdiction logging and mining. This could be a serious shortcoming since these two activities are typically accompanied by significant soil erosion.

Federal Soil Loss Legislation

The focus of Federal legislation has not been on controlling soil loss from agriculture. However, an attempt was made to include nonpoint sources of rural runoff in recent Federal legislation.²⁹ An amendment to the Federal Water Pollution Control Act (Muskie Bill), passed by the Senate in November 1971, specifically dealt with nonpoint sources of water pollution. Section 201 of the Bill required that waste treatment plans provide for control or treatment of nonpoint sources of pollution including urban and rural runoff. Section 301 made it necessary for the Administrator (EPA) to furnish (1) guidelines for identifying and evaluating the nature and extent of nonpoint sources of water pollutants and (2) processes, procedures and methods to control water pollution resulting from, inter alia, agricultural and silvicultural activities such as runoff from crop and forest land.

The legislation currently in effect, while retaining the essential features of the Muskie Bill does not allude to establishing Federal standards for nonpoint sources of pollution.³⁰ It may be worth noting that soil or sediment is not included in the law's definition of a pollutant.

CHAPTER IV. FOOTNOTES

1. Wells A. Hulchins, Water Rights in the Nineteen Western States, U.S. Department of Agriculture, Miscellaneous Publication No. 1206 (Washington: U.S. Government Printing Office, 1971), p. 21.
2. Frank P. Grad., Environmental Law: Sources and Problems (New York: Mathew-Bender, 1971), Chapter I, p. 6.
3. Robert R. Lohrmann, "Environmental Lawsuit: Traditional Doctrines and Evolving Theories to Control Pollution," Wayne Law Review XVI, 1970, 1086-1106.
4. Lohrmann, loc. cit., p. 1086.
5. Lohrmann, loc. cit., p. 1106-1122.
6. Donald R. Levi and Dale Colger, "Legal Remedies for Pollution Abatement," Science CLXXV (March, 1972) 1085.
7. Ibid., p. 1086.
8. Lohrmann, loc. cit., p. 1127.
9. Levi, loc. cit., p. 1086.
10. Levi, loc. cit., p. 1087.
11. Lohrmann, loc. cit., p. 1106.
12. Raleigh Barlowe, "Public Land Policy: Inputs and Consequences," paper presented at a conference at Michigan State University, May 18, 1973, p. 15.
13. Sax, Joseph P. "Legal Strategies Applicable to Environmental Quality Management Decisions," in Environmental Quality Analysis: Theories and Methods in the Social Sciences edit. Kneese, Allen V. and Bower, Blair G., Johns Hopkins Press 1972, p. 402.
14. Levi, loc. cit., p. 1086.
15. Johnson, James B. and Connor, Larry J., "Potential Impacts of Alternative Measures of Minimizing Pollution Originating from Annual Wastes," Michigan State University, p. 5, 1971.

16. Freeman, G. Myrick III; Havaman, Robert A. and Kneese, Allen V. The Economics of Environmental Policy (New York: J. Wiley and Sons, 1973), p. 166.
17. Lohrmann, op. cit., p. 1134.
18. William N. Hines, "Legal Aspects," Agricultural Practices and Water Quality, ed. Ted L. Wallich and George E. Smith (Ames, Iowa: Iowa State University Press, 1970), p. 365.
19. See Chapter II of this work for a discussion of soil conservation.
20. Iowa House File 73. Enacted by the General Assembly of the State of Iowa, 1971.
21. William H. Greiner, Director, Department of Soil Conservation, State of Iowa, "A Legislative Approach to Erosion Control," paper presented at a conference, Toronto, Ontario, Canada, April 25, 1972.
22. The universal soil loss equation will be used to estimate soil loss. The soil loss equation is discussed in Chapter V of this study. This equation is said to offer the best known method for determining soil loss and to provide a sound basis for selecting the right combination of conservation practices to control soil loss. Greiner, op. cit.
23. Conversation with William White, ASCS, REAP, Specialist for Iowa, June 26, 1972.
24. U.S., Department of Agriculture, ASCS, National Environmental Assistance Program for 1971 and Subsequent Years, Article 701-46. Reprinted from the Federal Register of September 11 and 24, 1971.
25. Conversation with Richard Wilcox, Iowa Department of Soil Conservation, June 4, 1973.
26. Wisconsin laws, Soil and Water Conservation, Chapter 92, as amended by the 1971 Senate Bill 288.
27. Michigan, Michigan Public Acts of 1972, Act No. 347.
28. Michigan, Department of Agriculture, Michigan's Soil Erosion and Sedimentation Control Program, May 1973.
29. U.S., Congress, Senate Bill 52770.
30. U.S., Congress, Federal Water Pollution Control Act, Amendments of 1972. Enacted October 18, 1972.

CHAPTER V

THE ANALYTICAL MODEL

Introduction

Impact assessment of soil loss controls can be facilitated through use of a crop production model. This chapter outlines the input description and specifications of such a model.

The model inputs include soils, land use, crop yields, soil loss, budgets, and dairy feed requirements. The basic resource of the farm is, of course, the soil. The productivity of the soil resource is measured by the yield potential given a specific type of management. Crop yields are estimated given soil type for each crop rotation, conservation practice, tillage system, and plant and harvest date. A joint product of crop production is accelerated soil loss. Losses are calculated for each soil type as a function of crop rotation, conservation practice, and tillage system. Budgets outline the machinery and materials costs and labor hours required per acre to produce each crop. Feed requirements are necessary to meet the needs of the dairy operation. These requirements may be produced or purchased off the farm. The last section describes the activities, constraints, and specifications of the linear programming model.

etting

As noted in the introductory chapter the case study farm is a dairy enterprise in a Southeast Wisconsin dairy area. The farmstead consists 273 acres of land divided into twelve fields based on historical land use. The fields are considered management units for purposes of crop production and soil management.

The dairy herd consists of 96 milking and dry cows with 37 head of replacement stock in various stages of development. The labor used for milking and crop production is all family supplied with the exception of hay baling and stacking which is custom hired.

Land Use/Soils

Since this is a case study an attempt was made to reconstruct the farm, i.e., how land was used, the machinery complement available, and labor constraints, etc. Land use information was obtained from 1971 airphotos obtained from the Soil Conservation Service, United States Department of Agriculture. Land use patterns determined from the airphotos were verified by the land user. Each field was planimetered and the land use pattern for the whole farm developed.

The next step was to identify the soils within each field. This was accomplished by overlaying field boundaries on soils maps. The soils within each field were planimetered and tabulated.

Twelve soil groups were identified for the case study farm.¹ Five of these (Miami Silt Loam, Calamus Silt Loam, Clyman Silt Loam, Elba Silty Clay Loam, and Ehler Silt Loam) account for approximately 90 per cent of the farm. Three of the remaining soils (seven per cent) were grouped with the major five based on similarities in soil descriptions, while the remaining soils (three per cent) were allocated to the major soils based on the distribution of the major soils for the total farm.

Crop Yields

Crop yields are a function of, inter alia, climate, soil type, soil fertility, soil loss, weeds, insects, and crop management. Crop management in this model refers to crop rotations, soil conservation practices, tillage systems, and planting and harvest dates. Given certain assumptions, fertility is maintained, weeds and insects are controlled, etc.; crop management is the key in determining crop yields.

Crop management is an important variable in explaining soil loss. In order to assess the economic implications of alternative means to control soil loss it is necessary to determine crop yields associated with each crop management system. Also important in choosing crop management systems are flexibility and timeliness, relative to other required farm operations.

As indicated in the literature survey chapter, knowledge

defining the relationship between tillage systems, crop rotations, soil conservation practices, and plant and harvest dates is incomplete. Research exists evaluating the influence of each of these variables on yield by soil type (primarily for corn); however, their interrelationships have not been precisely determined.

Estimates of the interaction and relative importance of each of the crop management variables have been made.² These estimates make it possible to determine a crop yield for each combination of soil, tillage system, conservation practice, crop rotation, and plant and harvest dates. Each of the variables are listed below.

<u>Soil</u>	<u>Rotations</u>	<u>Conservation Practices</u>	<u>Tillage Systems</u>	<u>Plant and Harvest Dates</u>	
Elba	CCC	Up & Down	Conventional	Corn	15
Calamus	CCCOH	Contour	Minimum	Oats	8
Clyman	CCOHH		No-Till	Hay	12
Ehler	CCOHHH				
Miami	HHH				

The number of combinations of these variables is large, approximately 2,800, requiring use of a computer to estimate each of the yields. The procedure used was to develop indices for the influence of relevant variables on corn, oats, and hay yields and then to estimate weights to assign relative importance to each of these indices. After a discussion of the data in Table 1 an example will be used to show how yields were calculated for corn. Similar procedures are used for oats.

In the upper left hand corner of Table 1 are estimated

Table 1--Corn Yield Index.

ESTIMATED YIELDS					INDEX NUMBERS														
Soil					Rotation					Tillage ¹					Planting Dates ²				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
Elba					CCC	OOOOH	HHOOH	OOHHH	Conven.	Minimum	No-Till.	(1)	(2)	(3)	(4)	(5)	Up & Down		
Calamus																			
Clyman																			
Ehler																			
Miami																			
Slope																			
(1) Elba	0				125														
(2) Calamus	3				110														
(3) Clyman	3				120														
(4) Ehler	0				130														
(5) Miami	5-11				101														
Actual Numbers																			
Rotations																			
4	CCC				107														
5	OOOOH				102														
6	OOOOH				100														
7	OOOOHH				100														
Harvest Dates																			
8	Sept. 27-Oct. 18				100	95	0	0	0	0	0	0	0	0	0	0	0	0	
9	Oct. 19-Nov. 8				98	94	91	82	74	74	74	74	74	74	74	74	74	74	
10	Nov. 9-Nov. 29				94	89	85	76	67	67	67	67	67	67	67	67	67	67	
Conservation Practices																			
11	Up and Down																		
12	Contour																		

1. Assumes CCC Rotation.
2. 13 = May 3-9; 14 = May 10-16; 15 = May 17-23; 16 = May 24-30; 17 = May 31-June 6.

yield values by soil.³ These values assume good management, adequate drainage, and over 140 frost-free days annually. These are the base yields to which the indices are applied.

Corn yields are influenced by the number of years of sod in rotation. Yield values for continuous corn were thought to be less when a sod crop (legume) was in the rotation.⁴ Increased yield for corn following sod was largely a function of added nitrogen from the sod crop. More recent experience indicates yields for continuous corn may be higher than with a sod crop in the rotation given adequate fertilizer applications.⁵

Research on tillage and corn yields from Ohio was used.⁶ The work was done by soil type and covers recent periods ranging from three to five years in duration. The Ohio soils were matched with Wisconsin soils and the yield values transferred accordingly.⁷ The influence of tillage on crop yields by soil is shown at the intersection of columns 10 through 12 and rows 1 through 5 in Table 1. The yield response to tillage was indexed from no-tillage. On three soils conventional tillage increased yields and on two soils yields were reduced. All these yield indexes are based on a continuous corn rotation with adequate fertilizer, insecticide, and herbicide applications. Another set of yield indexes was developed for corn following sod.

The response of corn yields to planting and harvest dates are indicated at the intersection of columns 13 through 17 and rows 8 through 10. The calculation of these values is

presented in Table 1a as an example of how all index values are calculated. An index of zero indicates no crop can be produced within the time frame established by the planting and harvest dates. Index values for soil conservation practices are presented at the intersection of columns 18 and 19 with rows 11 and 12.⁸ They are estimates based on observed historical relationships.

The next step after determining crop yields by soil and developing indices for crop management practices is to combine this information with weights indicating the relative importance of each crop management practice. The weights are presented in Table 2. The combination of index values and weights to estimate crop yields for each combination of soil, crop rotation, tillage system, conservation practice, and plant and harvest dates are illustrated with the following formula.⁹

$$(1) \quad y = y_{a,b} \left(\frac{\sum_{i=1}^4 x_i w_i}{\sum_{i=1}^4 w_i} \right)$$

where: y = adjusted crop yield

$y_{a,b}$ = base yield for crop a on soil b

x_i = index value for crop management practice i

w_i = weight assigned to index value i

These values are presented in Appendix 2.

Corn yields for each combination of soil and practice can be estimated using Equation (1). For example, on Elba soil (base yield 125 bu./acre) a particular combination of variables influencing crop yields gives a yield of 122 bu./

Table 1a--Corn Yield by Planting and Harvest Dates.

Harvest Period	Actual Yields by Planting Period				
	May 3-	May 10-	May 17-	May 24-	May 31-
	May 9	May 16	May 23	May 30	June 6
	(1)	(2)	(3)	(4)	(5)
(1) Sept.27-Oct.18	145	138	0	0	0
(2) Oct. 19-Nov. 8	142	136	132	119	107
(3) Nov. 9-Nov.29	136	129	123	110	98
	Indexed Yields by Planting Period				
	May 3-	May 10-	May 17-	May 24-	May 31-
	May 9	May 16	May 23	May 30	June 6
	(1)	(2)	(3)	(4)	(5)
(1) Sept.27-Oct.18	100	95	0	0	0
(2) Oct. 19-Nov. 8	98	94	91	82	74
(3) Nov. 9-Nov.29	94	89	85	76	67

Source: Howard D. Doster, "Economics of No-Tillage," presented at the National No-Tillage Systems Symposium, Ohio State University, Columbus, Ohio, February 21, 1972, Table 1.

Table 2--Relative Weights for Indexed Values Influencing Crop Yields.¹

Category	<u>Corn</u>		<u>Oats</u>	
	Weights	Index	Weights	Index
Plant & Harvest Dates		1.0		1.0
Tillage System	.4	.50		
Rotation	.1	.125		
Conservation Practice	.3	.375	.3	.30

1. Weights provided by Leyton Nelson, Department of Crops and Soils, Michigan State University, March 26, 1973. The index weight for plant and harvest dates is used separately so that its full index value will influence crop yields.

acre. This calculation is made in the following way. The index value (from Table 1) for each variable is indicated below in parentheses. The weight (from Table 2) indicating the relative importance of each of these variables is the second number in parenthesis. Assume that a continuous corn rotation (1.07, 0.1) is combined with conventional tillage (1.05, 0.4) on the contour (1.00, 0.3) and is planted between May 10th and 16th and harvested between September 27th and October 18th (0.95, 1.0). Following the formula, the yield indicating the combined influence of these variables equals 122 bu./acre.

Oat yields and yield indices are presented in Table 3. The yield values by soil are from the same source as corn yields. The influence of crop management on oat yields is supported by only very limited published research compared to corn. Hence, judgment estimates were made for the influence of planting and harvest dates and conservation practices on oat yields.¹⁰ Index values for crop management practices influencing oat yields are presented in Table 3 and similarly based on judgment estimates. Only conventional tillage is used for oat production. They are produced as a nurse crop for alfalfa. Alfalfa requires a good seedbed and only conventional tillage is recommended. Since oats and alfalfa are planted together only conventional tillage can be used for oats.

Alfalfa yields are based on recent research done at Michigan State University. Alfalfa dry matter yields in tons

per acre, vary with the cutting date.¹¹ The first cutting date influences the regrowth period for the second and, similarly, the second influences the regrowth period and yield for the third cutting. Feed value also varies with the first cutting date. These two considerations are combined with yield variation by soil type in the procedure outlined below.

The first step was to graph yields to convert point to period estimates. The second step was to adjust for in vitro dry matter variation by first cutting date,¹² (see Table 4).

Table 4--Digestible Dry Matter by First Cutting Date.

	:	First Cutting Date		
		May 24-30	May 31-June 6	June 7-13
Digestible Dry	:			
Matter per Acre	:	3.54	3.58	3.35
Index	:	99.00	100.00	93.00

This was accomplished by generating feed value indexes (Table 4) by first cutting dates and applying these to base yields. The results are presented in Table 5.

For modeling purposes there are three possible first cutting dates. For each of these there are two second cutting dates. Given the second cutting date it is assumed that the third cutting date will be made such that optimal yields will be obtained. Each of these yields is then adjusted for

Table 5--Alfalfa Yield by Cutting Date.

<u>First Cutting</u>		:	<u>Second Cutting</u>		:	<u>Third Cutting</u>	
Date	Yield	:	Date	Yield	:	Date	Yield
May 24-30	1.5	:	July 12-18	1.6	:	Aug.23-29	1.5
		:	July 19-25	1.5	:	Aug.30-Sep.5	1.5
May 31-June 6	2.0	:	July 19-25	1.5	:	Aug.30-Sep.5	1.7
		:	July 26-Aug.1	1.4	:	Sep. 6-12	1.7
June 7-13	2.1	:	July 26-Aug.1	1.3	:	Aug.30-Sep.5	1.5
		:	Aug. 2-8	1.2	:	Sep.6-12	1.5
		:			:		

Table 6--Alfalfa Yield and Yield Index by Soil

Category	<u>Soil</u>				
	Elba	Calamus	Clyman	Ehler	Miami
Alfalfa Yield	5.7	4.8	5.5	6.0	4.6
Index Value	1.04	.87	1.0	1.09	.84

differences in soil type using the index values presented in Table 6, followed by an adjustment made for field to storage losses. The resulting yield values by soil type and cutting dates are presented in Appendix 2.

Recent experiments at Michigan State University indicate little variance in annual yield over the life of a four or five year rotation.¹³ Hence, the same set of yields will be used for each rotation containing alfalfa.

The second step after determining crop yields by soil, rotation, conservation practice, tillage system, and plant and harvest dates is to convert these yields to a composite acre basis. This is necessary to compress time into a single frame to facilitate mathematical programming. This is accomplished by factoring an acre according to the distribution of crops in a given rotation. For example, with rotation CCCOH the composite acre would be 0.6 C, 0.2 O, and 0.2 H.

The third step is to convert composite yields by soil to composite yields by field. This is necessary because fields, not soils, are considered management units by the land user. This is accomplished by calculating a weighted average yield by field for each crop as follows:

$$(2) \quad y_1 C_1 = \sum_{i=1}^5 s_{i1} b_{i1} / a_1$$

where: $y_1 C_1$ = weighted average yield for crop one in field one.

s_{i1} = soil i, field one, yield per acre

b_{i1} = acres of soil i in field one

a_1 = acres in field one

To convert yields per acre to crop production an adjustment is necessary for field to storage losses. These adjustments are incorporated in the yields presented in Appendix 2.

Soil Loss Calculations

In order to assess the imposition of government soil loss controls, it is necessary to estimate soil loss under all relevant circumstances. As indicated in the literature review the "universal soil loss equation" has been developed for this purpose. It is designed to estimate long term (25 years) soil loss from rainfall for individual farm yields. This procedure will be used to estimate soil loss under alternative management conditions for the case study farm.

Computed soil loss, as expressed in tons per acre, is equal to the product of five factors:

$$A = RKLSCP$$

where:

- A = the average annual soil loss in tons per acre
- R = the rainfall erosion factor locally determined. Soil loss is directly proportional to the product of kinetic energy times the maximum intensity of a rainstorm. The sum of these products for a given period provides a numerical value.
- K = the soil erodibility factor. It expresses the tons of soil loss per acre for a given R on a nine per cent slope 73 feet in length. It represents the loss from continuous cultivated fallow without cover crops.

L = the length of slope factor. It is the ratio of soil loss from a slope of a specific length to the length for which the K value is calculated.

S = the steepness of slope factor. It is the ratio of soil loss from a soil with a specific per cent slope to the slope specified for the K value.

C = the crop management factor. It combines the effects of crop sequences and various management practices. It is the expected ratio of soil loss from land cropped under specified conditions to soil loss for continuous cultivated fallow on an identical soil, slope, and rainfall.

P = the erosion control practice factor. It is the ratio of soil loss with a specific practice to that with up and down hill operations holding other factors constant.

Values for RKL and S by field are indicated in Table 7. Crop management factors (C) are displayed in Table 8. The erosion control practice factors (P) are 1 and .6 for up and down the slope and contour tillage practices, respectively.

Soil loss values for each combination of field, crop rotation, tillage system, and conservation practice are presented in Appendix 3. Note that no soil loss occurs on fields 5, 7, 10, and 11. Fields 5 and 11 are woodlots under permanent vegetation. Field 10 is in marsh hay and field 7 is an exercise lot. These nontilled fields account for 18 per cent of the total farm land. Of the tilled land 62 acres or 25 per cent, 73 acres or 30 per cent, and 112 acres or 45 per cent are subject to heavy, moderate, and negligible rainfall erosion, respectively.

Table 7--Soil Loss Equation Coefficients.^{1, 2}

Factor :	1	2	3	4	5	6	FIELD					11	12
							7	8	9	10			
R :	125	125	125	125	WOODLOT	125	EXERCISE	125	125	MARSH	WOODLOT	125	
K :	.37	.37	.37	.37		.37		.37	.37			.37	
L :	250	100	150	200		200		0	0			150	
S :	5%	3%	1%	11%		5%	LOT	0	0			2%	
LS :	.85	.30	.15	2.25		.75		0	0			.30	
Acres :	20.6	20.4	34.7	20.8	20.1	20.1	7.0	84.3	27.4	7.1	2.4	18.1	

1. Values for length of slope and per cent of slope were provided by Larry Decker, District Conservationist, Soil Conservation Service, U.S.D.A., Juneau, Wisconsin. Values estimated could vary between observers. Typically the soil with the steepest slope is used to design conservation practices for a whole field if the soil represents a third or more of the field.
2. See Appendix 3 for soil loss calculations by field, rotation, conservation practice and tillage system.

Table 8--Crop Management Factors.

Rotation	"C" VALUES			
	Conventional Tillage ¹	Minimum ² Tillage ²	No-Tillage ³	
	Plow Fall Spring			
CCC	.37 .35	.18	.12	
CCCOH	.243 .174	.093	.076	
CCOHH	.109 .101	.059	.045	
CCOHHH	.092 .087	.050	.038	
HHH	.030 .009	.008	.00	

1. Conventional tillage operations include: plow, disk, plant, cultivate,* harvest; residue left.
 2. Minimum tillage operations include: chisel plow, plant, cultivate,* harvest; 3,000 - 4,000 lbs. corn residue left/acre.
 3. No-tillage operations include: plant,* harvest.
- * May be in combination with herbicides.

Source: Crop Management "C" Factor Values for South-eastern Wisconsin, Table 3, Soil Conservation Service, U.S.D.A., Madison, Wisconsin.

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Machinery, Labor, and Materials Costs

Conventional, minimum, and no-tillage systems are budgeted and defined below. No attempt has been made to determine an optimum machinery complement for each tillage system which means the least cost system per unit of yield where the trade off between machinery cost and yield associated with timely field operations has been made. The existing farm machinery complement will be used as a base for comparison. Tillage tool size selection is based on the horsepower of existing tractors (50 and 70 horsepower).

The case study farm is using a chisel plow as the primary tillage tool. This is in contrast to most other dairy farms in the area which use conventional plows and disks. Aside from soil loss control, conventional tillage has many strong points. These are effectiveness for weed, rodent and insect control and also that future livestock waste regulation, for environmental reasons, may require plowing down of animal wastes as opposed to broadcasting wastes on the soil surface.

Several economic evaluations have been made of reduced and no-tillage corn.^{14, 15, 16} They conclude that with limited tillage there is a reduction in machine cost but that this is offset or more than offset by increased cost of sprays for weed and insect control. There is a saving in total labor hours and this may be the deciding variable for dairy farmers. The economic significance of reduced total labor requirements with limited tillage systems has not been

assessed. This is an objective of this study and will be approached by estimating labor requirements by tillage system and evaluating them within the constraints imposed by a dairy farm.

What is meant by the terms conventional, minimum, and no-tillage varies widely. The definitions as used in this study are outlined below. The field operations common to all three tillage systems are shredding corn stalks and harvesting. Differences in equipment are illustrated in Table 9. The differences are further illustrated in the detailed budgets.¹⁷ Man-hours and machine operation costs per acre are developed for each tillage system for corn and oats. Field efficiency is reduced approximately five per cent for operations on the contour as opposed to up and down the slope. Adjustments are made in labor hours and machine costs accordingly.

No-tillage systems have seen only limited use in Michigan and Wisconsin, perhaps because no-tillage research is concentrated in Kentucky and Ohio. The primary benefit from reduced tillage systems is in curtailing erosion and it has been made possible through the use of herbicides for weed control.^{18, 19, 20} Crop yields are generally maintained although results vary by soil and soil surface cover.

In addition to herbicide applications other adjustments are necessary to maintain corn yields with reduced tillage systems.²¹ Pest problems with no-tillage corn are more severe and frequent than with minimum tillage corn. Hence,

Table 9--Definition of Tillage Systems.

Practice	Conventional	Minimum	No
Tillage	Plow, disk & Spring tooth	Chisel Plow	None
Plant	4 MPH, insecticide	3.5 MPH, insecticide	3.0 MPH, no-till planter, insecticide
Fertilizer ¹	Spread N, P. & K	Spread N, P. & K	Spread P & K, Knife in NH ₃
Herbicide	Banded with plant-ing	Complete coverage	Complete coverage, 2 applications
Cultivate	Yes	Yes	No

1. Applied in the Spring.

insecticide applications are generally recommended. Fertilizer rate increases of 20 to 30 per cent are recommended in killed sod because of higher volatilization and leaching losses for no-tillage. Further, reduced seed germination suggests increasing seeding rates 10 to 15 per cent to ensure good stands with no-tillage. These adjustments are made in the budgets that follow.

Tables 10 and 11 present machinery costs and labor hours per acre by conservation practice and tillage system. These machine costs and labor budgets are summarized from Appendix 4, Machinery Budgets. Labor hours per acre are further summarized in Table 12. Labor is broken down into field operations by crop. Also, on Tables 10 and 11 seed, herbicide, and insecticide costs per acre by conservation practice and tillage system. Fertilizer costs per acre by crop rotation and tillage system are shown in Table 13. Detailed calculations are presented in Appendix 5, Fertilizer, Herbicide, Seed, and Insecticide Costs per Acre.

Dairy Feed Requirements

The purpose of the crop production activities, of course, is to meet the feed requirements of the dairy herd and replacement stock. The dairyman's feeding objective is to formulate the least cost combination of available feeds such that the dairy herd's nutrient requirements are met.²²

The inputs in this calculation are herd characteristics, feeds available, and feeding preferences of the dairyman.

Table 10-- Summary: Corn and Oats Costs and Labor/Acre.¹

Conservation Practice	CORN				OATS			
	Conventional Tillage		Minimum Tillage		No-Tillage		Conventional Tillage	
	Up & Down	Contour	Up & Down	Contour	Up & Down	Contour	Up & Down	Contour
Machinery Operating	4.10	3.82	4.03	3.75	4.09	3.69	3.33	3.03
Insecticide	4.83	4.83	4.83	4.83	4.83	4.83	1.54	1.54
Seed	2.15	2.15	2.36	2.36	2.58	2.58	3.60	3.60
Herbicide ²	6.25	6.25	10.50	10.50	10.75	10.75	.34	.34
TOTAL	17.33	17.05	21.72	21.44	22.25	21.85	8.81	8.51
Labor Hours/Acre	3.98	3.70	4.00	3.64	3.82	3.48	3.26	3.03

1. Fertilizer costs per acre are calculated separately; See Appendix 5, Table 1, for detail by input.
2. Herbicide is banded for Conventional Tillage and sprayed for Minimum and No-Tillage. For No-Tillage an additional sod killing operation is necessary one year in the rotation. Average cost of killing sod per rotation:

Rotation	Average Cost
CCCOH	3.65
CCOHH	3.65
CCOHHH	3.04
CCC	3.04
HHHO	4.56

Table 11--Summary Alfalfa-Costs and Labor/Acre.¹

Conservation Practice	CCCOH Rotation		CCOHH Rotation		CCOHHH & HHH Rotation	
	Contour	Up & Down	Contour	Up & Down	Contour	Up & Down
-----Input Cost/Acre-----						
Insecticide ²	2.22	2.22	2.22	2.22	2.22	2.22
Seed	6.95	6.95	3.47	3.47	2.32	2.32
Machinery Operating ²	.97	.98	.98	.98	.98	.98
TOTAL	10.14	10.15	6.66	6.67	5.51	5.52
Labor Hours/Acre ²	.84	.77	.77	.77	.77	.77

96

1. Fertilizer costs per acre are calculated separately. See Appendix 5 for detail by input.
2. Costs are for only one crop, year and labor hours for one cutting. Baling and stacking are custom hired.

Table 12--Corn, Oats, and Alfalfa Labor Summary.¹

Labor Use	Conventional Tillage		Minimum Tillage		No-Tillage		Planted w/Oats	
	Contour	Up & Down	Contour	Up & Down	Contour	Up & Dn.	Contour	Up & Down
CORN								
Pre-plant	1.18	1.12	.84	.78	1.17	1.05		
Plant	.32	.29	.33	.31	.43	.39		
Cultivate	.26	.24	.61	.51				
Harvest	2.22	2.04	2.22	2.04	2.22	2.04		
Total Hrs./Acre	<u>3.98</u>	<u>3.70</u>	<u>4.00</u>	<u>3.64</u>	<u>3.82</u>	<u>3.48</u>		
OATS								
Pre-Plant	1.18	1.11						
Plant & Spray	.83	.77						
Harvest	1.25	1.17						
Total Hrs./Acre	<u>3.26</u>	<u>3.05</u>						
ALFALFA								
Spray & Fertilize							.63	.58
Harvest per cutting								
(Excluding baling								
and stacking)							.21	.19
Total Hrs./Acre							<u>.84</u>	<u>.77</u>

1. See Appendix 4 for details.

Table 13--Summary, Average Fertilizer Cost Per Acre by
Rotation and Tillage.¹

Tillage	:	CCC	:	CCCOH	:	CCOHH	:	CCOHHH	:	HHHO
	:		:		:		:		:	
Conventional	:	27.12		29.08		35.45		39.15		49.97
Minimum	:	27.12		29.40		35.81		39.67		51.15
No-tillage	:	27.12		29.99		36.38		40.13		52.92
	:									

1. See Appendix 5 for detailed calculations

With this information a linear programming model is used to compute feed requirements and balance a ration. The result is the least cost means to satisfy feed requirements.

Dairy cattle nutrient requirements are based on the National Research Council recommendations and are a function of average cow weight and milk and butterfat production. In addition, there are a number of restrictions incorporated in the model. These restrictions limit dry matter intake, non-protein nitrogen, the proportion that certain feeds can be of the concentrate, and ensure that minimum fiber levels are met. Beyond these a management constraint was added to ensure that 20 per cent of the replacement stock's ration consisted of oatlage.

The model was run for three different milk production levels and for replacement stock in three weight categories.²³ In calculating feed requirements it is assumed that weighted average daily feed requirements over the milk production cycle are incorporated in the least cost ration program. Total feed requirements for the lactation can be approximated by multiplying this weighted average production level by 305 days. Feed requirements for the remaining 90 calendar days (13 month cycle) is made for nonlactating cows.

Feed requirements for replacement heifers assumed that on the average during the year a certain mix would be in one of three weight classes. Annual feed requirements for each of the weight classes was calculated and multiplied by the number of head in each class.

The Model

The model inputs discussed thus far can be generalized in the following way. Maximize:

$$(3) \quad Z = C_1X_1 + C_2X_2 + \dots + C_jX_j + \dots + C_kX_k$$

Subject to:

$$a_{11}X_1 + a_{12}X_2 + \dots + a_{1j}X_j + \dots + a_{1k}X_k \leq b_1$$

$$a_{21}X_1 + a_{22}X_2 + \dots + a_{2j}X_j + \dots + a_{2k}X_k \leq b_2$$

$$a_{i1}X_1 + a_{i2}X_2 + \dots + a_{ij}X_j + \dots + a_{ik}X_k \leq b_i$$

$$a_{n1}X_1 + a_{n2}X_2 + \dots + a_{nk}X_j + \dots + a_{nk}X_k \leq b_n$$

$$X_j \geq 0, \text{ for all } j.$$

This can be described more simply with the diagram on the following page.

The alternative means of producing crops are represented by the column vector X_j ($j=1\dots n$) and are included in the box labeled Activities in the Crop Production Model diagram. They include each combination of field, crop rotation, and planting and harvest dates. Each activity has associated with it a series of input-output coefficients represented by the column vector a_j ($j=1\dots n$) or the Technical Coefficients box in the Crop Production Model diagram. Examples of these coefficients are crop yields, labor requirements, and soil loss per field.

The net return associated with each activity is represented by the row vector C_j ($j=1\dots n$) or the Net Return box

Crop Production Model*

		Net Returns (C_j 's)						n=193
Maximize		C_1	C_2				C_n	

Activities (X_j 's)						
CORN	OATS	HAY	COWS	FEED PURCHASE	CROP SELLING	CAPITAL

Technical Coefficients (a_{ij} 's)						RHS (b_j 's)	
+	+	+	0			1	LAND i=1-8
+	+	+	0			1	LABOR i=1-33
+	+	+	0			1	SOIL LOSS i=1-3
-	-	-	-	-	+	1	CROP PRODUCTION i=1-550
-	-	-				+	FEED PURCHASE i=1-3
+	+	+			-		CROP SELLING i=1-3
+	+	+	-	+			FEED REQUIREMENTS
				+		1	CAPITAL

* Sign convention is as follows:

- (-) producing activities
- (+) consuming or using activities

in the Crop Production Model. Machinery operation, repairs, and agronomic inputs per acre are included in these costs. Equation (3), the objective function, indicates the objective is to maximize returns from crop production activities.

The column vector of b_j 's represents the right hand sides (RHS) and includes resource constraints and model requirements. The constraints are comprised of the acreage in each field, the labor hours available, and soil loss limits. The model requirements are based on crop production needed for dairy feed.

Technical Coefficients

The technical coefficients require little explanation with the exception of labor. Crop yields and soil loss per acre for each combination of soil, tillage system, etc. are presented in Appendices 2 and 3, respectively.

Labor coefficients for field operations are divided into four classes: pre-plant, plant, cultivate, and harvest. Of these, planting and harvest dates influence crop yields. The time periods selected for these operations reflect the sensitivity of yields to field operations. For example, corn planting periods are seven days and corn harvest periods are 21 days.

Pre-plant field operations are necessary for conventional and minimum tillage; however, timing is not critical except that they precede planting. For programming purposes pre-planting periods will consist of all periods prior to planting dates. For example, the pre-plant period for plant

dates May 18-24 is February 22 to May 17.

Labor requirements for alfalfa are complicated by the fact that the first cutting date determines the second and third cutting dates. Table 5 shows the second and third cutting date for each first cutting date.

R.H.S.

Land constraints, developed in Appendix 1, are summarized below.

Table 14--Land Constraints.

Field	Acreage	:	Field	Acreage
1	20.6	:	6	20.1
2	20.4	:	8	84.3
3	34.7	:	9	27.4
4	20.8	:	12	18.1
		:		

The acreage in each field indicates the maximum land available with given characteristics for crop production activities.

Labor for cropping activities is limited to that of the operator. It is assumed that the operator's family will provide labor for the dairy herd when field operations are being performed.

Labor constraints should reflect more than simply calendar days per period. They must be adjusted for actual field working days based on weather and soil conditions. Research at Michigan State University, Departments of Agricultural Engineering and Agricultural Economics has generated

the probability of a "go" or "no go" day for field operations by calendar day.²⁴ Criteria for defining a "go" or "no go" day for planting and pre-planting field operations are based on the soil moisture profile. Different values are used for harvest activities, by soil type. Expected soil moisture figures are based on 16 years of historical data. Soil moisture levels defining a "go" or "no go" day, by soil type, were developed from several years of field observations.

The results are presented in Table 15. The program to determine "go" days for field operators does not determine the number of hours worked per "go" day. It is intuitive that the hours worked per day should vary with the probability of "go" days per period and period length.²⁵ For example, if the probability of a "go" day per period is low, a land user will choose to work longer hours to reduce yield losses. If the period is long and the probability of "go" days are high, the land user will choose fewer working hours per day. Lacking precise values, estimates were made for the maximum labor hours available by week.

Soil loss constraints are based on the standards set by the Iowa Conservancy Law. Soil loss values typically range from one to five tons per acre and are a function of the allowable loss that will maintain long term agricultural productivity. Using this criterion soil loss constraints for the case study farm should be three tons per acre per year.

Crop production activities consist of each combination

Table 15--Labor Constraints (Seven Day Periods).

Dates		: Period : Number :	: "Go" Days : Out Of Ten :	: Hours : Worked : Per Day	: Total Hours : Per Period :
April	5-11	0	1.09	8	8.8
	12-18	1	1.75	8	14.0
	19-25	2	1.81	8	14.5
April	26-May 2	3	2.50	14	35.0
May	3- 9	4	3.94	14	55.1
	10-16	5	3.25	14	45.5
	17-23	6	4.75	14	66.5
	24-30	7	5.44	14	76.1
May	31-June 6	8	5.19	14	72.6
June	7-13	9	4.75	10	47.5
	14-20	10	4.56	10	45.6
	21-27	11	5.06	10	50.6
June	28-July 4	12	5.44	10	54.4
July	5-11	13	5.50	10	55.0
	12-18	14	5.94	10	59.4
	19-25	15	5.12	10	51.3
July	26-Aug. 1	16	4.44	10	44.4
August	2- 8	17	4.94	10	49.4
	9-15	18	5.81	10	58.1
	16-22	19	4.94	10	49.4
	23-29	20	4.00	10	40.0
August	30-Sept. 5	21	5.44	10	54.4
	6-12	22	5.87	10	48.8
Sept.	27-Oct. 4	25	5.09	8	40.8
October	5-11	26	4.75	8	38.0
	12-18	27	5.12	8	41.0
	19-25	28	4.65	8	37.3
October	26-Nov. 1	29	4.15	8	33.3
Nov.	2- 8	30	3.62	8	29.0
	9-15	31	3.25	8	26.0
	16-22	32	1.90	8	15.3
	23-29	33	1.06	8	8.5

of field, crop rotation, conservation practice, tillage system, and plant and harvest date. These combinations are illustrated in the table below.

Table 16--Crop Activities.

Crop	Rotations	Fields	Plant and Harvest Date	Total
Corn	4	8	12	384
Oats	4	8	7	224
Hay	1	8	6	<u>48</u>
TOTAL				656

For each of these combinations for corn (384) there will be three tillage practices and for each tillage practice there will be two conservation practices for a total of 2,304 potential corn activities.

In addition to the crop producing activities are feed purchase, feed selling, and soil loss activities. The latter are joint with crop producing activities. Prices for the crops fed, sold, and purchased are listed below.

Table 17--Crop Prices.

Category	Corn (bu.)	Oatlage (tons)	Alfalfa (tons)
Crops Purchased	\$1.45	\$10.00	\$40.00
Crops Sold or Fed	1.17	8.00	31.00

Source: Prices are 1972 Michigan averages suggested by Ray Hogg-lund, Professor, Agricultural Economics, Michigan State Univ.

Separate runs are made for each of the three tillage systems. Each tillage system is run with both conservation practices. These runs are necessarily distinct because in practice more than one tillage or conservation practice is not used on the same field. This gives a set of six basic runs, one for each combination of tillage and conservation practice. This set of basic runs is made with three different levels of soil loss constraints. The total number of runs is 18. The model only considers variable costs and without assuming some annual usage values for fixed factors as a basis for allocating fixed costs, they cannot be satisfactorily assigned to activities. Hence, relevant fixed costs are handled outside the model.

CHAPTER V. FOOTNOTES

1. See Appendix 2 for soil descriptions, inventory of soils by field, and comparability of soils with those in Ohio and Michigan.
2. Professor Leyton Nelson, Michigan State University, Department of Crops and Soils, provided initial estimates which were reviewed by other crops and soils specialists after yield estimates were made.
3. Yield values obtained from: "Fertilizer Recommendations for Michigan Vegetables and Field Crops," Extension Bulletin E-550, Farm Science Series, November 1972, p. 31. See also Soils Appendix 2.
4. "Productivity of Soils in the North Central Region of the United States," North Central Regional Research Publication 166, University of Illinois Experiment Station, Bulletin Number 710, Table 1, p. 12, May 1965.
5. Conversation with Dr. George McQueen, Shiawassee County, Michigan Extension Director.
6. "1972-73 Ohio Agronomy Guide," Bulletin 472, Cooperative Extension Service, The Ohio State University, p. 53-56.
7. See Appendix 2, Soils.
8. Personal contact with the Soil Conservation Service, USDA, Madison, Wisconsin.
9. An extension of this yield generating program could provide prescription crop management practices for a given set of circumstances. The opportunity cost in terms of yields forgone, with a given capital expenditure, could be estimated for less than optimum crop management practices.
10. Personal contact with Professor Leyton Nelson, Michigan State University, Department of Crops and Soils, March 1973.

11. Jue Sun Lee, "Productivity, Total Non-structural Carbohydrates in Roots, and in Vitro Dry Matter Disappearance of Alfalfa, Given Different Four-Cutting Systems Under Three Different First Cutting Dates," unpublished Ph.D. Thesis, Department of Crops and Soils, Michigan State University, 1973, Table 19, page 65.
12. Ibid., Table 14, page 44.
13. Private communication with Professor Milo B. Tesar, Michigan State University, Department of Crops and Soils, May 15, 1973.
14. USDA Soil Conservation Service, Columbus, Ohio, Agronomy Information Release, Number 9, January 2, 1968.
15. Howard D. Doster, "Economic Characteristics of Selected Tillage Systems," Purdue Top Farmer Workshop Corn Proceedings, August 1968. Cooperative Extension Service, Purdue University, Lafayette, Indiana.
16. Norman Rask, G. B. Triplett, Jr., and D. M. Van Doren, Jr., "A Cost Analysis of No-Tillage Corn," Ohio Report 52(1), p. 14-15, January-February 1967.
17. See Appendix 4, Machinery Budgets.
18. L. Lloyd Harrold, "Soil Erosion as Affected by Reduced Tillage Systems," a contribution from the North Appalachian Experimental Watershed Corn Belt Branch, Soil and Water Conservation Research Division, Agricultural Research Service, USDA, Coshocton, Ohio, in cooperation with the Ohio Agricultural Research and Development Center, Wooster, Ohio.
19. L. Lloyd Harrold, G. B. Triplett, Jr., and R. E. Youker, "Less Soil and Water Loss from No-Tillage, Corn," Ohio Report 52(2), p. 22-23, March-April 1967.
20. Roscoe Isaacs, Jr. and Dentis A. Colson, "No-Tillage--A New Production Management System," Technical Note, Agronomy Number 59, March 26, 1971, Soil Conservation Service, USDA, Lexington, Kentucky.
21. Op. cit., 1972-73 Ohio Agronomy Guide," pp. 53-56.
22. W. W. Gregory, et. al., "1972 No-Tillage Recommendations--Planting and Pesticide Information," University of Kentucky, Cooperative Extension Service Publication ID-1.

23. Stephen Harsh, et. al., "Least-Cost Dairy Rations--A Telplan Program," Program 31, Michigan State University. This work was used for the ration calculation. The herd characteristics, feeds available, and owners' preferences were obtained by interviews from the dairymen.
24. See Appendix 6 for detailed feed requirements calculations.
25. This program was obtained from Benjamin Holtman, Associate Professor of Agricultural Engineering, Michigan State University, April 1973.
26. Period length refers to the period over which there will be a crop yield reduction for lack of timely field operations.
27. The hours per day in Table 16 were suggested by Roy Black, Assistant Professor, Agricultural Economics Department, Michigan State University.

CHAPTER VI

EMPIRICAL RESULTS

Introduction

The purpose of this chapter is to outline the economic impact of imposing soil loss controls on a case study farm. Assuming forced (legal) compliance, the question becomes one of choosing the appropriate compliance strategy and estimating the impact of controls on profit, labor requirements, crop production, and land use. To assess the impact of controls, a linear programming crop production model, outlined in the last chapter, is used. The first model runs were made with 40 tons per acre as the soil loss limit. This amounts to no constraint since no combination of soil and management practice exceeds this soil loss value. This level is included so that an evaluation can be made with and without controls. The second run was made with a three tons per acre soil loss constraint. This is the loss level that would be imposed if the farm were under the jurisdiction of the Iowa Conservancy law. A third run was made with a one ton per acre constraint, the most stringent constraint specified in the Iowa law.

A set of runs were made for each soil loss level. A "set" means each combination of three tillage systems with two soil conservation practices or a total of six runs. The

tillage systems are conventional, minimum, and no-tillage. The conventional system includes plowing, disking, and planting; minimum includes chisel plowing and planting; no-tillage system is planting in killed sod. The conservation practices are tillage on the contour and tillage up and down the slope. The latter is essentially no soil conservation practice and is included for comparison.

Since separate computer runs are made for each tillage and conservation practice, they are in effect held constant while cropping pattern and plant and harvest dates are variable. Hence, given tillage and conservation practice, the model maximizes profit subject to the various constraints. The result is the most profitable distribution of crops across farm fields and over time (plant and harvest dates).

Soil Loss

The profit maximizing use of each tillage and conservation practice, without soil loss constraints, results in widely differing soil loss. Contrary to expectation, reduced tillage systems do not necessarily produce the least soil loss. In fact, where no limits on soil loss are imposed, the no-tillage system produces the most soil loss.

Constraints on soil loss reduce soil loss but, again the no-tillage system does not necessarily produce the least soil loss.

As allowable soil loss is reduced, the number of crop rotations consistent with the constraints is reduced. Hence,

with fewer rotations available soil loss becomes more similar between tillage systems. Soil loss constraints force soil conserving crop rotations on sloping land; and it appears that matching rotations with slope is more important than tillage systems, per se in controlling soil loss. Evidence for this is provided by the fact that with a one ton per acre soil loss constraint total soil loss is similar across tillage systems.

Table 18--Total Soil Loss by Tillage System and Soil Loss Constraint Level (tons) for Up and Down the Slope Soil Conservation Tillage System.

Soil Loss Constraint	:	Tillage System		
		Conventional	Minimum	No-Tillage
Tons/Acre	:	-----Tons/Farm-----		
40	:	437	212	496
3	:	164	120	116
1	:	59	56	38
	:			

As expected soil loss is less when farming on the contour for conventional and minimum tillage. Farming on the contour generates approximately half the soil loss that farming up and down the slope produces. The exception, as shown in Table 19, is for no-tillage with one and three ton soil loss constraints. Again, the distribution of crop rotations across fields appears to provide the explanation.

Table 19--Total Soil Loss by Tillage System and Soil Loss Constraint Level (tons) for Contour Tillage.

Soil Loss Constraint	Tillage System		
	Conventional	Minimum	No-Tillage
<u>Tons/Acre</u>	<u>Tons/Farm</u>		
40	173	108	297
3	119	56	194
1	60	36	51

Profit

Profit is calculated as gross revenue minus variable costs of crop production which includes machinery operation, seed, fertilizer, herbicides, and pesticides. Labor is supplied by the operator and is fixed for the farm but variable between crops. Labor costs are not included in the profit calculations.

There is no significant change in profit as tillage is reduced or as allowable soil loss is reduced. The difference is total profit between the most and the least profitable tillage and conservation practice is only \$265 with no soil loss constraint. As the soil loss constraints of three and one ton per acre are imposed, the difference between tillage systems is \$250 and \$231, respectively. Total profit for all three soil loss levels across all tillage and conservation practice combinations ranges from \$13,632 to \$13,365. Table 20 illustrates the similarity in profit between tillage

systems for up and down the slope tillage.

Table 20--Profit by Tillage System and Soil Loss Constraint Level.

Soil Loss Constraint	:	Tillage System		
		Conventional	Minimum	No-Tillage
Tons/Acre	:	-----Dollars-----		
40	:	13,632	13,515	13,477
3	:	13,615	13,511	13,401
1	:	13,594	13,493	13,358
	:			

A look at variable costs in the budgets, soil loss constraints aside, indicates that conventional tillage is less costly per acre than reduced tillage. The higher machinery operating costs of conventional tillage are more than offset by the additional herbicide required for reduced tillage. This difference between systems represents a substitution of herbicides for machine operations. In addition, more seed and fertilizer are required for reduced tillage.

The cost difference between tillage systems is such that a greater difference in profitability would be anticipated than is shown in the table above. An explanation for this is that more labor hours, a fixed and limiting factor are required for conventional tillage operations. The result is that less profitable but less labor-using rotations enter the model.

Another factor that tends to have a leveling effect on

profit is that costs vary between tillage systems only for row crops. Only conventional tillage is used for alfalfa; and, since oats are used primarily as a nurse crop, it too is tilled conventionally. In other words, variable costs for alfalfa and oats are constant across tillage systems.

Profit calculations do not include the fixed costs for the various tillage tool complements. Table 21 outlines the investment costs of each tillage system. Assuming the existing complement is conventional, an expenditure of \$1,160 for a chisel plow is necessary for conversion to minimum tillage. To convert to no-tillage an expenditure of \$5,200 is required for a knife fertilizer applicator and a no-till planter.

Table 21--Investment Costs of Tillage Equipment.¹

Activity	Tillage System		
	Conventional	Minimum	No-Tillage
	Dollars		
Apply Fertilizer			
Spreader	1,500	1,500	1,500
Knife	--	--	1,200
Plow	2,000	--	--
Disk and Spring Tooth	2,300	--	--
Chisel Plow	--	1,160	--
Herbicide Application	520	520	520
Planter	2,570	2,570	4,000
Cultivator	1,200	1,200	--
TOTAL	\$10,090	\$6,950	\$7,220

1. See Appendix 4 for detailed machinery budgets.

To estimate the relative impact of investment costs on profit requires making a few assumptions. These assumptions are:

- 1) Corn is grown continuously with tillage up and down the slope.
- 2) Corn yields are 100 bushels/acre and do not vary between tillage systems.
- 3) 100 acres of corn are harvested (consistent with L-P results for the case study farm).
- 4) Corn price is \$1.45/bushel.
- 5) The useful life of tillage equipment is 8 years.

The results are presented in Table 22. Profit is adjusted for labor charges at various rates per hour.

Table 22--Budgeted Profit per Acre by Tillage System.

Tillage System	:	:Minimum	:	Minus Labor Cost/Hour ²		
	:Gross	:Ownership	:			
	:Profit	:Costs for	:			
	:	:Tillage	:	\$2.00	\$3.50	\$5.00
	:	:and Plant-	:			
	:	:ing Equip. ¹	:			
Conventional	:100.83	91.74	:	84.34	78.79	73.24
Minimum	: 96.44	91.50	:	84.22	78.76	73.30
No Tillage	: 96.03	89.14	:	82.18	76.96	71.74

1. Only ownership costs that vary between tillage systems have been included. These costs include depreciation and interest on investment.
2. See Table 10 for labor hours per acre by tillage system.

From the table it is evident that there is little difference in profit between conventional and minimum tillage systems after adjustment for tillage ownership costs and labor.

No tillage is less profitable than conventional or minimum tillage by approximately 2 per cent.

As labor costs increase from \$2.00 to \$5.00 per hour there is a shift in profitability between conventional and minimum tillage. At \$2.00 per hour minimum tillage is less profitable than conventional. At \$5.00 per hour this situation is reversed with minimum tillage more profitable than conventional tillage.

It should be pointed out that these budget figures show only total labor requirements. Not shown are differences in the timing of labor requirements between tillage systems. As tillage is reduced so are peak labor requirements in pre-planting and planting periods. These differences are shown better in the linear programming model results.

Upon adopting reduced tillage it is not likely that conventional tillage equipment will be sold or traded. Conventional tillage is necessary for certain weed and rodent problems. It is also necessary for preparing a good seedbed for alfalfa.

It is difficult to compare the relative profitability of combinations of tillage systems except under specifically defined circumstances. It is necessary to make assumptions about the acreage tilled by each system and differences in crop yields if any. At one extreme, given soil loss constraints, reduced tillage allows row crop production where sod would be required if conventionally tilled. A profit comparison in this case would be the difference between the

profitability of an acre of row crop versus an acre of a sod crop. The decision to adopt reduced tillage would be based on this profit differential compared to the investment cost of reduced tillage systems. At the other extreme, tillage systems could be used interchangeably on the same crop with limited impact on yields. An example of this situation is shown in Table 23.

Table 23--Budgeted Average Profit per Acre for Multiple Tillage Systems.¹

Tillage System	:Gross	:Minus	: Minus Labor Cost		
	:Profit	:Ownership	: Per Hour		
		:Costs for	\$2.00	\$3.50	\$5.00
		:Tillage			
		:and Plant-			
		:ing Equip.			
		:			
Conventional	:	:			
and	: 98.64	84.61	77.27	71.77	66.26
Minimum	:				
	:				
Conventional	:	:			
and	: 96.24	84.41	77.29	71.95	66.61
No-Tillage	:				
	:				

1. Each tillage system in a combination is used on 100 acres.

The combination of conventional and no-tillage systems are slightly more profitable than the combination of conventional and minimum tillage systems. The total profit is reduced compared to Table 22 equal to added ownership costs of the second tillage complement.

Off-Farm Corn Sales

Feed produced in excess of dairy feed requirements is sold off the farm. For all combinations of tillage and conservation practices, excess corn and oats were produced. Alfalfa is the least profitable crop and only enough was produced to meet dairy feed requirements.

The amount of corn produced in excess of feed requirements increases as tillage is reduced. This is true for all three soil loss levels; however, the range is reduced as the constraints increase. Assuming an average yield of 100 bushels per acre approximately 4, 8, and 11 acres are planted in excess of feed requirements for conventional, minimum, and no-tillage respectively.

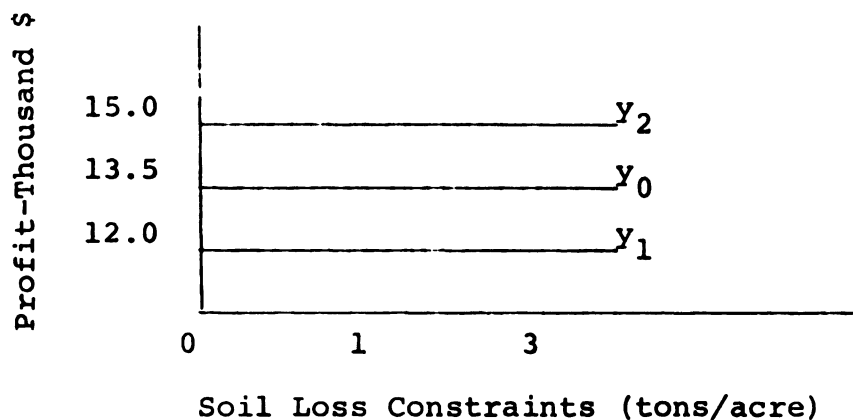
Reduced tillage allows corn to be grown on land that would otherwise be eliminated from row crop production by soil loss constraints. Further explanation for the inverse relationship between corn production and tillage may rest with the relative efficiency with which available labor is used. As tillage is reduced fewer labor hours are required per unit of product. Labor is a limiting factor of production; hence, there is a shift toward more labor-intensive crop rotations as more labor is released.

Sensitivity of Profitability to Changes in Prices and Yields

It has been observed for the case study farm that soil loss constraints do not materially affect profitability and that this is independent of the tillage system used. The question arises as to how sensitive this result is to a

change in crop prices or yields. The effect of a change in yields is to change unit costs and, hence, profitability from the cost side of the profit equation. The effect of a change in crop price influences profit directly from the revenue side of the profit equation. This relationship is tested by changing corn yield and price by 10 and 15 per cent respectively in separate runs. The results for corn yield changes, similar to the change in price, are that profits are insensitive across tillage systems. These results for yield changes are summarized in Figure 4.

Figure 4--Change in Profit Due to a Change in Corn Yield for All Tillage and Conservation Practices.



where:

y_0 = the current normal corn yield

y_2 = the current normal plus 10 per cent, and

y_1 = the current normal minus 10 per cent

The general conclusion is that the changes in corn prices and yields specified for the case study farm have a very limited impact upon the relative profitability of tillage and conservation practice combinations and soil loss levels.

Land Use

With no soil loss constraints, land use patterns (crop rotations) vary between tillage systems. As tillage is reduced, crop rotations approach continuous hay and corn as opposed to rotations containing both hay and corn. This represents a substitution of reduced tillage for crop rotations to reduce soil loss. A further explanation is that less labor is required during periods of peak labor demands for minimum tillage; hence, more is available for labor intensive rotations like continuous corn. Within a tillage system land use varies between conservation practices, but much less than between tillage systems.

As constraints are imposed, the range of land use on a particular field is reduced. Fewer rotations are consistent with soil loss limits; hence, land use becomes more similar as soil loss constraints increase. In the case of one ton per acre soil loss constraints, land use is similar between tillage systems for particular fields.

Impact of Limited Land Use Adjustment

Up to this point it can be concluded, at least for the case study farm, that soil loss constraints of three and one ton per acre have only a minor impact on profit. Profit is essentially constant for no, one, and three tons per acre constraints. Further, the tillage systems are not limiting since all three tillage systems can meet the soil loss constraints imposed without reducing profit. A result is that

the added investment for minimum and no-tillage equipment is not necessary to comply with legislation similar to the Iowa Conservancy Law.

In each instance profitability was maintained and soil loss reduced by changing land use patterns. As might be expected, sod crops shifted to sloping soils and row crops were produced on level or nearly level soils.

The consequences of not making these land use adjustments can be assessed by imposing soil loss constraints on the land use pattern in the solution unconstrained for soil loss. Intuitively it can be seen that profits will be reduced because the cropping pattern on some fields will violate soil loss constraints and be eliminated. This approach represents the extreme, the opportunity cost of not adjusting land use for soil loss constraints where land use is allowed to vary.

The impact of allowing no land use adjustment for soil loss controls varies widely between tillage up and down the slope and on the contour. This is illustrated in Table 24. In both cases profits are reduced compared to when the optimum land use adjustment is made. For the three ton soil loss constraints, profits are reduced ranging from 13 to 19 per cent for contour tillage. For up and down the slope tillage, profit is reduced from 77 to 128 (net loss) per cent.

There is a dramatic difference in profit reduction between contour and up and down the slope tillage. One reason is that contour tillage is soil conserving; hence, more intensive rotations (i.e., continuous corn) are possible. A second is

that the corn yields from contour tillage are slightly higher than yields for up and down the slope. Both of these factors have a positive effect on profitability.

Table 24--Per Cent Reduction in Profit Due to Lack of Land Use Adjustment.

Category	Tillage and Conservation Practice					
	Conventional		Minimum		No-Tillage	
	Up & Dn.Contour	Up & Dn.Contour	Up & Dn.Contour	Up & Dn.Contour	Up & Dn.Contour	Up & Dn.Contour
-----Per Cent-----						
Three Ton Soil Loss Limit	77	13	91	19	128	16
One Ton Soil Loss Limit	161	53	95	42	157	15

Imposing the land use pattern from the solution unconstrained for soil loss with three and one ton per acre soil loss constraints gives rather unrealistic results. Some land use adjustment is likely even though not optimum with respect to profit. To approximate a suboptimal adjustment, hay was grown where row crops were eliminated because of the soil loss constraints. The result approximates an initial adjustment representing something within the continuum between no adjustment and an optimal adjustment.

Allowing this initial adjustment improves profitability considerably with the exception of no-tillage. The summary results are presented in Table 25.

Table 25--Per Cent Reduction in Profit From Optimum Land Use
After an Initial Adjustment in Land Use.

	:	Tillage and Conservation Practice					
	:						
Category	:	Conventional		Minimum		No-Tillage	
	:	Up & Dn.Contour		Up & Dn.Contour		Up & Dn.Contour	
	:						
	:	-----Per Cent-----					
	:						
Three Ton	:						
Soil Loss	:						
Limit	:	25	1	15	2	112	12
	:						

In fact, with conventional and minimum tillage on the contour, profit reduction is minor. The exception for no-tillage occurs because row crops were produced on sloping land on the initial no-tillage run. When this production was eliminated because of soil loss constraints and replaced with hay production, a large share of the corn requirements had to be purchased.

Labor

The calendar for labor usage is divided into thirty-three one-week periods. Activities in these periods include pre-planting, planting, cultivating, and harvesting. These activities may compete for labor in a given week particularly for pre-planting corn and planting oats and alfalfa.

According to theory the marginal value of labor in a given use can be expressed as follows:

$$MVP_x = MP_x P_y$$

where: MVP_x is the marginal value product of labor in period x.

MP_x is the marginal product of labor in period x ,
 and P_y is the price of the product produced with labor
 from period x .

Since product prices are fixed the marginal value product of labor varies with the marginal product of labor. The marginal product of labor varies between tillage systems as illustrated in the following table.

Table 26--Marginal Value Product of Labor (Periods 0, 1, and 2) in Dollars.

Soil Loss Constraints	:	Tillage System		
		Conventional	Minimum	No-Tillage
<u>Tons/Acre</u>	:	-----Dollars-----		
40	:	4.58	4.36	2.53
3	:	4.58	4.36	2.69
1	:	4.58	4.41	2.51

These numbers indicate what the farmer can afford to pay for another unit of labor by tillage system. Or stated differently, another unit of labor would increase profit by an amount equal to the marginal value product of labor.

Each tillage system represents a different production function; a comparison indicates the relative efficiency with which labor is used by tillage system, given the profit maximizing output mix. Labor requirements are less as tillage is reduced and labor becomes less limiting, i.e., its marginal product is reduced.

Interpretation of these numbers is complicated by the fact that tillage varies only for corn. Conventional tillage is used in all cases for alfalfa and oats; hence, minimum tillage means minimum tillage for corn and conventional tillage for oats and alfalfa. If tillage varied across all crops, differences in the marginal value product of labor between tillage systems would be greater since reduced tillage would be applied to all crops.

Another problem in interpretation is that both planting and pre-planting activities occur during labor periods 0 through 2; the marginal value product of labor in these periods cannot be attributed solely to the marginal product of labor used in tillage operations. The speed with which planting operations are performed is inversely related to the amount of tillage. Whereas labor requirements for pre-planting are reduced as tillage is reduced, labor requirements for planting increase.

The net effect of these forces is displayed in Table 26. What can be inferred is that labor is more limiting as the amount of tillage is increased. And, ceteris paribus, reduced tillage would be preferred where labor is a limiting factor. This is not a new finding and is simply in agreement with previous budgetary studies of alternative tillage systems.

Table 26 also shows that the value of labor does not vary significantly as soil loss constraints are changed. This is primarily because soil loss constraints have no effect on the marginal product of labor. What varies as soil loss

constraints are reduced is the distribution of crops across farm fields.

Energy Shortage and Soil Loss Controls

There are several aspects of the current energy situation that have implications for soil loss controls. Most obvious is the price and availability of fuel and other petroleum products to farmers. The price and availability of fuels in agricultural service industries will influence factor costs, primarily those associated with transportation and for the production of fertilizer.

If the price of petroleum should increase significantly or become limited in supply the different energy requirements of alternative tillage systems becomes more important. However, fuel savings alone will not have strong influence on the selection of tillage equipment. If fuel prices should double, fuel savings would pay approximately 13 per cent of the total conversion cost between conventional and minimum tillage and 5 per cent between conventional and no-tillage systems.¹ To the extent fuel becomes limiting to agriculture reduced tillage equipment will enable more acres to be planted and increase gross farm income. This, however, is an unlikely prospect with the high priority fuel allocation assured agriculture.

1. This assumes the additional investments are amortized over a seven year period at 7 per cent and used on the whole farm.

Generalization of Results

To facilitate generalization of study results, the high roughage feed requirements of the dairy farm were dropped. What remains is essentially a cash grain farm producing a combination of row and sod crops. The three and forty tons per acre soil loss constraints were imposed on the three tillage systems. Profit increased between nine and ten per cent for all combinations of tillage and conservation practices for both soil loss levels. However, one caution should be mentioned in generalizing to cash crop farms. Typically, dairy farms do not employ the latest crop production technology compared with cash crop operations. The direction of the difference in profitability between a dairy and cash grain farm may be the same but the magnitude may be larger. The important distinction is that profitability is very similar for the runs with and without soil loss constraints.

In summary, converting the case study dairy farm to a cash crop farm increases profits from crop production even given compliance with soil loss constraints. The case study farm itself is fairly typical of Southeast Wisconsin dairy farms according to the U.S. Soil Conservation Service and the Production Credit Association records. How far beyond this region generalization is possible is open to question. A compliance strategy to soil loss controls can only be suggested within the setting of the case study farm and generalization of results will depend upon the similarity of conditions with those discussed here. The results indicate that

any of the three tillage systems are capable of meeting the specified soil loss constraints and with little differential impact on profit. There is a slight profit advantage to conventional tillage based on a variable cost comparison; however, labor requirements are higher during pre-planting and planting.

It should be pointed out that reduced tillage systems per se do not necessarily mean less soil loss. As with other tillage systems, the crop rotation must be matched with soil conditions to control soil loss.

CHAPTER VII

SUMMARY AND CONCLUSIONS

Introduction

This final chapter includes a summary and conclusions for the analysis presented in the previous six chapters. The primary purpose of the study has been to evaluate the economic impact of legislated soil loss controls on a case study farm. Legislated controls represent an attempt to reduce environmental degradation through imposed regulation. They are another manifestation of our contemporary concern for the quality of our natural environment.

The primary objectives of the study are listed below:

1. Review the literature on physical and economic aspects of controlling erosion and sedimentation.
2. Review environmental law, in particular soil loss legislation as it applies to the case study farm.
3. Determine the economic impact of soil loss regulations on the case study farm.

The results of pursuing these objectives are discussed in turn followed by a summary of the implications for land users, policy makers and other researchers.

Past Research on Soil Loss Control

Sedimentation is a complicated process which includes the initial detachment of soil particles (erosion), transportation of these particles and their ultimate deposition. Physical research on sedimentation is voluminous and continues to grow. One of the most significant outcomes of this research is a soil loss estimating technique used by the action agencies in planning conservation systems. This technique, referred to as the "Universal Soil Loss Equation" incorporates all the major variables influencing erosion and can easily accommodate new research findings. The equation does not, however, estimate sedimentation. The problem of translating erosion to sedimentation has not been solved and remains intractable because of the many variables to consider between the erosion of soil particles and their subsequent deposition.

Hydrology simulation models have been developed in an attempt to consider as many variables as possible in estimating sediment yields. A major problem in constructing these models is in assembling the required information.

Soil conservation from the standpoint of maintaining soil productivity for agricultural purposes has been national policy for decades and yet the extent of adoption is less than desired. Many studies were made on voluntary adoption of soil conservation practices, the most recent of which were completed in the early sixties. These studies outlined a

number of problems preventing wider adoption of soil conserving agricultural practices. In general these problems include economic considerations, customs and legal arrangements.

The studies were carried out during a period of rapidly increasing crop yields where fertilizers were easily substituted for eroded soil. More currently timeliness of field operations is viewed as an impediment to the adoption of certain soil conserving practices.

Recent research on the economics of soil conservation focuses on the environmental quality dimension. Numerous references can be found defining sediment as an environmental quality problem. Sediment is a carrier of agricultural chemicals, bacteria and other potentially harmful elements.

An attempt has been made to evaluate the economic impact of reduced nitrogen fertilizer applications as a means of slowing eutrophication and improving water quality. Other research involves the construction of conceptual models; however, the level of detail has been inadequate to evaluate the impact of soil loss controls.

A relatively new development is the use of minimum tillage to reduce soil loss. Its use is dependent on the substitution of chemicals for tillage to control weeds, insects and other pests. Additional physical research is necessary to support economic evaluations of soil loss controls on farm firms. Many technical relationships need to be more firmly established.

Legal Considerations

Environmental problems as well as our sensitivity to them have increased steadily in recent years. Many of these environmental problems can be traced to gaps in property rights and hence, can theoretically be reduced by revising property rights. Revising property rights, particularly those associated with environmental resources, is in the domain of environmental law.

Legal concepts used in environmental cases can be grouped into procedural considerations, common law, statutory law and constitutional law. Procedural considerations include standing to sue, class actions and burden of proof. In recent times the courts have exhibited a more liberal interpretation of procedural rules and thereby increased the potential for successful environmental suits. Common law concepts used most often in environmental cases are trespass, liability, negligence and nuisance. The latter provides the basis for controlling soil loss in the Iowa Conservancy Law.

Statutory law, enactments of Congress and other governmental units provide potential environmental remedies under law. An example is the National Environmental Policy Act of 1969 (NEPA).

Federal and state constitutions provide yet another means of combating environmental degradation. For example, some contend that a pollution-free environment is guaranteed by the 9th Amendment of the Federal Constitution. The public

trust doctrine could also become a basis for environmental lawsuits.

The trend in environmental law is toward a more liberal interpretation of existing laws in favor of environmental cases. Further, a shift in environmental management has been made from the courts to state legislatures. And perhaps more importantly, past law minimizing the role of citizens in environmental cases has undergone a reinterpretation in favor of private citizens.

It should be pointed out that current environmental legal efforts are neither forward looking nor adequately funded and accordingly can have only a limited impact on improving environmental quality. A major problem is that legal solutions provide remedies for past actions and possibly under injunction prevent specific future occurrences. They do not necessarily prevent pollution, irreversible acts or provide any general approach. As for funding, there is some question as to whether private legal efforts based on philanthropic financial sources can be sustained. It should be noted also that the current energy situation means at least a temporary relaxation of existing pollution control laws.

Compared with other environmental problems little attention has been given to nonpoint pollution from land runoff. In fact, soil erosion has only recently been thought of as a pollution problem. Historically the focal point of erosion control has been on promoting voluntary efforts to

maintain soil productivity for agricultural purposes.

The creation of watershed management units with authority to set and enforce standards for land and water resource use has received considerable attention lately. The Iowa Conservancy Legislation is an example and represents a first in the area of agricultural soil loss legislation. Under the law excess soil loss is declared a nuisance and abatement is required under provisions of the law. The states of Michigan and Wisconsin have followed Iowa in adopting soil loss legislation. There are some significant differences in the laws particularly with regard to cost sharing provisions.

The current situation is that legislated soil loss controls have preceded an evaluation of the economic impact of controls. Both the outcomes of past soil loss research and economic theory provide rationale for the use of controls. Past experience with voluntary soil loss control efforts according to those initiating soil legislation is that inadequate control levels have been achieved. Soil loss represents an uncompensated damage or externality hence it is not considered in a farm firm's profit calculus. Legislation is one means of internalizing the external costs associated with soil loss.

Case Study Analysis

Empirical analysis of the impact of soil loss controls was accomplished by using a case study approach. A case study was used because soil loss legislation applies to

individual land users with all their subtle differences in enterprises, location, and scale of operation. Soil loss is sensitive to differences in the types and distribution of soils as well as crop management practices employed. Hence, soil loss assessment must be made on a case-by-case basis. Another reason for a case study analysis is the large quantity of primary data necessary to assess soil loss accurately. Detailed information is needed for each farm field including soil type, slope length, conservation practice, tillage system, and cropping pattern.

A profit maximizing linear crop production model, based on the characteristics of the case study farm, was used to assess the impact of soil loss limits. Soil loss limits imposed are 3 and 1 tons per acre per year. The former is the soil loss level that would be imposed on the case study farm if it were under the jurisdiction of the Iowa Conservancy Law.

Study Results

Prior to outlining the results study limitations will be summarized.

Limitations.

1. A case study approach was used and while the farm studied is reasonably representative of other farms in the area, how far generalization can be made remains a question.

2. The farm machinery used on the case study farm represents what was actually used and not necessarily the

optimum complement in terms of efficiency. It is possible that there are scale differences in tillage equipment that would affect the relative profitability of tillage systems.

3. Land use on the case study farm was divided into fields according to existing fence lines not necessarily the optimum land use pattern with respect to the distribution of soils and efficient use of farm labor and machinery. It is likely that this would influence total farm profit more than the relative profitability of tillage and conservation systems.

4. Case study results represent optimum behavior under defined circumstances and only approximate actual behavior of the farm operator.

5. Labor is not a cost in the model; it is only a constraint. Therefore, labor requirement differentials between tillage systems may not be fully reflected.

6. Only the operator's labor is included in crop production activities. It is possible that some family labor would be available during peak labor demands and hence, reduce the constraints imposed by limited operator labor.

7. The tillage and conservation systems used represent only a few of many possible combinations. Only two widely adopted reduced tillage methods were used. Others are available and no doubt further research will reveal still more tillage tools designed for specific circumstances.

8. This analysis of soil loss controls assumes soil loss control technology will remain constant after the imposition of controls. The impact of controls is evaluated

within present fixed assets of the firm. No indication is possible of what production technology might be developed in response to controls.

Major Findings

The following is a summary of the linear programming crop production model results for the case study farm. A set of runs were made for each soil loss level. A set means each combination of three tillage systems and two soil conservation practices for a total of six runs. The tillage systems are conventional, minimum, and no-tillage. The conservation practices are tillage on the contour and tillage up and down the slope.

Since separate runs were made for each tillage and conservation practice, they are in effect held constant while cropping pattern and plant and harvest dates are variable. Hence, given tillage and conservation practice, the model maximizes profit subject to the various constraints. The result is the most profitable distribution of crops across farm fields.

Without soil loss constraints soil loss varies widely between tillage practices. Reduced tillage systems per se may not have the lowest soil loss unless they are matched appropriately with slope and soil conditions. When soil loss constraints are imposed they force a matching of soil conserving crop rotations with erosive sloping soils. And generally with constraints, reduced tillage means less soil loss.

There is no significant change in profit as tillage is reduced or as soil loss constraints are tightened.¹ Higher machinery operating costs for conventional tillage are more than offset by additional herbicide, seed and fertilizer required for reduced tillage. Another factor that tends to have a leveling effect on profit is that more labor hours, a fixed factor, are required for conventional tillage than reduced tillage. Labor is limiting during tillage operations and the result is that less profitable but less labor-using crop rotations enter the model. Other reasons for similarity in profit between tillage systems are due to the model design which excludes fixed tillage costs.

With all tillage and soil loss limit combinations corn was produced beyond that required for the dairy operation. And as tillage is reduced the amount of corn produced in excess of feed requirements increases. The explanation may rest with the relative efficiency with which available labor is used. As tillage was reduced fewer hours of labor were required during the periods of peak labor demands. Labor was a limiting factor of production; hence, there was a shift toward more labor-intensive crop rotations as more labor was released.

The stability of the relationship between soil loss constraints and profitability was tested by changing corn price and yield 15 and 10 per cent respectively. For both changes

1. Fixed costs of tillage complements are not included in the profit calculus.

profit was nearly constant across tillage systems. Of course, the level of profit changes directly with the change in price and yield.

As soil loss constraints are imposed land use patterns (crop rotations) become more similar across tillage systems. Fewer rotations are consistent with soil loss limits; hence, land use becomes more similar. Land use approaches either continuous corn or hay depending on the physical limitations of particular fields.

The profit consequence of not adjusting land use patterns to soil loss constraints can be estimated by imposing soil loss constraints on the land use pattern in the solution unconstrained for soil loss. The result was that when soil loss limits were exceeded on a particular field the field does not enter the solution. The effect was a dramatic reduction in profit, especially for the one ton soil loss constraint without a soil conservation practice. There was a marked difference in impact between runs with and without contour tillage. Contouring is soil conserving and hence, consistent with lower soil loss constraints.

To approximate a partial adjustment hay was substituted wherever a rotation containing corn was eliminated because of excessive soil loss. Profit was improved considerably compared to where no adjustment was allowed. Profit was reduced only 1 and 12 per cent for conventional and no-tillage on the contour, respectively.

Budget comparisons of tillage systems including ownership

costs indicate little difference in the profitability of conventional and no tillage systems. However, as labor costs per hour increase there was a shift from conventional to minimum tillage as the most profitable system. No tillage was approximately 2 per cent less profitable than conventional and minimum tillage. These budget comparisons assume no difference in crop yields and will not hold for all soil types.

Budget comparisons consider only total labor requirements and not the timing or relative labor requirements between labor periods. Labor was a limiting factor of production during planting and pre-planting periods. Since labor peak requirements are reduced as tillage is decreased, reduced tillage systems can be substituted for labor. The decision to adopt reduced tillage systems may rest on a comparison between the opportunity cost of labor and the increased fixed costs of reduced tillage equipment.

To facilitate generalization of the study results, the high roughage feed requirements of the dairy farm were dropped. What remains is a cash crop farm. More acres were planted to corn and accordingly total farm profits were increased along with total soil loss but the latter was still within the constraints.

At least for the case study farm, soil loss constraints of three and one ton per acre will have only a minor impact on profit. Profit is nearly the same for soil loss limits of no, one, and three tons per acre. Further, the tillage

systems are not limiting. All three tillage systems (conventional, minimum, and no-tillage) can meet the soil loss constraints imposed without reducing profit. The implications are that the added investment for minimum and no-tillage equipment may not be necessary to comply with legislation similar to the Iowa Conservancy Law.

A compliance strategy can be suggested within the setting of the case study farm. Any of the three tillage systems are capable of meeting the soil loss constraints specified and with little differential impact on profit. There was a slight profit advantage to conventional tillage based on a variable cost comparison; however, labor requirements are higher. This should be considered prior to undertaking the additional investment necessary for reduced tillage systems.

Implications

Based on theoretical and empirical assessment of soil loss control the implications for land users, policy makers and other researchers can be outlined.

Land Users

The implications for land users within the context of the case study farm are:

1. Any of the tillage and conservation systems outlined can meet the specified soil loss limits. What is important to all tillage systems is to match land management systems with soil characteristics and slope if reduced soil loss is

to be achieved.

2. Where labor is particularly limiting the reduced labor requirements of reduced tillage systems should be evaluated but in the context of the additional investment required.

3. When planning for expansion land acquisitions should be evaluated in the context of potential soil loss controls. Are soil limitations consistent with anticipated land use?

Policy Makers

Implications for policy makers are:

1. Since controls have a limited impact on profit for the case study farm, a broader application of soil loss controls may be justified. However, cautions are in order. Soil loss controls are likely to have different impacts on land users depending on their location, soil type, enterprise combinations, etc. For example, to comply with soil loss constraints intensive row crop production is not possible on some case study farm fields. This is true even when no-tillage is used on the contour. Hence, drastic changes in land use may be required of owners of steeply sloping land. These changes would entail less intensive land use and reduced farm income.

2. Soil loss regulations should not specify the means of control. Costs of compliance will be minimized if land users are allowed to select the land management system that makes the most efficient use of controlled resources.

Further Research

1. This study can be viewed as one of a series of case studies to permit generalization to larger geographical areas. Other studies might encompass a broader range of physical and economic circumstances under which soil loss controls might be imposed. As a part of other case studies the relative impact on crop and livestock enterprises needs further evaluation. Highly erosive soils that can be controlled with sod would tend to favor ruminant livestock production. The experimental design of these case studies might include the reduction of the land base selectively to facilitate control impact evaluation more specifically by soil type.

2. A careful study of labor requirements for various tillage systems may reveal scale economies. Reduced tillage may be facilitated through the use of larger equipment.

3. Further study of the costs and benefits of alternative means to implement soil loss controls is needed. An incentive system to promote compliance might include information on the social benefits and costs associated with various control levels. Another approach with potential for research is the combination of soil loss controls (conservation) with crop production control programs.

4. The economics of alternative crop production soil loss controlling technology is another research area with potential. This should include a study of the physical interaction effects between tillage, soil, rotations, soil conservation practices, etc., influencing crop yields.

5. The value to society of holding soil in place needs to be researched. Multiperiod programming or similar tools could be used to study the economic dynamics of holding soil in place.

6. Physical research necessary to assess the broader environmental implications of soil loss controls includes the relationship between erosion and sedimentation. A practical and accurate means to convert erosion to sediment is needed.

BIBLIOGRAPHY

BIBLIOGRAPHY

- Andersen, Jay C., et al., "Profit-Maximizing Plans for Soil Conserving Farming in the Spring-Valley Creek Watershed in Southwest Iowa" Research Bulletin 519, Agricultural and Home Economics Experiment Station, Iowa State University of Science and Technology, July 1963.
- Atkins, S. W. "Economics Appraisal of Conservation Farming in the Grenada-Loring-Memphis Soil Area of West Tennessee." Agricultural Experiment Station Bulletin No. 369. University of Tennessee, October 1963.
- Ball, Gordon, et al., "Economic Evaluation of Use of Soil Conservation and Improvement Practices in Western Iowa." Technical Bulletin No. 1162. U.S. Department of Agriculture. Washington, D.C.: Government Printing Office. June 1957.
- Barkley, Paul W. and Seckler, David W. Economic Growth and Environmental Decay: The Solution Becomes the Problem. Harcourt Brace, 1972.
- Baumol, William J. "On Taxation and the Control of Externalities." American Economic Review, LXII(3).
- Biniek, Joseph P. "Economics of Water Pollution Control Measures." Paper presented at a meeting, Fort Collins. August 1-13, 1969.
- Blase, Melvin, G. and Timmons, John F. "Soil Erosion Control in Western Iowa: Progress and Problems." Research Bulletin 498. Agriculture and Home Economics Experiment Station: Iowa State University of Science and Technology. August 1962.
- Barlowe, Raleigh. "Public Land Policy: Inputs and Consequences." Paper presented at a conference at Michigan State University. May 18, 1973.
- Boulding, Kenneth. Economics As A Science. New York. McGraw-Hill. 1970.
- Connor, Larry J. "Environmental Pollution--Causes, Costs, Controls, and Tradeoffs." Ag. Econ. Misc. 1971-(8), Michigan State University. Dept. of Agric. Economics. July 1971.

- _____, and Hoglund, C. R. "An Economic Appraisal of Farm Pollution and Waste Management." Ag. Econ. Misc. 1970-(4). Michigan State University. Dept. of Agricultural Economics. 1970.
- Coutu, Arthur J. "Methods for an Economic Evaluation of Soil Conservation Practices." Technical Bulletin 137. North Carolina Agricultural Experiment Station. January 1959.
- Davis, Otto A., and Kamien, Morton I. "Externalities, Information and Alternative Collective Action." Joint Economic Committee. Analysis and Evaluation of Public Expenditures: The PPB System. Joint Committee Print, Vol. 1 Washington, D.C.: Government Printing Office, 1969.
- Doster, Howard D. "Economic Characteristic of Selected Tillage Systems." Purdue Top Farmer Workshop Corn Production Proceedings. Cooperative Extension Service: Purdue University, Lafayette, Indiana. August 1968.
- _____, "Economics of No-Tillage." Presented at the National No-Tillage Systems Symposium. Ohio State University. Columbus, Ohio. February 21, 1972.
- Dow Chemical Company. "An Economic Analysis of Erosion and Sediment Control Methods for Watersheds Undergoing Urbanization." Midland, Michigan. February, 1972.
- Fleming, George. "Hydrologic Simulation Procedures as Applied to Vegetation Management." Hydrocomp International Incorp. Palo Alto, California, 1971.
- Freeman, G. Myrick, III., Havaman, Robert A., and Kneese, Allen V. "The Economics of Environmental Policy." New York: John Wiley and Sons Inc., 1973.
- Grad, Frank P. Environmental Law: Sources and Problems. New York: Mathew-Bender, 1971.
- Gregory, W. W., et al. "1972 No-Tillage Recommendations--Planting and Pesticide Information." Cooperative Extension Service Publication ID-1. Lexington, Kentucky: University of Kentucky 1972.
- Greiner, William H. "A Legislative Approach to Erosion Control." Paper presented at a conference. Toronto, Ontario, Canada. April 25, 1972.
- Gottschalk, L. C. "Effects of Watershed Protection Measures on Reduction of Erosion and Sediment Damages in the United States." Extract of Publication No. 59 of the I.A.S.H. Commission of Land Erosion. P. 426-47.

Harrold, L. Lloyd. "Soil Erosion as Affected by Reduced Tillage Systems." A contribution from the North Appalachian Experimental Watershed, Corn Belt Branch, Soil and Water Conservation Research Division, Agricultural Research Service, USDA, Coshocton, Ohio. In cooperation with the Ohio Agricultural Research and Development Center, Wooster, Ohio. February 1972.

_____, G. B. Triplett, Jr., and R. E. Youker. "Less Soil and Water Loss from No-Tillage Corn." Ohio Report 52 (2):22-23. March-April 1967.

Harsh, Stephen, et al. "Least-Cost Dairy Rations--A Telplan Program." Program 31. Michigan State University. 1971.

Headley, J. Charles. "Agricultural Productivity and Environmental Quality." American Journal of Agricultural Economics 54:749-56.

Held, Burnell R., et al. "Soil Erosion and Some Means for its Control." Special Report No. 29. Agricultural and Home Economics Experiment Station: Iowa State University of Science and Technology, August 1962.

_____, and Timmons, John F. "Soil Erosion Control in Process in Western Iowa." Research Bulletin 460. Agricultural and Home Economics Experiment Station: Iowa State College. August 1958.

Hines, William N. "Legal Aspects." Agricultural Practices and Water Quality. Ed. Ted L. Wallich and George E. Smith. Ames, Iowa: Iowa State University Press. 1970.

Hutchins, Wells A. "Water Rights in the Nineteen Western States." U.S. Department of Agriculture. Miscellaneous Publication No. 1206. Washington, D.C.: U.S. Government Printing Office. 1971.

Iowa, State of. "Iowa House File 73." Enacted by the General Assembly.

Isaacs, Roscoe, Jr., and Colson, Dentis A. "No-Tillage--A New Production Management System." Technical Note, Agronomy Number 59. Soil Conservation Service: USDA, Lexington, Kentucky. March 26, 1971.

Jacobs, James J. "Economics of Water Quality Management: Exemplified by Specified Pollutants in Agricultural Runoff." Unpublished Ph.D. Dissertation. Ames, Iowa: Iowa State University, Department of Economics, 1972.

- Johnson, James B., and Larry J. Connor. "Origins and Implications of Environmental Quality Standards for Animal Production." Reprint from Proceedings of the International Symposium of Livestock Wastes. American Society of Agricultural Engineers. St. Joseph, Michigan 1971.
- _____. "Potential Impacts of Alternative Measures of Minimizing Pollution Originating from Animal Wastes." Michigan State University. 1971.
- Kneese, Allen V. "Environmental Pollution: Economics and Policy." American Economic Review, LXI(2). 153-66. December 1970.
- _____. "Protecting Our Environment and Natural Resources in the 1970s." Resources for the Future. Reprint No. 88. August 1970.
- Landgren, Norman E., and Andersen, Jay C. "A Method for Evaluating Erosion Control in Farm Planning." Agricultural Economics Research. USDA. XIV(2): April 1962.
- Lee, Jue Sun. "Productivity, Total Non-Structural Carbohydrates in Roots, and in Vitro Dry Matter Disappearance of Alfalfa, Given Different Four-Cutting Systems Under Three Different First Cutting Dates." Unpublished Ph.D. Dissertation. Michigan State University: Department of Crops and Soils. 1973.
- Levi, Donald R., and Colger, Dale. "Legal Remedies for Pollution Abatement." Science, CLXXV, March, 1972. p. 1085-87.
- Lohrmann, Robert R. "Environmental Lawsuit: Traditional Doctrines and Evolving Theories to Control Pollution." Wayne Law Review XVI, 1970. p. 1085-1135.
- Meyer, L. D., and Wischmeier, Walter H. "Mathematical Simulation of the Process of Soil Erosion by Water." Transactions of A.S.E.A., 12(6): 1969.
- Michael, Charles C., and Nauheim, Charles W. "Economics of Soil Conservation in Northeastern Kansas." Agricultural Economics Report No. 101. Kansas State University. December 1961.
- Michigan. Michigan Public Acts of 1972. Act. No. 347.
- _____. Department of Agriculture. Michigan's Soil Erosion and Sedimentation Control Program. May 1973.

National Association of Counties Research Foundation. "Urban Soil Erosion and Sediment Control." 1001 Connecticut Avenue, N.W., Washington, D.C., 20036. May 1970.

Negev, Moshe. "A Sediment Model on a Digital Computer." Technical Report No. 76. Stanford University: Department of Civil Engineering. March 1967.

North Central Regional Research. "Productivity of Soils in the North Central Region of the United States." Publication 166. University of Illinois Experiment Station, Bulletin No. 710. May 1965.

Ohio State University. Cooperative Extension Service. "1972-73 Ohio Agronomy Guide." Bulletin 472.

Randall, Alan. "Market Solutions to Externalities Problems: Theory and Practice." American Journal of Agricultural Economics 54:175-83. May 1972.

Rask, Norman, G. B. Triplett, Jr., and D. M. Van Doren, Jr. "A Cost Analysis of No-Tillage Corn." Ohio Report 52(1): January-February 1967.

Robinson, A. R. "A Primer on Sediment." Journal of Soil and Water Conservation. March-April 1971.

_____. "Sediment is still the Largest Single Pollutant of Water." Farm Journal. April 1971.

Roehl, John W. "Sediment Source Areas, Delivery Ratios and Influencing Morphological Factors." Presented at the Symposium on Land Erosion. October 1962.

Rosenberry, Paul E. "Evaluating Soil Management Practices to Reduce Erosion and Sediment in a River Basin." Economic Research Service. Iowa State University, Ames, Iowa, 1973.

_____, and Moldenhauer, W. C. "Economic Implications of Soil Conservation." Journal of Soil and Water Conservation, (November-December 1971), 221-224.

Sax, Joseph P., "Legal Strategies Applicable to Environmental Quality Management Decisions." Environmental Quality Analysis: Theories and Methods in the Social Sciences. Ed. Kneese, Allen V., and Bower, Blair G. Johns Hopkins Press. 1972.

Schmid, A. Allen. "Analytical Institutional Economics: Challenging Problems in the Economics of Resources for a New Environment." American Journal of Agricultural Economics. 54:893-901. December 1972.

- Seay, Edmond Eggleston, Jr., "Minimizing Abatement Cost of Water Pollutants from Agriculture: A Parametric Linear Programming Approach." Unpublished Ph.D. Dissertation. Ames, Iowa: Iowa State University, Department of Economics. 1970.
- Smith, Wesley G., and Heady, Earl O. "Use of a Dynamic Model in Programming Optimum Conservation Farm Plans on Ida-Monona Soils." Research Bulletin 475. Agricultural and Home Economics Experiment Station, Iowa State University of Science and Technology. February 1960.
- Swanson, Earl R. "Environmental Aspects of Fertilizer Use." Paper presented in the Department of Agricultural Economics. Michigan State University. East Lansing, Michigan. September 28, 1972.
- _____, and A. V. S. Narayanan. "Evaluation of the Effect of Alternative Agricultural Systems on Water Quality: A Linear Programming Approach." Unpublished, University of Illinois, Urbana, 1972.
- Udall, Stewart L. The Quiet Crisis. New York. Holt, Rinehart and Winston, 1963.
- U. S. Congress. Senate Bill 52-70.
- U. S. Congress. Federal Water Pollution Control Act. Amendments of 1972. Enacted October 18, 1972.
- U. S. Department of Agriculture. "A National Program of Research for Soil and Land Use." Prepared by a Joint Task Force of the USDA, the State Universities and Land Grant Colleges. April 1969.
- _____. Agricultural Stabilization and Conservation Service. National Environmental Assistance Program for 1971 and Subsequent Years. Article 701-46. Reprinted from the Federal Register of September 11 and 24, 1971.
- _____. Soil Conservation Service, Engineering and Watershed Planning Unit. "Economic Evaluation of Conservation." Portland, Oregon. January 1958.
- _____. Agricultural Research Service. Proceedings, Federal Inter-Agency Sedimentation Conference. Miscellaneous Publication No. 970. 1963.
- _____. Soil Conservation Service. Agronomy Information Release, No. 9. Columbus, Ohio. January 2, 1968.

- _____. Agricultural Research Service. USDA, H.L.-70 Model of Watershed Hydrology." 1971.
- _____. Water. 1955 Yearbook of Agriculture. Washington, D.C.: U. S. Government Printing Office.
- U. S. Government Council on Environmental Quality. "Environmental Quality." The First Annual Report of the Council on Environmental Quality Transmittal to Congress. Washington, D.C.: U. S. Government Printing Office, August 1970.
- Wall Street Journal. "Environmental Outlays Rising to \$287 Billion in 10 Years Through 1980, U. S. Panel Says." August 8, 1972.
- Wischmeier, Walter H., and Smith, Dwight D. "Predicting Rainfall-Erosion Losses from Cropland East of the Rocky Mountains." Agricultural Handbook No. 282. USDA Agricultural Research Service. Washington, D.C.: U. S. Government Printing Office, May 1965.
- Wisconsin Farm Business Summary, Cooperative Extension Programs--University Extension Department of Agricultural Economics. Madison, Wisconsin. 1971.
- Wisconsin Laws. Soil and Water Conservation. Chapter 92. As amended by the 1971 Senate Bill 288.
- Wunderlick, Gene. "Emerging Views of Property in Land." Issues in Natural Resource Use and Development. Report No. 1. North Central Regional Strategy. Committee on Natural Resource Development. Ed. Dan Bromley and Lloyd Fischer. October 1971.

APPENDICES

APPENDIX 1. SOILS

Table 1. Soil Comparability.¹

Wisconsin	<u>Soil Series Name</u>		Michigan Soil Management Group
	Ohio		
Miami Silt Loam	Wooster Silt Loam	2.5a Miami	
Calamus Silt Loam	Canfield Silt Loam	2.5a Miami	
Clyman Silt Loam	Crosly Silt Loam	2.5b Conover	
Elba Silty Clay Loam	Hoytville Silty Clay Loam	1.5c Hettinger	
Ehler Silt Loam	Brookston Silt Loam	2.5c Brookston	

1. Soils correlation by Professor Eugene Whiteside, Department of Crops and Soils, Michigan State University, March 30, 1973.

APPENDIX 1. SOILS (continued)

Table 2. Soils Distribution by Field.

Field	Soils	Acres	Field	Soils	Acres
I	177-3-1	1.4	VI	55-11-2	1.0
	55-6-2	3.3		178A-1	1.5
	178-2+	4.4		290A-1	3.3
	61-3-1	2.4		215A-1	2.7
	178A-1	4.4		55-7-2	3.7
	215A-1	4.9		177-3-1	4.3
		<u>20.8</u>		215A-1	<u>3.7</u>
					20.2
II	61-7-1	2.5	VII	178A-1	2.8
	177-3-1	.4		55-11-2	1.6
	55-6-2	3.0		178-3-1	.6
	178A-1	5.9		178A-1	1.0
	328A+	4.6		55-11-2	<u>1.0</u>
	290A+	4.0			7.0
		<u>20.4</u>			
III	328A+	1.6	VIII	215A-1	39.2
	178A-1	8.8		215A	36.4
	290A-1	3.2		290A-1	4.4
	177A-1	12.8		178A-1	<u>4.4</u>
	177-3-1	6.4			84.4
	253-1	2.0			
		<u>34.8</u>	IX	55-5-2	1.0
IV	55-11-2	10.9		215A-1	23.5
	177A-1	2.6		426-2-1	1.5
	178A-1	4.7		226A-1	<u>1.5</u>
	177A-1	2.6			27.5
		<u>20.8</u>	X	215A-1	7.1
V	177A-1	6.3			
	177-3-1	3.4	XI	177-3-1	2.4
	55-11-2	7.1	XII	215-A-1	4.5
	55-5-1	1.5		177-2-1	6.3
	177A-1	1.9		178-2-1	4.5
		<u>20.2</u>		177-3-1	<u>2.7</u>
					18.0

APPENDIX 1. SOILS (continued)

Table 3. Description of Soils on the Case Study Farm.

Soil Mapping #	
25	Dane silt loam: Well drained, grayish-brown silt loam underlain by brown silty clay loam subsoil which grades into yellowish brown silty material that is underlain by loamy glacial till at about 48 inches.
55	Miami silt loam: Well drained, dark grayish-brown silt loam grading into dark brown silty clay loam into clay loam underlain by loamy glacial till at about 32 inches.
56	Casco loam: Well drained, dark grayish-brown loam grading into dark brown clay loam underlain by loose sand and gravel at 12 to 20 inches.
61	Dodge Silt loam: Well drained, dark grayish-brown silt loam grading into dark brown to dark yellowish brown silty clay loam underlain by loamy glacial till at 36 to 48 inches.
118	Spinks loamy fine sands: Well to excessively drained dark grayish-brown loamy fine sand grading into yellowish-brown loose sand with thin layers of brown sandy loam between 40 and 56 inches.
177	Calamus Silt loam: Moderately well drained, dark grayish brown silt loam grading into silty clay loam with a few yellow and gray mottles underlain by loamy glacial till at about 45 inches.
178	Clyman silt loam: Somewhat poorly drained, very dark grayish brown silt loam grading into brown to grayish brown silty clay loam with many yellow and brown mottles underlain by loamy glacial till at 36 to 50 inches.
215	Elba silty clay loam: Very poorly drained, black silty clay grading into olive gray and grayish brown silty clay loam with yellowish brown mottles.
226	Bristol silt loam: Somewhat poorly drained, black silt loam grading into brown to dark brown heavy silt loam with many yellowish brown mottles underlain at about 45 inches by loamy glacial till.

Table 3 (continued)

290	Ehler silt loam: Poorly drained, very dark gray silt loam grading into grayish brown clay loam and gray silty clay loam with dark brown, gray and yellow mottles, underlain at about 30 inches by grayish brown silt loam.
328	Wastenau silt loam: Poorly drained, dark grayish brown silty alluvium, 12 to 30 inches deep, underlain by dark colored, poorly drained mineral soil.
426	Keyser silt loam: Moderately well-drained, black silt loam grading into dark brown silty, clay loam with faint mottling in the lower part; underlain by loamy glacial material at depths ranging from 3 to 5 feet.

APPENDIX 1. SOILS (continued)

Table 4. Distribution of Soils by Field.

Field	<u>Soil</u>				
	Elba	Calamus	Clyman	Ehler	Miami
	-----Percentage distribution-----				
I	23.7	6.5	54.0		15.8
II		2.9	51.2	26.5	19.4
III		63.8	26.6	9.6	
IV		25.0	22.5		52.5
V		57.4			42.6
VI	31.7	21.1	7.6	16.6	23.0
VII			62.9		37.1
VIII	89.8		5.0	5.2	
IX	94.4				5.6
X					
XI					
XII	25.0	50.0	25.0		

APPENDIX 2. CROP YIELDS

	Page
Corn Yields	160
Oat Yields	181
Alfalfa Yields	187

WEIGHTS ARE (1) PLANT & HARVEST =1.000 (2) TILLAGE = .500 (3) ROTATION = .125 (4) CONSERVATION = .375

CORN IN CCCOH ROTATION ON ELBA SOIL WITH UP\$DOWN CONVENT. TILLAGE
INDEX =1.07 BASE YIELD =125.0 INDEX = .90 INDEX = 1.05

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
112.3	1.00	.95	109.5	0.0	0.00	0.0	0.0	0.00	0.0	0.00
111.2	.98	.94	108.9	.94	107.2	.91	102.2	.82	97.7	.74
108.9	.94	.89	106.1	.89	103.9	.85	98.8	.76	93.7	.67

CORN IN CCCOH ROTATION ON ELBA SOIL WITH UP\$DOWN MINIMUM TILLAGE
INDEX =1.07 BASE YIELD =125.0 INDEX = .90 INDEX = 1.00

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
110.9	1.00	.95	108.1	0.0	0.00	0.0	0.0	0.00	0.0	0.00
109.8	.98	.94	107.5	.94	105.8	.91	100.8	.82	96.3	.74
107.5	.94	.89	104.7	.89	102.4	.85	97.4	.76	92.3	.67

CORN IN CCCOH ROTATION ON ELBA SOIL WITH UP\$DOWN NO - TILLAGE
INDEX =1.07 BASE YIELD =125.0 INDEX = .90 INDEX = 1.00

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
110.9	1.00	.95	108.1	0.0	0.00	0.0	0.0	0.00	0.0	0.00
109.8	.98	.94	107.5	.94	105.8	.91	100.8	.82	96.3	.74
107.5	.94	.89	104.7	.89	102.4	.85	97.4	.76	92.3	.67

CORN IN CCCOH ROTATION ON ELBA SOIL WITH CONTOUR CONVENT. TILLAGE
INDEX =1.07 BASE YIELD =125.0 INDEX = 1.00 INDEX = 1.05

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
114.4	1.00	.95	111.6	0.0	0.00	0.0	0.0	0.00	0.0	0.00
113.3	.98	.94	111.0	.94	109.3	.91	104.3	.82	99.8	.74
111.0	.94	.89	108.2	.89	106.0	.85	100.9	.76	95.8	.67

CORN IN CCCOH ROTATION ON ELBA SOIL WITH CONTOUR MINIMUM TILLAGE
INDEX =1.07 BASE YIELD =125.0 INDEX = 1.00 INDEX = 1.00

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
113.0	1.00	.95	110.2	0.0	0.00	0.0	0.0	0.00	0.0	0.00
111.9	.98	.94	109.6	.94	107.9	.91	102.9	.82	98.4	.74
109.6	.94	.89	106.8	.89	104.6	.85	99.5	.76	94.4	.67

CORN IN CCCOH ROTATION ON ELBA SOIL WITH CONTOUR NO - TILLAGE
INDEX =1.07 BASE YIELD =125.0 INDEX = 1.00 INDEX = 1.00

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
113.0	1.00	.95	110.2	0.0	0.00	0.0	0.0	0.00	0.0	0.00
111.9	.98	.94	109.6	.94	107.9	.91	102.9	.82	98.4	.74
109.6	.94	.89	106.8	.89	104.6	.85	99.5	.76	94.4	.67

WEIGHTS ARE (1) PLANT \$ HARVEST =1.000 (2) TILLAGE = .500 (3) ROTATION = .125 (4) CONSERVATION = .375

CORN IN CCOHH ROTATION ON ELBA SOIL WITH UP\$DOWN CONVENT. TILLAGE														
INDEX =1.02 BASE YIELD =125.0 INDEX = .90 INDEX = 1.00														
PLANTING DATES														
HARVEST DATE	SEPT 27 - OCT 18	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX			
HARVEST DATE	OCT 19 - NOV 8	110.5	1.00	107.7	.95	0.0	0.00	0.0	0.00	0.0	0.00			
HARVEST DATE	NOV 9 - 29	109.4	.98	107.2	.94	105.5	.91	100.4	.82	95.9	.74			
HARVEST DATE		107.2	.94	104.3	.89	102.1	.85	97.0	.76	92.0	.67			
CORN IN CCOHH ROTATION ON ELBA SOIL WITH UP\$DOWN MINIMUM TILLAGE														
INDEX =1.02 BASE YIELD =125.0 INDEX = .90 INDEX = 1.00														
PLANTING DATES														
HARVEST DATE	SEPT 27 - OCT 18	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX			
HARVEST DATE	OCT 19 - NOV 8	110.5	1.00	107.7	.95	0.0	0.00	0.0	0.00	0.0	0.00			
HARVEST DATE	NOV 9 - 29	109.4	.98	107.2	.94	105.5	.91	100.4	.82	95.9	.74			
HARVEST DATE		107.2	.94	104.3	.89	102.1	.85	97.0	.76	92.0	.67			
CORN IN CCOHH ROTATION ON ELBA SOIL WITH UP\$DOWN NO - TILLAGE														
INDEX =1.02 BASE YIELD =125.0 INDEX = .90 INDEX = 1.00														
PLANTING DATES														
HARVEST DATE	SEPT 27 - OCT 18	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX			
HARVEST DATE	OCT 19 - NOV 8	110.5	1.00	107.7	.95	0.0	0.00	0.0	0.00	0.0	0.00			
HARVEST DATE	NOV 9 - 29	109.4	.98	107.2	.94	105.5	.91	100.4	.82	95.9	.74			
HARVEST DATE		107.2	.94	104.3	.89	102.1	.85	97.0	.76	92.0	.67			
CORN IN CCOHH ROTATION ON ELBA SOIL WITH CONTOUR CONVENT. TILLAGE														
INDEX =1.02 BASE YIELD =125.0 INDEX = 1.00 INDEX = 1.00														
PLANTING DATES														
HARVEST DATE	SEPT 27 - OCT 18	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX			
HARVEST DATE	OCT 19 - NOV 8	112.6	1.00	109.8	.95	0.0	0.00	0.0	0.00	0.0	0.00			
HARVEST DATE	NOV 9 - 29	111.5	.98	109.3	.94	107.6	.91	102.5	.82	98.0	.74			
HARVEST DATE		109.3	.94	106.5	.89	104.2	.85	99.1	.76	94.1	.67			
CORN IN CCOHH ROTATION ON ELBA SOIL WITH CONTOUR MINIMUM TILLAGE														
INDEX =1.02 BASE YIELD =125.0 INDEX = 1.00 INDEX = 1.00														
PLANTING DATES														
HARVEST DATE	SEPT 27 - OCT 18	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX			
HARVEST DATE	OCT 19 - NOV 8	112.6	1.00	109.8	.95	0.0	0.00	0.0	0.00	0.0	0.00			
HARVEST DATE	NOV 9 - 29	111.5	.98	109.3	.94	107.6	.91	102.5	.82	98.0	.74			
HARVEST DATE		109.3	.94	106.5	.89	104.2	.85	99.1	.76	94.1	.67			
CORN IN CCOHH ROTATION ON ELBA SOIL WITH CONTOUR NO - TILLAGE														
INDEX =1.02 BASE YIELD =125.0 INDEX = 1.00 INDEX = 1.00														
PLANTING DATES														
HARVEST DATE	SEPT 27 - OCT 18	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX			
HARVEST DATE	OCT 19 - NOV 8	112.6	1.00	109.8	.95	0.0	0.00	0.0	0.00	0.0	0.00			
HARVEST DATE	NOV 9 - 29	111.5	.98	109.3	.94	107.6	.91	102.5	.82	98.0	.74			
HARVEST DATE		109.3	.94	106.5	.89	104.2	.85	99.1	.76	94.1	.67			

WEIGHTS ARE (1) PLANT & HARVEST =1.000 (2) TILLAGE = .500 (3) ROTATION = .125 (4) CONSERVATION = .375

CORN IN CCONHH ROTATION ON ELBA SOIL WITH UP\$DOWN CONVENT. TILLAGE
INDEX =1.00 BASE YIELD =125.0 INDEX = .90 INDEX = 1.00

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
110.4	1.00	107.6	.95	0.0	0.00	0.0	0.00	0.0	0.00
109.3	.94	107.0	.94	105.3	.91	100.3	.82	95.8	.74
107.0	.94	104.2	.89	102.0	.85	96.9	.76	91.8	.67

CORN IN CCONHH ROTATION ON ELBA SOIL WITH UP\$DOWN MINIMUM TILLAGE
INDEX =1.00 BASE YIELD =125.0 INDEX = .90 INDEX = 1.00

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
110.4	1.00	107.6	.95	0.0	0.00	0.0	0.00	0.0	0.00
109.3	.98	107.0	.94	105.3	.91	100.3	.82	95.8	.74
107.0	.94	104.2	.89	102.0	.85	96.9	.76	91.8	.67

CORN IN CCONHH ROTATION ON ELBA SOIL WITH UP\$DOWN NO - TILLAGE
INDEX =1.00 BASE YIELD =125.0 INDEX = .90 INDEX = 1.00

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
110.4	1.00	107.6	.95	0.0	0.00	0.0	0.00	0.0	0.00
109.3	.98	107.0	.94	105.3	.91	100.3	.82	95.8	.74
107.0	.94	104.2	.89	102.0	.85	96.9	.76	91.8	.67

CORN IN CCONHH ROTATION ON ELBA SOIL WITH CONTOUR CONVENT. TILLAGE
INDEX =1.00 BASE YIELD =125.0 INDEX = 1.00 INDEX = 1.00

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
112.5	1.00	109.7	.95	0.0	0.00	0.0	0.00	0.0	0.00
111.4	.98	109.1	.94	107.4	.91	102.4	.82	97.9	.74
109.1	.94	106.3	.89	104.1	.85	99.0	.76	93.9	.67

CORN IN CCONHH ROTATION ON ELBA SOIL WITH CONTOUR MINIMUM TILLAGE
INDEX =1.00 BASE YIELD =125.0 INDEX = 1.00 INDEX = 1.00

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
112.5	1.00	109.7	.95	0.0	0.00	0.0	0.00	0.0	0.00
111.4	.98	109.1	.94	107.4	.91	102.4	.82	97.9	.74
109.1	.94	106.3	.89	104.1	.85	99.0	.76	93.9	.67

CORN IN CCONHH ROTATION ON ELBA SOIL WITH CONTOUR NO - TILLAGE
INDEX =1.00 BASE YIELD =125.0 INDEX = 1.00 INDEX = 1.00

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
112.5	1.00	109.7	.95	0.0	0.00	0.0	0.00	0.0	0.00
111.4	.98	109.1	.94	107.4	.91	102.4	.82	97.9	.74
109.1	.94	106.3	.89	104.1	.85	99.0	.76	93.9	.67

WEIGHTS ARE (1) PLANT & HARVEST =1.000 (2) TILLAGE = .500 (3) ROTATION = .125 (4) CONSERVATION = .375

CORN IN CCC ROTATION ON ELBA SOIL WITH UPDOWN CONVENT. TILLAGE														
INDEX =1.00			BASE YIELD =125.0			INDEX = .90			INDEX = 1.00					
MAY 3-9			MAY 10-16			MAY 17-23			MAY 24-30			MAY 31-JU 6		
INDEX	DATE	SEPT 27 - OCT 18	INDEX	DATE	SEPT 27 - OCT 18	INDEX	DATE	SEPT 27 - OCT 18	INDEX	DATE	SEPT 27 - OCT 18	INDEX	DATE	SEPT 27 - OCT 18
110.4	1.00		107.6	.95		105.3	.91		100.3	.82		95.8	.74	
109.3	.98		107.0	.94		102.0	.85		96.9	.76		91.8	.67	
107.0	.94		104.2	.89										
PLANTING DATES														
HARVEST	DATE	SEPT 27 - OCT 18												
HARVEST	DATE	OCT 19 - NOV 8												
HARVEST	DATE	NOV 9 - 29												
CORN IN CCC ROTATION ON ELBA SOIL WITH UPDOWN MINIMUM TILLAGE														
INDEX =1.00			BASE YIELD =125.0			INDEX = .90			INDEX = 1.00					
MAY 3-9			MAY 10-16			MAY 17-23			MAY 24-30			MAY 31-JU 6		
INDEX	DATE	SEPT 27 - OCT 18	INDEX	DATE	SEPT 27 - OCT 18	INDEX	DATE	SEPT 27 - OCT 18	INDEX	DATE	SEPT 27 - OCT 18	INDEX	DATE	SEPT 27 - OCT 18
110.4	1.00		107.6	.95		105.3	.91		100.3	.82		95.8	.74	
109.3	.98		107.0	.94		102.0	.85		96.9	.76		91.8	.67	
107.0	.94		104.2	.89										
PLANTING DATES														
HARVEST	DATE	SEPT 27 - OCT 18												
HARVEST	DATE	OCT 19 - NOV 8												
HARVEST	DATE	NOV 9 - 29												
CORN IN CCC ROTATION ON ELBA SOIL WITH CONTOUR CONVENT. TILLAGE														
INDEX =1.00			BASE YIELD =125.0			INDEX = 1.00			INDEX = 1.00					
MAY 3-9			MAY 10-16			MAY 17-23			MAY 24-30			MAY 31-JU 6		
INDEX	DATE	SEPT 27 - OCT 18	INDEX	DATE	SEPT 27 - OCT 18	INDEX	DATE	SEPT 27 - OCT 18	INDEX	DATE	SEPT 27 - OCT 18	INDEX	DATE	SEPT 27 - OCT 18
112.5	1.00		109.7	.95		107.4	.91		102.4	.82		97.9	.74	
111.4	.98		109.1	.94		104.1	.85		99.0	.76		93.9	.67	
109.1	.94		106.3	.89										
PLANTING DATES														
HARVEST	DATE	SEPT 27 - OCT 18												
HARVEST	DATE	OCT 19 - NOV 8												
HARVEST	DATE	NOV 9 - 29												
CORN IN CCC ROTATION ON ELBA SOIL WITH CONTOUR MINIMUM TILLAGE														
INDEX =1.00			BASE YIELD =125.0			INDEX = 1.00			INDEX = 1.00					
MAY 3-9			MAY 10-16			MAY 17-23			MAY 24-30			MAY 31-JU 6		
INDEX	DATE	SEPT 27 - OCT 18	INDEX	DATE	SEPT 27 - OCT 18	INDEX	DATE	SEPT 27 - OCT 18	INDEX	DATE	SEPT 27 - OCT 18	INDEX	DATE	SEPT 27 - OCT 18
112.5	1.00		109.7	.95		107.4	.91		102.4	.82		97.9	.74	
111.4	.98		109.1	.94		104.1	.85		99.0	.76		93.9	.67	
109.1	.94		106.3	.89										
PLANTING DATES														
HARVEST	DATE	SEPT 27 - OCT 18												
HARVEST	DATE	OCT 19 - NOV 8												
HARVEST	DATE	NOV 9 - 29												

WEIGHTS ARE (1) PLANT \$ HARVEST =1.000 (2) TILLAGE = .500 (3) ROTATION = .125 (4) CONSERVATION = .375

CORN IN CCCOM ROTATION ON CALAMUS SOIL WITH UPSDOWN CONVENT. TILLAGE
INDEX =1.07 BASE YIELD =110.0 INDEX = .90 INDEX = .95

PLANTING DATES	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST DATE SEPT 27 - OCT 18	96.3	1.00	93.9	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST DATE OCT 19 - NOV 8	95.3	.98	93.4	.94	91.9	.91	87.4	.82	83.5	.74
HARVEST DATE NOV 9 - 29	93.4	.94	90.9	.89	88.9	.85	84.5	.76	80.0	.67

CORN IN CCCOM ROTATION ON CALAMUS SOIL WITH UPSDOWN MINIMUM TILLAGE
INDEX =1.07 BASE YIELD =110.0 INDEX = .90 INDEX = .87

PLANTING DATES	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST DATE SEPT 27 - OCT 18	94.4	1.00	91.9	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST DATE OCT 19 - NOV 8	93.4	.98	91.4	.94	89.9	.91	85.4	.82	81.5	.74
HARVEST DATE NOV 9 - 29	91.4	.94	88.9	.89	86.9	.85	82.5	.76	78.0	.67

CORN IN CCCOM ROTATION ON CALAMUS SOIL WITH UPSDOWN NO - TILLAGE
INDEX =1.07 BASE YIELD =110.0 INDEX = .90 INDEX = 1.00

PLANTING DATES	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST DATE SEPT 27 - OCT 18	97.6	1.00	95.1	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST DATE OCT 19 - NOV 8	96.6	.98	94.6	.94	93.1	.91	88.7	.82	84.7	.74
HARVEST DATE NOV 9 - 29	94.6	.94	92.1	.89	90.2	.85	85.7	.76	81.2	.67

CORN IN CCCOM ROTATION ON CALAMUS SOIL WITH CONTOUR CONVENT. TILLAGE
INDEX =1.07 BASE YIELD =110.0 INDEX = 1.00 INDEX = .95

PLANTING DATES	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST DATE SEPT 27 - OCT 18	98.2	1.00	95.7	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST DATE OCT 19 - NOV 8	97.2	.98	95.2	.94	93.7	.91	89.3	.82	85.3	.74
HARVEST DATE NOV 9 - 29	95.2	.94	92.8	.89	90.8	.85	86.3	.76	81.9	.67

CORN IN CCCOM ROTATION ON CALAMUS SOIL WITH CONTOUR MINIMUM TILLAGE
INDEX =1.07 BASE YIELD =110.0 INDEX = 1.00 INDEX = .87

PLANTING DATES	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST DATE SEPT 27 - OCT 18	96.2	1.00	93.7	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST DATE OCT 19 - NOV 8	95.2	.98	93.2	.94	91.8	.91	87.3	.82	83.3	.74
HARVEST DATE NOV 9 - 29	93.2	.94	90.8	.89	88.8	.85	84.3	.76	79.9	.67

CORN IN CCCOM ROTATION ON CALAMUS SOIL WITH CONTOUR NO - TILLAGE
INDEX =1.07 BASE YIELD =110.0 INDEX = 1.00 INDEX = 1.00

PLANTING DATES	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST DATE SEPT 27 - OCT 18	99.4	1.00	97.0	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST DATE OCT 19 - NOV 8	98.4	.98	96.5	.94	95.0	.91	90.5	.82	86.6	.74
HARVEST DATE NOV 9 - 29	96.5	.94	94.0	.89	92.0	.85	87.6	.76	83.1	.67

WEIGHTS ARE (1) PLANT & HARVEST = 1.000 (2) TILLAGE = .500 (3) ROTATION = .125 (4) CONSERVATION = .375

CORN IN CCOHH ROTATION ON CALAMUS SOIL WITH UPSDOWN CONVENT. TILLAGE
INDEX = 1.02 BASE YIELD = 110.0 INDEX = .90 INDEX = .84

PLANTING DATES	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST DATE SEPT 27 - OCT 18	93.3	1.00	90.8	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST DATE OCT 19 - NOV 8	92.3	.98	90.3	.94	88.9	.91	84.4	.82	80.4	.74
HARVEST DATE NOV 9 - 29	90.3	.94	87.9	.89	85.9	.85	81.4	.76	77.0	.67

CORN IN CCOHH ROTATION ON CALAMUS SOIL WITH UPSDOWN MINIMUM TILLAGE
INDEX = 1.02 BASE YIELD = 110.0 INDEX = .90 INDEX = .85

PLANTING DATES	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST DATE SEPT 27 - OCT 18	93.6	1.00	91.1	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST DATE OCT 19 - NOV 8	92.6	.98	90.6	.94	89.1	.91	84.6	.82	80.7	.74
HARVEST DATE NOV 9 - 29	90.6	.94	88.1	.89	86.1	.85	81.7	.76	77.2	.67

CORN IN CCOHH ROTATION ON CALAMUS SOIL WITH UPSDOWN NO - TILLAGE
INDEX = 1.02 BASE YIELD = 110.0 INDEX = .90 INDEX = 1.00

PLANTING DATES	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST DATE SEPT 27 - OCT 18	97.3	1.00	94.8	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST DATE OCT 19 - NOV 8	96.3	.98	94.3	.94	92.8	.91	88.4	.82	84.4	.74
HARVEST DATE NOV 9 - 29	94.3	.94	91.8	.89	89.8	.85	85.4	.76	80.9	.67

CORN IN CCOHH ROTATION ON CALAMUS SOIL WITH CONTOUR CONVENT. TILLAGE
INDEX = 1.02 BASE YIELD = 110.0 INDEX = 1.00 INDEX = .84

PLANTING DATES	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST DATE SEPT 27 - OCT 18	95.2	1.00	92.7	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST DATE OCT 19 - NOV 8	94.2	.98	92.2	.94	90.7	.91	86.3	.82	82.3	.74
HARVEST DATE NOV 9 - 29	92.2	.94	89.7	.89	87.7	.85	83.3	.76	78.8	.67

CORN IN CCOHH ROTATION ON CALAMUS SOIL WITH CONTOUR MINIMUM TILLAGE
INDEX = 1.02 BASE YIELD = 110.0 INDEX = 1.00 INDEX = .85

PLANTING DATES	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST DATE SEPT 27 - OCT 18	95.4	1.00	92.9	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST DATE OCT 19 - NOV 8	94.4	.98	92.4	.94	91.0	.91	86.5	.82	82.5	.74
HARVEST DATE NOV 9 - 29	92.4	.94	90.0	.89	88.0	.85	83.5	.76	79.1	.67

CORN IN CCOHH ROTATION ON CALAMUS SOIL WITH CONTOUR NO - TILLAGE
INDEX = 1.02 BASE YIELD = 110.0 INDEX = 1.00 INDEX = 1.00

PLANTING DATES	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST DATE SEPT 27 - OCT 18	99.1	1.00	96.6	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST DATE OCT 19 - NOV 8	98.1	.98	96.2	.94	94.7	.91	90.2	.82	86.3	.74
HARVEST DATE NOV 9 - 29	96.2	.94	93.7	.89	91.7	.85	87.2	.76	82.8	.67

WEIGHTS ARE (1) PLANT & HARVEST = 1.000 (2) TILLAGE = .500 (3) ROTATION = .125 (4) CONSERVATION = .375

CORN IN CCOHHH ROTATION ON CALAMUS SOIL WITH UP&DOWN CONVENT. TILLAGE
INDEX = 1.00 BASE YIELD = 110.0 INDEX = .90 INDEX = .84

PLANTING DATES

HARVEST DATE	SEPT 27 - OCT 18	HARVEST DATE	OCT 19 - NOV 8	HARVEST DATE	NOV 9 - 29	MAY 3-9 INDEX	MAY 10-16 INDEX	MAY 17-23 INDEX	MAY 24-30 INDEX	MAY 31-JU 6 INDEX
HARVEST DATE	93.2	1.00	90.7	.95	0.0	0.00	0.00	0.00	0.0	0.0
HARVEST DATE	92.2	.98	90.2	.94	88.7	.91	84.3	.82	80.3	.74
HARVEST DATE	90.2	.94	87.7	.89	85.8	.85	81.3	.76	76.8	.67

CORN IN CCOHHH ROTATION ON CALAMUS SOIL WITH UP&DOWN MINIMUM TILLAGE
INDEX = 1.00 BASE YIELD = 110.0 INDEX = .90 INDEX = .85

PLANTING DATES

HARVEST DATE	SEPT 27 - OCT 18	HARVEST DATE	OCT 19 - NOV 8	HARVEST DATE	NOV 9 - 29	MAY 3-9 INDEX	MAY 10-16 INDEX	MAY 17-23 INDEX	MAY 24-30 INDEX	MAY 31-JU 6 INDEX
HARVEST DATE	93.4	1.00	91.0	.95	0.0	0.00	0.0	0.00	0.0	0.0
HARVEST DATE	92.4	.98	90.5	.94	89.0	.91	84.5	.82	80.6	.74
HARVEST DATE	90.5	.94	88.0	.89	86.0	.85	81.6	.76	77.1	.67

CORN IN CCOHHH ROTATION ON CALAMUS SOIL WITH UP&DOWN NO - TILLAGE
INDEX = 1.00 BASE YIELD = 110.0 INDEX = .90 INDEX = 1.00

PLANTING DATES

HARVEST DATE	SEPT 27 - OCT 18	HARVEST DATE	OCT 19 - NOV 8	HARVEST DATE	NOV 9 - 29	MAY 3-9 INDEX	MAY 10-16 INDEX	MAY 17-23 INDEX	MAY 24-30 INDEX	MAY 31-JU 6 INDEX
HARVEST DATE	97.1	1.00	94.7	.95	0.0	0.00	0.0	0.00	0.0	0.0
HARVEST DATE	96.2	.98	94.2	.94	92.7	.91	88.2	.82	84.3	.74
HARVEST DATE	94.2	.94	91.7	.89	89.7	.85	85.3	.76	80.8	.67

CORN IN CCOHHH ROTATION ON CALAMUS SOIL WITH CONTOUR CONVENT. TILLAGE
INDEX = 1.00 BASE YIELD = 110.0 INDEX = 1.00 INDEX = .84

PLANTING DATES

HARVEST DATE	SEPT 27 - OCT 18	HARVEST DATE	OCT 19 - NOV 8	HARVEST DATE	NOV 9 - 29	MAY 3-9 INDEX	MAY 10-16 INDEX	MAY 17-23 INDEX	MAY 24-30 INDEX	MAY 31-JU 6 INDEX
HARVEST DATE	95.0	1.00	92.6	.95	0.0	0.00	0.0	0.00	0.0	0.0
HARVEST DATE	94.0	.98	92.1	.94	90.6	.91	86.1	.82	82.2	.74
HARVEST DATE	92.1	.94	89.6	.89	87.6	.85	83.2	.76	78.7	.67

CORN IN CCOHHH ROTATION ON CALAMUS SOIL WITH CONTOUR MINIMUM TILLAGE
INDEX = 1.00 BASE YIELD = 110.0 INDEX = 1.00 INDEX = .85

PLANTING DATES

HARVEST DATE	SEPT 27 - OCT 18	HARVEST DATE	OCT 19 - NOV 8	HARVEST DATE	NOV 9 - 29	MAY 3-9 INDEX	MAY 10-16 INDEX	MAY 17-23 INDEX	MAY 24-30 INDEX	MAY 31-JU 6 INDEX
HARVEST DATE	95.3	1.00	92.8	.95	0.0	0.00	0.0	0.00	0.0	0.0
HARVEST DATE	94.3	.98	92.3	.94	90.8	.91	86.4	.82	82.4	.74
HARVEST DATE	92.3	.94	89.8	.89	87.9	.85	83.4	.76	79.0	.67

CORN IN CCOHHH ROTATION ON CALAMUS SOIL WITH CONTOUR NO - TILLAGE
INDEX = 1.00 BASE YIELD = 110.0 INDEX = 1.00 INDEX = 1.00

PLANTING DATES

HARVEST DATE	SEPT 27 - OCT 18	HARVEST DATE	OCT 19 - NOV 8	HARVEST DATE	NOV 9 - 29	MAY 3-9 INDEX	MAY 10-16 INDEX	MAY 17-23 INDEX	MAY 24-30 INDEX	MAY 31-JU 6 INDEX
HARVEST DATE	99.0	1.00	96.5	.95	0.0	0.00	0.0	0.00	0.0	0.0
HARVEST DATE	98.0	.98	96.0	.94	94.5	.91	90.1	.82	86.1	.74
HARVEST DATE	96.0	.94	93.6	.89	91.6	.85	87.1	.76	82.7	.67

WEIGHTS ARE (1) PLANT & HARVEST =1.000 (2) TILLAGE = .500 (3) ROTATION = .125 (4) CONSERVATION = .375

CORN IN CCC ROTATION ON CALAMUS SOIL WITH UPSDOWN CONVENT. TILLAGE												
INDEX =1.00			BASE YIELD =110.0			INDEX = .90			INDEX = .84			
PLANTING DATES			MAY 10-16 INDEX			MAY 17-23 INDEX			MAY 24-30 INDEX			
HARVEST DATE	SEPT 27 - OCT 18		MAY 3-9 INDEX	90.7 .95	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
HARVEST DATE	OCT 19 - NOV 8		93.2 1.00	90.2 .94	86.7 .91	84.3 .82	80.3 .74	76.8 .67	74.3 .67	70.8 .67	67.3 .67	
HARVEST DATE	NOV 9 - 29		90.2 .94	87.7 .89	85.8 .85	81.3 .76	76.8 .67	72.3 .67	67.8 .67	63.3 .67	58.8 .67	
CORN IN CCC ROTATION ON CALAMUS SOIL WITH UPSDOWN MINIMUM TILLAGE												
INDEX =1.00			BASE YIELD =110.0			INDEX = .90			INDEX = .85			
PLANTING DATES			MAY 10-16 INDEX			MAY 17-23 INDEX			MAY 24-30 INDEX			
HARVEST DATE	SEPT 27 - OCT 18		MAY 3-9 INDEX	91.0 .95	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
HARVEST DATE	OCT 19 - NOV 8		93.4 1.00	90.5 .94	89.0 .91	84.5 .82	80.6 .74	77.1 .67	72.6 .67	68.1 .67	63.6 .67	
HARVEST DATE	NOV 9 - 29		90.5 .94	88.0 .89	86.0 .85	81.6 .76	77.1 .67	72.6 .67	68.1 .67	63.6 .67	59.1 .67	
CORN IN CCC ROTATION ON CALAMUS SOIL WITH UPSDOWN NO - TILLAGE												
INDEX =1.00			BASE YIELD =110.0			INDEX = .90			INDEX = 1.00			
PLANTING DATES			MAY 10-16 INDEX			MAY 17-23 INDEX			MAY 24-30 INDEX			
HARVEST DATE	SEPT 27 - OCT 18		MAY 3-9 INDEX	94.7 .95	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
HARVEST DATE	OCT 19 - NOV 8		97.1 1.00	94.2 .94	92.7 .91	88.2 .82	84.3 .74	80.8 .67	76.3 .67	71.8 .67	67.3 .67	
HARVEST DATE	NOV 9 - 29		94.2 .94	91.7 .89	89.7 .85	85.3 .76	80.8 .67	76.3 .67	71.8 .67	67.3 .67	62.8 .67	
CORN IN CCC ROTATION ON CALAMUS SOIL WITH CONTOUR CONVENT. TILLAGE												
INDEX =1.00			BASE YIELD =110.0			INDEX = 1.00			INDEX = .84			
PLANTING DATES			MAY 10-16 INDEX			MAY 17-23 INDEX			MAY 24-30 INDEX			
HARVEST DATE	SEPT 27 - OCT 18		MAY 3-9 INDEX	92.6 .95	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
HARVEST DATE	OCT 19 - NOV 8		95.0 1.00	92.1 .94	90.6 .91	86.1 .82	82.2 .74	78.7 .67	74.2 .67	70.7 .67	66.2 .67	
HARVEST DATE	NOV 9 - 29		92.1 .94	89.6 .89	87.6 .85	83.2 .76	78.7 .67	74.2 .67	69.7 .67	65.2 .67	60.7 .67	
CORN IN CCC ROTATION ON CALAMUS SOIL WITH CONTOUR MINIMUM TILLAGE												
INDEX =1.00			BASE YIELD =110.0			INDEX = 1.00			INDEX = .85			
PLANTING DATES			MAY 10-16 INDEX			MAY 17-23 INDEX			MAY 24-30 INDEX			
HARVEST DATE	SEPT 27 - OCT 18		MAY 3-9 INDEX	92.8 .95	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
HARVEST DATE	OCT 19 - NOV 8		95.3 1.00	92.3 .94	90.8 .91	86.4 .82	82.4 .74	79.8 .67	75.3 .67	70.8 .67	66.3 .67	
HARVEST DATE	NOV 9 - 29		92.3 .94	89.8 .89	87.9 .85	83.4 .76	78.9 .67	74.4 .67	69.9 .67	65.4 .67	60.9 .67	
CORN IN CCC ROTATION ON CALAMUS SOIL WITH CONTOUR NO - TILLAGE												
INDEX =1.00			BASE YIELD =110.0			INDEX = 1.00			INDEX = 1.00			
PLANTING DATES			MAY 10-16 INDEX			MAY 17-23 INDEX			MAY 24-30 INDEX			
HARVEST DATE	SEPT 27 - OCT 18		MAY 3-9 INDEX	96.5 .95	0.0	0.00	0.0	0.00	0.0	0.00	0.0	
HARVEST DATE	OCT 19 - NOV 8		99.0 1.00	96.0 .94	94.5 .91	90.1 .82	86.1 .74	82.7 .67	78.7 .67	74.7 .67	70.7 .67	
HARVEST DATE	NOV 9 - 29		96.0 .94	93.6 .89	91.6 .85	87.1 .76	82.7 .67	78.7 .67	74.7 .67	70.7 .67	66.7 .67	

WEIGHTS ARE (1) PLANT \$ HARVEST =1.00 (2) YILLAGE = .500 (3) ROTATION = .125 (4) CONSERVATION = .375

CORN IN CCOH ROTATION ON CLYMAN SOIL WITH UP\$DOWN CONVENT. TILLAGE
INDEX =1.07 BASE YIELD =120.0 INDEX = .90 INDEX = 1.01

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
106.7	1.00	104.0	.95	0.0	0.00	0.0	0.00	0.0	0.00
105.6	.98	103.5	.94	101.9	.91	97.0	.82	92.7	.74
103.5	.94	100.8	.89	98.6	.85	93.8	.76	88.9	.67

CORN IN CCOH ROTATION ON CLYMAN SOIL WITH UP\$DOWN MINIMUM TILLAGE
INDEX =1.07 BASE YIELD =120.0 INDEX = .90 INDEX = 1.04

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
107.5	1.00	104.8	.95	0.0	0.00	0.0	0.00	0.0	0.00
106.4	.98	104.3	.94	102.7	.91	97.8	.82	93.5	.74
104.3	.94	101.6	.89	99.4	.85	94.6	.76	89.7	.67

CORN IN CCOH ROTATION ON CLYMAN SOIL WITH UP\$DOWN NO - TILLAGE
INDEX =1.07 BASE YIELD =120.0 INDEX = .90 INDEX = 1.00

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
106.4	1.00	103.7	.95	0.0	0.00	0.0	0.00	0.0	0.00
105.4	.98	103.2	.94	101.6	.91	96.7	.82	92.4	.74
103.2	.94	100.5	.89	98.3	.85	93.5	.76	88.6	.67

CORN IN CCOH ROTATION ON CLYMAN SOIL WITH CONTOUR CONVENT. TILLAGE
INDEX =1.07 BASE YIELD =120.0 INDEX = 1.00 INDEX = 1.01

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
106.7	1.00	106.0	.95	0.0	0.00	0.0	0.00	0.0	0.00
107.7	.98	105.5	.94	103.9	.91	99.0	.82	94.7	.74
105.5	.94	102.8	.89	100.6	.85	95.8	.76	90.9	.67

CORN IN CCOH ROTATION ON CLYMAN SOIL WITH CONTOUR MINIMUM TILLAGE
INDEX =1.07 BASE YIELD =120.0 INDEX = 1.00 INDEX = 1.04

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
109.6	1.00	106.9	.95	0.0	0.00	0.0	0.00	0.0	0.00
108.5	.98	106.3	.94	104.7	.91	99.8	.82	95.5	.74
106.3	.94	103.6	.89	101.5	.85	96.6	.76	91.7	.67

CORN IN CCOH ROTATION ON CLYMAN SOIL WITH CONTOUR NO - TILLAGE
INDEX =1.07 BASE YIELD =120.0 INDEX = 1.00 INDEX = 1.00

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
108.5	1.00	105.8	.95	0.0	0.00	0.0	0.00	0.0	0.00
107.4	.98	105.2	.94	103.6	.91	98.8	.82	94.4	.74
105.2	.94	102.5	.89	100.4	.85	95.5	.76	90.7	.67

WEIGHTS ARE (1) PLANT & HARVEST = 1.000 (2) TILLAGE = .500 (3) ROTATION = .125 (4) CONSERVATION = .375

CORN IN CCOHM ROTATION ON CLYMAN SOIL WITH UP\$DOWN CONVENT. TILLAGE													
INDEX = 1.02 BASE YIELD = 120.0 INDEX = .90 INDEX = .97													
PLANTING DATES													
HARVEST	DATE	SEPT 27 - OCT 18										MAY 31-JU 6	INDEX
HARVEST	DATE	OCT 19 - NOV 8	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX			
			105.3	1.00	102.6	.95	0.0	0.00	0.0	0.00		0.0	0.00
			104.2	.98	102.1	.94	100.4	.91	95.6	.82		91.3	.74
			102.1	.94	99.4	.89	97.2	.85	92.3	.76		87.5	.67
CORN IN CCOHM ROTATION ON CLYMAN SOIL WITH UP\$DOWN MINIMUM TILLAGE													
INDEX = 1.02 BASE YIELD = 120.0 INDEX = .90 INDEX = .97													
PLANTING DATES													
HARVEST	DATE	SEPT 27 - OCT 18											
HARVEST	DATE	OCT 19 - NOV 8	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX			
			105.3	1.00	102.6	.95	0.0	0.00	0.0	0.00		0.0	0.00
			104.2	.98	102.1	.94	100.4	.91	95.6	.82		91.3	.74
			102.1	.94	99.4	.89	97.2	.85	92.3	.76		87.5	.67
CORN IN CCOHM ROTATION ON CLYMAN SOIL WITH UP\$DOWN NO - TILLAGE													
INDEX = 1.02 BASE YIELD = 120.0 INDEX = .90 INDEX = 1.00													
PLANTING DATES													
HARVEST	DATE	SEPT 27 - OCT 18											
HARVEST	DATE	OCT 19 - NOV 8	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX			
			106.1	1.00	103.4	.95	0.0	0.00	0.0	0.00		0.0	0.00
			105.0	.98	102.9	.94	101.2	.91	96.4	.82		92.1	.74
			102.9	.94	100.2	.89	98.0	.85	93.1	.76		88.3	.67
CORN IN CCOHM ROTATION ON CLYMAN SOIL WITH CONTOUR CONVENT. TILLAGE													
INDEX = 1.02 BASE YIELD = 120.0 INDEX = 1.00 INDEX = .97													
PLANTING DATES													
HARVEST	DATE	SEPT 27 - OCT 18											
HARVEST	DATE	OCT 19 - NOV 8	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX			
			107.3	1.00	104.6	.95	0.0	0.00	0.0	0.00		0.0	0.00
			106.2	.98	104.1	.94	102.5	.91	97.6	.82		93.3	.74
			104.1	.94	101.4	.89	99.2	.85	94.4	.76		89.5	.67
CORN IN CCOHM ROTATION ON CLYMAN SOIL WITH CONTOUR MINIMUM TILLAGE													
INDEX = 1.02 BASE YIELD = 120.0 INDEX = 1.00 INDEX = .97													
PLANTING DATES													
HARVEST	DATE	SEPT 27 - OCT 18											
HARVEST	DATE	OCT 19 - NOV 8	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX			
			107.3	1.00	104.6	.95	0.0	0.00	0.0	0.00		0.0	0.00
			106.2	.98	104.1	.94	102.5	.91	97.6	.82		93.3	.74
			104.1	.94	101.4	.89	99.2	.85	94.4	.76		89.5	.67
CORN IN CCOHM ROTATION ON CLYMAN SOIL WITH CONTOUR NO - TILLAGE													
INDEX = 1.02 BASE YIELD = 120.0 INDEX = 1.00 INDEX = 1.00													
PLANTING DATES													
HARVEST	DATE	SEPT 27 - OCT 18											
HARVEST	DATE	OCT 19 - NOV 8	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX			
			108.1	1.00	105.4	.95	0.0	0.00	0.0	0.00		0.0	0.00
			107.1	.98	104.9	.94	103.3	.91	98.4	.82		94.1	.74
			104.9	.94	102.2	.89	100.0	.85	95.2	.76		90.3	.67

WEIGHTS ARE (1) PLANT & HARVEST =1.000 (2) TILLAGE = .500 (3) ROTATION = .125 (4) CONSERVATION = .375

CORN IN CCOHHH ROTATION ON CLYMAN SOIL WITH UP&DOWN CONVENT. TILLAGE
INDEX =1.00 BASE YIELD =120.0 INDEX = .90 INDEX = .97

PLANTING DATES	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST DATE SEPT 27 - OCT 18	105.2	1.00	102.5	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST DATE OCT 19 - NOV 8	104.1	.98	101.9	.94	100.3	.91	95.4	.82	91.1	.74
HARVEST DATE NOV 9 - 29	101.9	.94	99.2	.89	97.1	.85	92.2	.76	87.3	.67

CORN IN CCOHHH ROTATION ON CLYMAN SOIL WITH UP&DOWN MINIMUM TILLAGE
INDEX =1.00 BASE YIELD =120.0 INDEX = .90 INDEX = .97

PLANTING DATES	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST DATE SEPT 27 - OCT 18	105.2	1.00	102.5	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST DATE OCT 19 - NOV 8	104.1	.98	101.9	.94	100.3	.91	95.4	.82	91.1	.74
HARVEST DATE NOV 9 - 29	101.9	.94	99.2	.89	97.1	.85	92.2	.76	87.3	.67

CORN IN CCOHHH ROTATION ON CLYMAN SOIL WITH UP&DOWN NO - TILLAGE
INDEX =1.00 BASE YIELD =120.0 INDEX = .90 INDEX = 1.00

PLANTING DATES	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST DATE SEPT 27 - OCT 18	106.0	1.00	103.3	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST DATE OCT 19 - NOV 8	104.9	.98	102.7	.94	101.1	.91	96.3	.82	91.9	.74
HARVEST DATE NOV 9 - 29	102.7	.94	100.0	.89	97.9	.85	93.0	.76	88.2	.67

CORN IN CCOHHH ROTATION ON CLYMAN SOIL WITH CONTOUR CONVENT. TILLAGE
INDEX =1.00 BASE YIELD =120.0 INDEX = 1.00 INDEX = .97

PLANTING DATES	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST DATE SEPT 27 - OCT 18	107.2	1.00	104.5	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST DATE OCT 19 - NOV 8	106.1	.98	103.9	.94	102.3	.91	97.5	.82	93.1	.74
HARVEST DATE NOV 9 - 29	103.9	.94	101.2	.89	99.1	.85	94.2	.76	89.4	.67

CORN IN CCOHHH ROTATION ON CLYMAN SOIL WITH CONTOUR MINIMUM TILLAGE
INDEX =1.00 BASE YIELD =120.0 INDEX = 1.00 INDEX = .97

PLANTING DATES	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST DATE SEPT 27 - OCT 18	107.2	1.00	104.5	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST DATE OCT 19 - NOV 8	106.1	.98	103.9	.94	102.3	.91	97.5	.82	93.1	.74
HARVEST DATE NOV 9 - 29	103.9	.94	101.2	.89	99.1	.85	94.2	.76	89.4	.67

CORN IN CCOHHH ROTATION ON CLYMAN SOIL WITH CONTOUR NO - TILLAGE
INDEX =1.00 BASE YIELD =120.0 INDEX = 1.00 INDEX = 1.00

PLANTING DATES	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST DATE SEPT 27 - OCT 18	108.0	1.00	105.3	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST DATE OCT 19 - NOV 8	106.9	.98	104.6	.94	103.1	.91	98.3	.82	94.0	.74
HARVEST DATE NOV 9 - 29	104.6	.94	102.1	.89	99.9	.85	95.0	.76	90.2	.67

WEIGHTS ARE (1) PLANT & HARVEST = 1.000 (2) TILLAGE = .500 (3) ROTATION = .125 (4) CONSERVATION = .375

CORN IN CCC ROTATION ON CLYMAN SOIL WITH UPSDOWN CONVENT. TILLAGE
INDEX = 1.00 BASE YIELD = 120.0 INDEX = .90 INDEX = .97

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
105.2	1.00	102.5	.95	0.0	0.00	0.0	0.00	0.0	0.00
104.1	.98	101.9	.94	100.3	.91	95.4	.82	91.1	.74
101.9	.94	99.2	.89	97.1	.85	92.2	.76	87.3	.67

CORN IN CCC ROTATION ON CLYMAN SOIL WITH UPSDOWN MINIMUM TILLAGE
INDEX = 1.00 BASE YIELD = 120.0 INDEX = .90 INDEX = .97

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
105.2	1.00	102.5	.95	0.0	0.00	0.0	0.00	0.0	0.00
104.1	.98	101.9	.94	100.3	.91	95.4	.82	91.1	.74
101.9	.94	99.2	.89	97.1	.85	92.2	.76	87.3	.67

CORN IN CCC ROTATION ON CLYMAN SOIL WITH UPSDOWN NO - TILLAGE
INDEX = 1.00 BASE YIELD = 120.0 INDEX = .90 INDEX = 1.00

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
106.0	1.00	103.3	.95	0.0	0.00	0.0	0.00	0.0	0.00
104.9	.98	102.7	.94	101.1	.91	96.3	.82	91.9	.74
102.7	.94	100.0	.89	97.9	.85	93.0	.76	88.2	.67

CORN IN CCC ROTATION ON CLYMAN SOIL WITH CONTOUR CONVENT. TILLAGE
INDEX = 1.00 BASE YIELD = 120.0 INDEX = 1.00 INDEX = .97

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
107.2	1.00	104.5	.95	0.0	0.00	0.0	0.00	0.0	0.00
106.1	.98	103.9	.94	102.3	.91	97.5	.82	93.1	.74
103.9	.94	101.2	.89	99.1	.85	94.2	.76	89.4	.67

CORN IN CCC ROTATION ON CLYMAN SOIL WITH CONTOUR MINIMUM TILLAGE
INDEX = 1.00 BASE YIELD = 120.0 INDEX = 1.00 INDEX = .97

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
106.0	1.00	103.3	.95	0.0	0.00	0.0	0.00	0.0	0.00
104.9	.98	102.7	.94	101.1	.91	96.3	.82	91.9	.74
102.7	.94	100.0	.89	97.9	.85	93.0	.76	88.2	.67

CORN IN CCC ROTATION ON CLYMAN SOIL WITH CONTOUR NO - TILLAGE
INDEX = 1.00 BASE YIELD = 120.0 INDEX = 1.00 INDEX = 1.00

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
108.0	1.00	105.3	.95	0.0	0.00	0.0	0.00	0.0	0.00
106.9	.98	104.6	.94	103.1	.91	98.3	.82	94.0	.74
104.6	.94	102.1	.89	99.9	.85	95.0	.76	90.2	.67

HEIGHTS ARE (1) PLANT \$ HARVEST =1.100 (2) TILLAGE = .500 (3) ROTATION = .125 (4) CONSERVATION = .375

CORN IN CCCOH ROTATION ON EHLER SOIL WITH UP\$DOWN CONVENT. TILLAGE
INDEX =1.07 BASE YIELD =130.0 INDEX = .90 INDEX = 1.12

PLANTING DATES	MAY 3-9 INDEX	MAY 10-16 INDEX	MAY 17-23 INDEX	MAY 24-30 INDEX	MAY 31-JU 6 INDEX
HARVEST DATE SEPT 27 - OCT 18	118.8 1.00	115.9 .95	0.0 0.00	0.0 0.00	0.0 0.00
HARVEST DATE OCT 19 - NOV 8	117.7 .98	115.3 .94	113.6 .91	108.3 .82	103.6 .74
HARVEST DATE NOV 9 - 29	115.3 .94	112.4 .89	110.1 .85	104.8 .76	99.5 .67

CORN IN CCCOH ROTATION ON EHLER SOIL WITH UP\$DOWN MINIMUM TILLAGE
INDEX =1.07 BASE YIELD =130.0 INDEX = .90 INDEX = 1.01

PLANTING DATES	MAY 3-9 INDEX	MAY 10-16 INDEX	MAY 17-23 INDEX	MAY 24-30 INDEX	MAY 31-JU 6 INDEX
HARVEST DATE SEPT 27 - OCT 18	115.6 1.00	112.7 .95	0.0 0.00	0.0 0.00	0.0 0.00
HARVEST DATE OCT 19 - NOV 8	114.4 .98	112.1 .94	110.3 .91	105.1 .82	100.4 .74
HARVEST DATE NOV 9 - 29	112.1 .94	109.2 .89	106.8 .85	101.6 .76	96.3 .67

CORN IN CCCOH ROTATION ON EHLER SOIL WITH UP\$DOWN NO - TILLAGE
INDEX =1.07 BASE YIELD =130.0 INDEX = .90 INDEX = 1.00

PLANTING DATES	MAY 3-9 INDEX	MAY 10-16 INDEX	MAY 17-23 INDEX	MAY 24-30 INDEX	MAY 31-JU 6 INDEX
HARVEST DATE SEPT 27 - OCT 18	115.3 1.00	112.4 .95	0.0 0.00	0.0 0.00	0.0 0.00
HARVEST DATE OCT 19 - NOV 8	114.1 .98	111.0 .94	110.1 .91	104.8 .82	100.1 .74
HARVEST DATE NOV 9 - 29	111.8 .94	108.9 .89	106.5 .85	101.3 .76	96.0 .67

CORN IN CCCOH ROTATION ON EHLER SOIL WITH CONTOUR CONVENT. TILLAGE
INDEX =1.07 BASE YIELD =130.0 INDEX = 1.00 INDEX = 1.12

PLANTING DATES	MAY 3-9 INDEX	MAY 10-16 INDEX	MAY 17-23 INDEX	MAY 24-30 INDEX	MAY 31-JU 6 INDEX
HARVEST DATE SEPT 27 - OCT 18	121.0 1.00	118.1 .95	0.0 0.00	0.0 0.00	0.0 0.00
HARVEST DATE OCT 19 - NOV 8	119.9 .98	117.5 .94	115.8 .91	110.5 .82	105.8 .74
HARVEST DATE NOV 9 - 29	117.5 .94	114.6 .89	112.2 .85	107.0 .76	101.7 .67

CORN IN CCCOH ROTATION ON EHLER SOIL WITH CONTOUR MINIMUM TILLAGE
INDEX =1.07 BASE YIELD =130.0 INDEX = 1.00 INDEX = 1.01

PLANTING DATES	MAY 3-9 INDEX	MAY 10-16 INDEX	MAY 17-23 INDEX	MAY 24-30 INDEX	MAY 31-JU 6 INDEX
HARVEST DATE SEPT 27 - OCT 18	117.8 1.00	114.9 .95	0.0 0.00	0.0 0.00	0.0 0.00
HARVEST DATE OCT 19 - NOV 8	116.6 .98	114.3 .94	112.5 .91	107.3 .82	102.6 .74
HARVEST DATE NOV 9 - 29	114.3 .94	111.4 .89	109.0 .85	103.0 .76	98.5 .67

CORN IN CCCOH ROTATION ON EHLER SOIL WITH CONTOUR NO - TILLAGE
INDEX =1.07 BASE YIELD =130.0 INDEX = 1.00 INDEX = 1.00

PLANTING DATES	MAY 3-9 INDEX	MAY 10-16 INDEX	MAY 17-23 INDEX	MAY 24-30 INDEX	MAY 31-JU 6 INDEX
HARVEST DATE SEPT 27 - OCT 18	117.5 1.00	114.6 .95	0.0 0.00	0.0 0.00	0.0 0.00
HARVEST DATE OCT 19 - NOV 8	116.3 .98	114.0 .94	112.2 .91	107.0 .82	102.3 .74
HARVEST DATE NOV 9 - 29	114.0 .94	111.1 .89	108.7 .85	103.5 .76	98.2 .67

WEIGHTS ARE (1) PLANT & HARVEST =1.000 (2) TILLAGE = .500 (3) ROTATION = .125 (4) CONSERVATION = .375

CORN IN CCOHH ROTATION ON EHLER SOIL WITH UPSDOWN CONVENT. TILLAGE												
INDEX =1.02			BASE YIELD =130.0			INDEX = .90			INDEX = 1.12			
PLANTING DATES												
HARVEST	DATE	SEPT 27 - OCT 18	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST	DATE	OCT 19 - NOV 8	119.5	1.00	115.5	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST	DATE	NOV 9 - 29	117.3	.98	115.0	.94	113.2	.91	107.9	.82	103.3	.74
HARVEST	DATE		115.0	.94	112.0	.89	109.7	.85	104.4	.76	99.2	.67
CORN IN CCOHH ROTATION ON EHLER SOIL WITH UPSDOWN MINIMUM TILLAGE												
INDEX =1.02			BASE YIELD =130.0			INDEX = .90			INDEX = 1.01			
PLANTING DATES												
HARVEST	DATE	SEPT 27 - OCT 18	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST	DATE	OCT 19 - NOV 8	115.2	1.00	112.3	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST	DATE	NOV 9 - 29	114.1	.98	111.7	.94	110.0	.91	104.7	.82	100.0	.74
HARVEST	DATE		111.7	.94	108.8	.89	106.5	.85	101.2	.76	95.9	.67
CORN IN CCOHH ROTATION ON EHLER SOIL WITH UPSDOWN NO - TILLAGE												
INDEX =1.02			BASE YIELD =130.0			INDEX = .90			INDEX = 1.00			
PLANTING DATES												
HARVEST	DATE	SEPT 27 - OCT 18	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST	DATE	OCT 19 - NOV 8	115.0	1.00	112.0	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST	DATE	NOV 9 - 29	113.8	.98	111.4	.94	109.7	.91	104.4	.82	99.7	.74
HARVEST	DATE		111.4	.94	108.5	.89	106.2	.85	100.9	.76	95.6	.67
CORN IN CCOHH ROTATION ON EHLER SOIL WITH CONTOUR CONVENT. TILLAGE												
INDEX =1.02			BASE YIELD =130.0			INDEX = 1.00			INDEX = 1.12			
PLANTING DATES												
HARVEST	DATE	SEPT 27 - OCT 18	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST	DATE	OCT 19 - NOV 8	120.7	1.00	117.7	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST	DATE	NOV 9 - 29	119.5	.98	117.1	.94	115.4	.91	110.1	.82	105.4	.74
HARVEST	DATE		117.1	.94	114.2	.89	111.9	.85	106.6	.76	101.4	.67
CORN IN CCOHH ROTATION ON EHLER SOIL WITH CONTOUR MINIMUM TILLAGE												
INDEX =1.02			BASE YIELD =130.0			INDEX = 1.00			INDEX = 1.01			
PLANTING DATES												
HARVEST	DATE	SEPT 27 - OCT 18	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST	DATE	OCT 19 - NOV 8	117.4	1.00	114.5	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST	DATE	NOV 9 - 29	116.3	.98	113.9	.94	112.2	.91	106.9	.82	102.2	.74
HARVEST	DATE		113.9	.94	111.0	.89	108.7	.85	103.4	.75	98.1	.67
CORN IN CCOHH ROTATION ON EHLER SOIL WITH CONTOUR NO - TILLAGE												
INDEX =1.02			BASE YIELD =130.0			INDEX = 1.00			INDEX = 1.00			
PLANTING DATES												
HARVEST	DATE	SEPT 27 - OCT 18	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST	DATE	OCT 19 - NOV 8	117.1	1.00	114.2	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST	DATE	NOV 9 - 29	116.0	.98	113.6	.94	111.9	.91	106.6	.82	101.9	.74
HARVEST	DATE		113.6	.94	110.7	.89	108.4	.85	103.1	.76	97.8	.67

WEIGHTS ARE (1) PLANT & HARVEST = 1.000 (2) TILLAGE = .500 (3) ROTATION = .125 (4) CONSERVATION = .375

CORN IN CCOHHH ROTATION ON EHLER SOIL WITH UP\$DOWN CONVENT. TILLAGE													
INDEX = 1.00 BASE YIELD = 130.0 INDEX = .90 INDEX = 1.12													
PLANTING DATES													
HARVEST DATE	SEPT 27 - OCT 18											MAY 31-JU 6	INDEX
HARVEST DATE	OCT 19 - NOV 8	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX				
HARVEST DATE	NOV 9 - 29	118.3	1.00	115.4	.95	113.1	0.0	107.8	0.0				0.00
		117.1	.98	114.8	.94	113.1	.91	107.8	.82			103.1	.74
		114.6	.94	111.9	.89	109.5	.85	104.3	.76			99.0	.67
CORN IN CCOHHH ROTATION ON EHLER SOIL WITH UP\$DOWN MINIMUM TILLAGE													
INDEX = 1.00 BASE YIELD = 130.0 INDEX = .90 INDEX = 1.01													
PLANTING DATES													
HARVEST DATE	SEPT 27 - OCT 18											MAY 31-JU 6	INDEX
HARVEST DATE	OCT 19 - NOV 8	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX				
HARVEST DATE	NOV 9 - 29	115.1	1.00	112.2	.95	109.0	0.0	104.6	0.0				0.00
		113.9	.98	111.6	.94	109.0	.91	104.6	.82			99.9	.74
		111.6	.94	108.7	.89	106.3	.85	101.1	.76			95.8	.67
CORN IN CCOHHH ROTATION ON EHLER SOIL WITH UP\$DOWN NO - TILLAGE													
INDEX = 1.00 BASE YIELD = 130.0 INDEX = .90 INDEX = 1.00													
PLANTING DATES													
HARVEST DATE	SEPT 27 - OCT 18											MAY 31-JU 6	INDEX
HARVEST DATE	OCT 19 - NOV 8	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX				
HARVEST DATE	NOV 9 - 29	114.8	1.00	111.9	.95	109.5	0.0	104.3	0.0				0.00
		113.6	.98	111.3	.94	109.5	.91	104.3	.82			99.6	.74
		111.3	.94	108.4	.89	106.0	.85	100.0	.76			95.5	.67
CORN IN CCOHHH ROTATION ON EHLER SOIL WITH CONTOUR CONVENT. TILLAGE													
INDEX = 1.00 BASE YIELD = 130.0 INDEX = 1.00 INDEX = 1.12													
PLANTING DATES													
HARVEST DATE	SEPT 27 - OCT 18											MAY 31-JU 6	INDEX
HARVEST DATE	OCT 19 - NOV 8	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX				
HARVEST DATE	NOV 9 - 29	120.5	1.00	117.6	.95	115.2	0.0	110.0	0.0				0.00
		119.3	.98	117.0	.94	115.2	.91	110.0	.82			105.3	.74
		117.0	.94	114.1	.89	111.7	.85	106.5	.76			101.2	.67
CORN IN CCOHHH ROTATION ON EHLER SOIL WITH CONTOUR MINIMUM TILLAGE													
INDEX = 1.00 BASE YIELD = 130.0 INDEX = 1.00 INDEX = 1.01													
PLANTING DATES													
HARVEST DATE	SEPT 27 - OCT 18											MAY 31-JU 6	INDEX
HARVEST DATE	OCT 19 - NOV 8	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX				
HARVEST DATE	NOV 9 - 29	117.3	1.00	114.4	.95	112.0	0.0	106.8	0.0				0.00
		116.1	.98	113.8	.94	112.0	.91	106.8	.82			102.1	.74
		113.8	.94	110.9	.89	108.5	.85	103.3	.76			98.0	.67
CORN IN CCOHHH ROTATION ON EHLER SOIL WITH CONTOUR NO - TILLAGE													
INDEX = 1.00 BASE YIELD = 130.0 INDEX = 1.00 INDEX = 1.00													
PLANTING DATES													
HARVEST DATE	SEPT 27 - OCT 18											MAY 31-JU 6	INDEX
HARVEST DATE	OCT 19 - NOV 8	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX				
HARVEST DATE	NOV 9 - 29	117.0	1.00	114.1	.95	111.7	0.0	106.5	0.0				0.00
		115.8	.98	113.5	.94	111.7	.91	106.5	.82			101.8	.74
		113.5	.94	110.6	.89	108.2	.85	103.0	.76			97.7	.67

WEIGHTS ARE (1) PLANT & HARVEST = 1.000 (2) TILLAGE = .500 (3) ROTATION = .125 (4) CONSERVATION = .375

CORN IN CCC ROTATION ON EHLER SOIL WITH UPDOWN CONVENT. TILLAGE													
INDEX = 1.00		BASE YIELD = 130.0		INDEX = .90		INDEX = 1.12							
PLANTING DATES													
HARVEST DATE SEPT 27 - OCT 18		MAY 3-9 INDEX		MAY 10-16 INDEX		MAY 17-23 INDEX		MAY 24-30 INDEX		MAY 31-JU 6 INDEX			
HARVEST DATE OCT 19 - NOV 8		118.3 1.00		115.4 .95		0.0 0.00		0.0 0.00		0.0 0.00			
HARVEST DATE NOV 9 - 29		117.1 .98		114.8 .94		113.1 .91		107.8 .82		103.1 .74			
		114.8 .94		111.9 .89		109.5 .85		104.3 .76		99.0 .67			
CORN IN CCC ROTATION ON EHLER SOIL WITH UPDOWN MINIMUM TILLAGE													
INDEX = 1.00		BASE YIELD = 130.0		INDEX = .90		INDEX = 1.01							
PLANTING DATES													
HARVEST DATE SEPT 27 - OCT 18		MAY 3-9 INDEX		MAY 10-16 INDEX		MAY 17-23 INDEX		MAY 24-30 INDEX		MAY 31-JU 6 INDEX			
HARVEST DATE OCT 19 - NOV 8		115.1 1.00		112.2 .95		0.0 0.00		0.0 0.00		0.0 0.00			
HARVEST DATE NOV 9 - 29		113.9 .98		111.6 .94		109.8 .91		104.6 .82		99.9 .74			
		111.6 .94		108.7 .89		106.3 .85		101.1 .76		95.8 .67			
CORN IN CCC ROTATION ON EHLER SOIL WITH UPDOWN NO - TILLAGE													
INDEX = 1.00		BASE YIELD = 130.0		INDEX = .90		INDEX = 1.00							
PLANTING DATES													
HARVEST DATE SEPT 27 - OCT 18		MAY 3-9 INDEX		MAY 10-16 INDEX		MAY 17-23 INDEX		MAY 24-30 INDEX		MAY 31-JU 6 INDEX			
HARVEST DATE OCT 19 - NOV 8		114.8 1.00		111.9 .95		0.0 0.00		0.0 0.00		0.0 0.00			
HARVEST DATE NOV 9 - 29		113.6 .98		111.3 .94		109.5 .91		104.3 .82		99.6 .74			
		111.3 .94		108.4 .89		106.0 .85		100.8 .76		95.5 .67			
CORN IN CCC ROTATION ON EHLER SOIL WITH CONTOUR CONVENT. TILLAGE													
INDEX = 1.00		BASE YIELD = 130.0		INDEX = 1.00		INDEX = 1.12							
PLANTING DATES													
HARVEST DATE SEPT 27 - OCT 18		MAY 3-9 INDEX		MAY 10-16 INDEX		MAY 17-23 INDEX		MAY 24-30 INDEX		MAY 31-JU 6 INDEX			
HARVEST DATE OCT 19 - NOV 8		120.5 1.00		117.6 .95		0.0 0.00		0.0 0.00		0.0 0.00			
HARVEST DATE NOV 9 - 29		119.3 .98		117.0 .94		115.2 .91		110.0 .82		105.3 .74			
		117.0 .94		114.1 .89		111.7 .85		106.5 .76		101.2 .67			
CORN IN CCC ROTATION ON EHLER SOIL WITH CONTOUR MINIMUM TILLAGE													
INDEX = 1.00		BASE YIELD = 130.0		INDEX = 1.00		INDEX = 1.01							
PLANTING DATES													
HARVEST DATE SEPT 27 - OCT 18		MAY 3-9 INDEX		MAY 10-16 INDEX		MAY 17-23 INDEX		MAY 24-30 INDEX		MAY 31-JU 6 INDEX			
HARVEST DATE OCT 19 - NOV 8		117.3 1.00		114.4 .95		0.0 0.00		0.0 0.00		0.0 0.00			
HARVEST DATE NOV 9 - 29		116.1 .98		113.8 .94		112.0 .91		106.8 .82		102.1 .74			
		113.8 .94		110.9 .89		108.5 .85		103.3 .76		98.0 .67			
CORN IN CCC ROTATION ON EHLER SOIL WITH CONTOUR NO - TILLAGE													
INDEX = 1.00		BASE YIELD = 130.0		INDEX = 1.00		INDEX = 1.00							
PLANTING DATES													
HARVEST DATE SEPT 27 - OCT 18		MAY 3-9 INDEX		MAY 10-16 INDEX		MAY 17-23 INDEX		MAY 24-30 INDEX		MAY 31-JU 6 INDEX			
HARVEST DATE OCT 19 - NOV 8		117.0 1.00		114.1 .95		0.0 0.00		0.0 0.00		0.0 0.00			
HARVEST DATE NOV 9 - 29		115.8 .98		113.5 .94		111.7 .91		106.5 .82		101.8 .74			
		113.5 .94		110.6 .89		108.2 .85		103.0 .76		97.7 .67			

HEIGHTS ARE (1) PLANT 5 HARVEST =1.000 (2) TILLAGE = .500 (3) ROTATION = .125 (4) CONSERVATION = .375

CORN IN CCCOM ROTATION ON MIAMI SOIL WITH UP\$DOWN CONVENT. TILLAGE													
		INDEX =1.07		BASE YIELD =101.0		INDEX = .90		INDEX = .95					
PLANTING DATES		MAY 3-9		INDEX		MAY 10-16		INDEX		MAY 17-23		INDEX	
HARVEST DATE SEPT 27 - OCT 18		88.5		1.00		86.2		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		87.5		.98		85.7		.94		84.4		.91	
HARVEST DATE NOV 9 - 29		85.7		.94		83.5		.89		81.6		.85	
		MAY 24-30		INDEX		MAY 24-30		INDEX		MAY 24-30		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 24-30		INDEX		MAY 24-30		INDEX		MAY 24-30		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 24-30		INDEX		MAY 24-30		INDEX		MAY 24-30		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 24-30		INDEX		MAY 24-30		INDEX		MAY 24-30		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 24-30		INDEX		MAY 24-30		INDEX		MAY 24-30		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 24-30		INDEX		MAY 24-30		INDEX		MAY 24-30		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 24-30		INDEX		MAY 24-30		INDEX		MAY 24-30		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 24-30		INDEX		MAY 24-30		INDEX		MAY 24-30		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 24-30		INDEX		MAY 24-30		INDEX		MAY 24-30		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 24-30		INDEX		MAY 24-30		INDEX		MAY 24-30		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 24-30		INDEX		MAY 24-30		INDEX		MAY 24-30		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 24-30		INDEX		MAY 24-30		INDEX		MAY 24-30		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 24-30		INDEX		MAY 24-30		INDEX		MAY 24-30		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 24-30		INDEX		MAY 24-30		INDEX		MAY 24-30		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 24-30		INDEX		MAY 24-30		INDEX		MAY 24-30		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 24-30		INDEX		MAY 24-30		INDEX		MAY 24-30		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX		MAY 31-JU 6		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00		84.4		.95		0.0		0.0	
HARVEST DATE OCT 19 - NOV 8		85.7		.98		83.9		.94		82.5		.91	
HARVEST DATE NOV 9 - 29		83.9		.94		81.6		.89		79.8		.85	
		MAY 24-30		INDEX		MAY 24-30		INDEX		MAY 24-30		INDEX	
HARVEST DATE SEPT 27 - OCT 18		86.6		1.00									

WEIGHTS ARE (1) PLANT \$ HARVEST =1.000 (2) TILLAGE = .500 (3) ROTATION = .125 (4) CONSERVATION = .375

CORN IN CCOHH ROTATION ON MIAMI SOIL WITH UPSDOWN CONVENT. TILLAGE
INDEX =1.02 BASE YIELD =101.0 INDEX = .90 INDEX = .84

PLANTING DATES	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST DATE SEPT 27 - OCT 18	85.7	1.00	83.4	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST DATE OCT 19 - NOV 8	84.8	.98	82.9	.94	81.6	.91	77.5	.82	73.9	.74
HARVEST DATE NOV 9 - 29	82.9	.94	80.7	.89	78.9	.85	74.8	.76	70.7	.67

CORN IN CCOHH ROTATION ON MIAMI SOIL WITH UPSDOWN MINIMUM TILLAGE
INDEX =1.02 BASE YIELD =101.0 INDEX = .90 INDEX = .85

PLANTING DATES	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST DATE SEPT 27 - OCT 18	85.9	1.00	83.6	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST DATE OCT 19 - NOV 8	85.0	.98	83.2	.94	81.8	.91	77.7	.82	74.1	.74
HARVEST DATE NOV 9 - 29	83.2	.94	80.9	.89	79.1	.85	75.0	.76	70.9	.67

CORN IN CCOHH ROTATION ON MIAMI SOIL WITH UPSDOWN NO - TILLAGE
INDEX =1.02 BASE YIELD =101.0 INDEX = .90 INDEX = 1.00

PLANTING DATES	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST DATE SEPT 27 - OCT 18	89.3	1.00	87.0	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST DATE OCT 19 - NOV 8	86.4	.98	86.6	.94	85.2	.91	81.1	.82	77.5	.74
HARVEST DATE NOV 9 - 29	86.6	.94	84.3	.89	82.5	.85	78.4	.76	74.3	.67

CORN IN CCOHH ROTATION ON MIAMI SOIL WITH CONTOUR CONVENT. TILLAGE
INDEX =1.02 BASE YIELD =101.0 INDEX = 1.00 INDEX = .84

PLANTING DATES	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST DATE SEPT 27 - OCT 18	87.4	1.00	85.1	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST DATE OCT 19 - NOV 8	86.5	.98	84.7	.94	83.3	.91	79.2	.82	75.6	.74
HARVEST DATE NOV 9 - 29	84.7	.94	82.4	.89	80.6	.85	76.5	.76	72.4	.67

CORN IN CCOHH ROTATION ON MIAMI SOIL WITH CONTOUR MINIMUM TILLAGE
INDEX =1.02 BASE YIELD =101.0 INDEX = 1.00 INDEX = .85

PLANTING DATES	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST DATE SEPT 27 - OCT 18	87.6	1.00	85.3	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST DATE OCT 19 - NOV 8	86.7	.98	84.9	.94	83.5	.91	79.4	.82	75.8	.74
HARVEST DATE NOV 9 - 29	84.9	.94	82.6	.89	80.8	.85	76.7	.76	72.6	.67

CORN IN CCOHH ROTATION ON MIAMI SOIL WITH CONTOUR NO - TILLAGE
INDEX =1.02 BASE YIELD =101.0 INDEX = 1.00 INDEX = 1.00

PLANTING DATES	MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
HARVEST DATE SEPT 27 - OCT 18	91.0	1.00	88.7	.95	0.0	0.00	0.0	0.00	0.0	0.00
HARVEST DATE OCT 19 - NOV 8	90.1	.98	88.3	.94	86.9	.91	82.8	.82	79.2	.74
HARVEST DATE NOV 9 - 29	88.3	.94	86.0	.89	84.2	.85	80.1	.76	76.0	.67

WEIGHTS ARE (1) PLANT \$ HARVEST =1.000 (2) TILLAGE = .500 (3) ROTATION = .125 (4) CONSERVATION = .375

CORN IN CCOHHH ROTATION ON MIAMI SOIL WITH UP\$DOWN CONVENT. TILLAGE
INDEX =1.00 BASE YIELD =101.0 INDEX = .90 INDEX = .84

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
85.6	1.00	83.3	.95	0.0	0.00	0.0	0.00	0.0	0.00
84.7	.98	82.8	.94	81.5	.91	77.4	.82	73.7	.74
82.8	.94	80.6	.89	78.7	.85	74.7	.76	70.6	.67

CORN IN CCOHHH ROTATION ON MIAMI SOIL WITH UP\$DOWN MINIMUM TILLAGE
INDEX =1.00 BASE YIELD =101.0 INDEX = .90 INDEX = .85

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
85.6	1.00	83.5	.95	0.0	0.00	0.0	0.00	0.0	0.00
84.9	.98	83.1	.94	81.7	.91	77.6	.82	74.0	.74
83.1	.94	80.8	.89	79.0	.85	74.9	.76	70.8	.67

CORN IN CCOHHH ROTATION ON MIAMI SOIL WITH UP\$DOWN NO - TILLAGE
INDEX =1.00 BASE YIELD =101.0 INDEX = .90 INDEX = 1.00

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
86.2	1.00	86.9	.95	0.0	0.00	0.0	0.00	0.0	0.00
85.3	.98	86.5	.94	85.1	.91	81.0	.82	77.4	.74
86.5	.94	84.2	.89	82.4	.85	78.3	.76	74.2	.67

CORN IN CCOHHH ROTATION ON MIAMI SOIL WITH CONTOUR CONVENT. TILLAGE
INDEX =1.00 BASE YIELD =101.0 INDEX = 1.00 INDEX = .84

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
87.3	1.00	85.0	.95	0.0	0.00	0.0	0.00	0.0	0.00
86.4	.98	84.5	.94	83.2	.91	79.1	.82	75.4	.74
84.5	.94	82.3	.89	80.4	.85	76.4	.76	72.3	.67

CORN IN CCOHHH ROTATION ON MIAMI SOIL WITH CONTOUR MINIMUM TILLAGE
INDEX =1.00 BASE YIELD =101.0 INDEX = 1.00 INDEX = .85

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
87.5	1.00	85.2	.95	0.0	0.00	0.0	0.00	0.0	0.00
86.6	.98	84.8	.94	83.4	.91	79.3	.82	75.7	.74
84.8	.94	82.5	.89	80.7	.85	76.6	.76	72.5	.67

CORN IN CCOHHH ROTATION ON MIAMI SOIL WITH CONTOUR NO - TILLAGE
INDEX =1.00 BASE YIELD =101.0 INDEX = 1.00 INDEX = 1.00

PLANTING DATES
HARVEST DATE SEPT 27 - OCT 18
HARVEST DATE OCT 19 - NOV 8
HARVEST DATE NOV 9 - 29

MAY 3-9	INDEX	MAY 10-16	INDEX	MAY 17-23	INDEX	MAY 24-30	INDEX	MAY 31-JU 6	INDEX
90.9	1.00	88.6	.95	0.0	0.00	0.0	0.00	0.0	0.00
90.0	.98	88.2	.94	86.8	.91	82.7	.82	79.1	.74
88.2	.94	85.9	.89	84.1	.85	80.0	.76	75.9	.67

WEIGHTS ARE (1) PLANT \$ HARVEST = 1.000 (2) TILLAGE = .700 (3) ROTATION = 0.000 (4) CONSERVATION = .380

OATS IN CCOHH ROTATION ON		ELBA SOIL WITH UP\$DOWN		CONVENT. TILLAGE	
INDEX = 1.00		BASE YIELD = 11.1		INDEX = .98	
HARVEST DATES	JULY 26 - AUG 1 INDEX	AUG 2 - 8	INDEX	AUG 9 - 15	INDEX
PLANTING DATE APR 5 - 25	9.8 1.00	9.1	.86	8.1	.66
PLANTING DATE APR 26 - MAY 16	0.0 0.00	8.6	.76	7.9	.62
					7.3
					7.8
					.59
					.49
OATS IN CCOHH ROTATION ON ELBA SOIL WITH CONTOUR					
INDEX = 1.00		BASE YIELD = 11.1		INDEX = 1.00	
HARVEST DATES	JULY 26 - AUG 1 INDEX	AUG 2 - 8	INDEX	AUG 9 - 15	INDEX
PLANTING DATE APR 5 - 25	10.0 1.00	9.3	.86	8.3	.66
PLANTING DATE APR 26 - MAY 16	0.0 0.00	8.8	.76	8.1	.62
					7.4
					7.9
					.59
					.49
OATS IN CCOHH ROTATION ON ELBA SOIL WITH UP\$DOWN					
INDEX = 1.00		BASE YIELD = 11.1		INDEX = .98	
HARVEST DATES	JULY 26 - AUG 1 INDEX	AUG 2 - 8	INDEX	AUG 9 - 15	INDEX
PLANTING DATE APR 5 - 25	9.8 1.00	9.1	.86	8.1	.66
PLANTING DATE APR 26 - MAY 16	0.0 0.00	8.6	.76	7.9	.62
					7.3
					7.8
					.59
					.49
OATS IN CCOHH ROTATION ON ELBA SOIL WITH CONTOUR					
INDEX = 1.00		BASE YIELD = 11.1		INDEX = 1.00	
HARVEST DATES	JULY 26 - AUG 1 INDEX	AUG 2 - 8	INDEX	AUG 9 - 15	INDEX
PLANTING DATE APR 5 - 25	10.0 1.00	9.3	.86	8.3	.66
PLANTING DATE APR 26 - MAY 16	0.0 0.00	8.8	.76	8.1	.62
					7.4
					7.9
					.59
					.49
OATS IN CCOHH ROTATION ON ELBA SOIL WITH UP\$DOWN					
INDEX = 1.00		BASE YIELD = 11.1		INDEX = .98	
HARVEST DATES	JULY 26 - AUG 1 INDEX	AUG 2 - 8	INDEX	AUG 9 - 15	INDEX
PLANTING DATE APR 5 - 25	9.8 1.00	9.1	.86	8.1	.66
PLANTING DATE APR 26 - MAY 16	0.0 0.00	8.6	.76	7.9	.62
					7.3
					7.8
					.59
					.49
OATS IN CCOHH ROTATION ON ELBA SOIL WITH CONTOUR					
INDEX = 1.00		BASE YIELD = 11.1		INDEX = 1.00	
HARVEST DATES	JULY 26 - AUG 1 INDEX	AUG 2 - 8	INDEX	AUG 9 - 15	INDEX
PLANTING DATE APR 5 - 25	10.0 1.00	9.3	.86	8.3	.66
PLANTING DATE APR 26 - MAY 16	0.0 0.00	8.8	.76	8.1	.62
					7.4
					7.9
					.59
					.49
OATS IN MHMO ROTATION ON ELBA SOIL WITH UP\$DOWN					
INDEX = 1.00		BASE YIELD = 11.1		INDEX = .98	
HARVEST DATES	JULY 26 - AUG 1 INDEX	AUG 2 - 8	INDEX	AUG 9 - 15	INDEX
PLANTING DATE APR 5 - 25	9.8 1.00	9.1	.86	8.1	.66
PLANTING DATE APR 26 - MAY 16	0.0 0.00	8.6	.76	7.9	.62
					7.3
					7.8
					.59
					.49

WEIGHTS ARE (1) PLANT \$ HARVEST =1.000 (2) TILLAGE = .700 (3) ROTATION =0.000 (4) CONSERVATION = .300

OATS IN MHMO ROTATION ON ELBA SOIL WITH CONTOUR CONVENT. TILLAGE
 INDEX =1.00 BASE YIELD = 11.1 INDEX = 1.00 INDEX = 1.00
 HARVEST DATES
 PLANTING DATE APR 5 - 25
 PLANTING DATE APR 26 - MAY 16

JULY 26 -AUG 1 INDEX AUG 2 - 8 INDEX AUG 9 - 15 INDEX AUG 16 - 22 INDEX
 10.0 1.00 9.3 .86 8.3 .66 7.9 .59
 8.0 0.00 8.8 .76 8.1 .62 7.4 .49

OATS IN CCCOM ROTATION ON CALAMUS SOIL WITH UPSDOWN CONVENT. TILLAGE
 INDEX =1.00 BASE YIELD = 10.0 INDEX = .90 INDEX = .04
 HARVEST DATES
 PLANTING DATE APR 5 - 25
 PLANTING DATE APR 26 - MAY 16

JULY 26 -AUG 1 INDEX AUG 2 - 8 INDEX AUG 9 - 15 INDEX AUG 16 - 22 INDEX
 8.4 1.00 7.7 .86 6.8 .66 6.5 .59
 0.0 0.00 7.3 .76 6.7 .62 6.1 .49

OATS IN CCCOM ROTATION ON CALAMUS SOIL WITH CONTOUR CONVENT. TILLAGE
 INDEX =1.00 BASE YIELD = 10.0 INDEX = 1.00 INDEX = .04
 HARVEST DATES
 PLANTING DATE APR 5 - 25
 PLANTING DATE APR 26 - MAY 16

JULY 26 -AUG 1 INDEX AUG 2 - 8 INDEX AUG 9 - 15 INDEX AUG 16 - 22 INDEX
 8.5 1.00 7.9 .86 7.0 .66 6.7 .59
 8.0 0.00 7.4 .76 6.8 .62 6.2 .49

OATS IN CCCOM ROTATION ON CALAMUS SOIL WITH UPSDOWN CONVENT. TILLAGE
 INDEX =1.00 BASE YIELD = 10.0 INDEX = .90 INDEX = .04
 HARVEST DATES
 PLANTING DATE APR 5 - 25
 PLANTING DATE APR 26 - MAY 16

JULY 26 -AUG 1 INDEX AUG 2 - 8 INDEX AUG 9 - 15 INDEX AUG 16 - 22 INDEX
 8.4 1.00 7.7 .86 6.8 .66 6.5 .59
 0.0 0.00 7.3 .76 6.7 .62 6.1 .49

OATS IN CCCOM ROTATION ON CALAMUS SOIL WITH CONTOUR CONVENT. TILLAGE
 INDEX =1.00 BASE YIELD = 10.0 INDEX = 1.00 INDEX = .04
 HARVEST DATES
 PLANTING DATE APR 5 - 25
 PLANTING DATE APR 26 - MAY 16

JULY 26 -AUG 1 INDEX AUG 2 - 8 INDEX AUG 9 - 15 INDEX AUG 16 - 22 INDEX
 8.5 1.00 7.9 .86 7.0 .66 6.7 .59
 0.0 0.00 7.4 .76 6.8 .62 6.2 .49

OATS IN CCCOM ROTATION ON CALAMUS SOIL WITH UPSDOWN CONVENT. TILLAGE
 INDEX =1.00 BASE YIELD = 10.0 INDEX = .90 INDEX = .04
 HARVEST DATES
 PLANTING DATE APR 5 - 25
 PLANTING DATE APR 26 - MAY 16

JULY 26 -AUG 1 INDEX AUG 2 - 8 INDEX AUG 9 - 15 INDEX AUG 16 - 22 INDEX
 8.4 1.00 7.7 .86 6.8 .66 6.5 .59
 0.0 0.00 7.3 .76 6.7 .62 6.1 .49

OATS IN CCCOM ROTATION ON CALAMUS SOIL WITH CONTOUR CONVENT. TILLAGE
 INDEX =1.00 BASE YIELD = 10.0 INDEX = 1.00 INDEX = .04
 HARVEST DATES
 PLANTING DATE APR 5 - 25
 PLANTING DATE APR 26 - MAY 16

JULY 26 -AUG 1 INDEX AUG 2 - 8 INDEX AUG 9 - 15 INDEX AUG 16 - 22 INDEX
 8.5 1.00 7.9 .86 7.0 .66 6.7 .59
 0.0 0.00 7.4 .76 6.8 .62 6.2 .49

WEIGHTS ARE (1) PLANT \$ HARVEST =1.000 (2) YILLAGE = .700 (3) ROTATION =0.000 (4) CONSERVATION = .300

OATS IN HHMO ROTATION ON CALAMUS SOIL WITH UP\$DOWN		CONVENT. YILLAGE	
INDEX =1.00	BASE YIELD = 10.0	INDEX = .90	INDEX = .04
HARVEST DATES			
JULY 26 -AUG 1	INDEX AUG 2 - 8	INDEX AUG 9 - 15	INDEX AUG 16 - 22
PLANTING DATE APR 5 - 25	8.4 1.00	7.7 .86	6.8 .66
PLANTING DATE APR 26 - MAY 16	8.0 0.00	7.3 .76	6.7 .62
			6.1 .49
OATS IN HHMO ROTATION ON CALAMUS SOIL WITH CONTOUR			
INDEX =1.00	BASE YIELD = 10.0	INDEX = 1.00	INDEX = .04
HARVEST DATES			
JULY 26 -AUG 1	INDEX AUG 2 - 8	INDEX AUG 9 - 15	INDEX AUG 16 - 22
PLANTING DATE APR 5 - 25	8.5 1.00	7.9 .86	7.0 .66
PLANTING DATE APR 26 - MAY 16	8.0 0.00	7.4 .76	6.8 .62
			6.2 .49
OATS IN CCCOH ROTATION ON CLYMAN SOIL WITH UP\$DOWN			
INDEX =1.00	BASE YIELD = 11.1	INDEX = .90	INDEX = .97
HARVEST DATES			
JULY 26 -AUG 1	INDEX AUG 2 - 8	INDEX AUG 9 - 15	INDEX AUG 16 - 22
PLANTING DATE APR 5 - 25	9.7 1.00	9.0 .86	8.0 .66
PLANTING DATE APR 26 - MAY 16	8.0 0.00	8.5 .76	7.8 .62
			7.2 .49
OATS IN CCCOH ROTATION ON CLYMAN SOIL WITH CONTOUR			
INDEX =1.00	BASE YIELD = 11.1	INDEX = 1.00	INDEX = .97
HARVEST DATES			
JULY 26 -AUG 1	INDEX AUG 2 - 8	INDEX AUG 9 - 15	INDEX AUG 16 - 22
PLANTING DATE APR 5 - 25	9.9 1.00	9.2 .86	8.2 .66
PLANTING DATE APR 26 - MAY 16	8.0 0.00	8.7 .76	8.0 .62
			7.3 .49
OATS IN CCOHH ROTATION ON CLYMAN SOIL WITH UP\$DOWN			
INDEX =1.00	BASE YIELD = 11.1	INDEX = .90	INDEX = .97
HARVEST DATES			
JULY 26 -AUG 1	INDEX AUG 2 - 8	INDEX AUG 9 - 15	INDEX AUG 16 - 22
PLANTING DATE APR 5 - 25	9.7 1.00	9.0 .86	8.0 .66
PLANTING DATE APR 26 - MAY 16	8.0 0.00	8.5 .76	7.8 .62
			7.2 .49
OATS IN CCOHH ROTATION ON CLYMAN SOIL WITH CONTOUR			
INDEX =1.00	BASE YIELD = 11.1	INDEX = 1.00	INDEX = .97
HARVEST DATES			
JULY 26 -AUG 1	INDEX AUG 2 - 8	INDEX AUG 9 - 15	INDEX AUG 16 - 22
PLANTING DATE APR 5 - 25	9.9 1.00	9.2 .86	8.2 .66
PLANTING DATE APR 26 - MAY 16	8.0 0.00	8.7 .76	8.0 .62
			7.3 .49
OATS IN CCOHH ROTATION ON CLYMAN SOIL WITH UP\$DOWN			
INDEX =1.00	BASE YIELD = 11.1	INDEX = .90	INDEX = .97
HARVEST DATES			
JULY 26 -AUG 1	INDEX AUG 2 - 8	INDEX AUG 9 - 15	INDEX AUG 16 - 22
PLANTING DATE APR 5 - 25	9.7 1.00	9.0 .86	8.0 .66
PLANTING DATE APR 26 - MAY 16	8.0 0.00	8.5 .76	7.8 .62
			7.2 .49

WEIGHTS ARE (1) PLANT & HARVEST = 1.000 (2) TILLAGE = .700 (3) ROTATION = 0.000 (4) CONSERVATION = .300

OATS IN CCOMH ROTATION ON CLYMAN SOIL WITH CONTOUR CONVENT. TILLAGE											
INDEX = 1.00			BASE YIELD = 11.1			INDEX = 1.00			INDEX = .97		
HARVEST DATES	JULY 26	-AUG 1	INDEX	AUG 2	- 8	INDEX	AUG 9	- 15	INDEX	AUG 16	- 22
PLANTING DATE APR 5 - 25	9.9	1.00		9.2	.86		8.2		.66	7.8	
PLANTING DATE APR 26 - MAY 16	0.0	0.00		8.7	.76		8.0		.62	7.3	
INDEX	9.9	1.00		9.2	.86		8.2		.66	7.8	
INDEX	0.0	0.00		8.7	.76		8.0		.62	7.3	
OATS IN HHM10 ROTATION ON CLYMAN SOIL WITH UPSDOWN CONVENT. TILLAGE											
INDEX = 1.00			BASE YIELD = 11.1			INDEX = .90			INDEX = .97		
HARVEST DATES	JULY 26	-AUG 1	INDEX	AUG 2	- 8	INDEX	AUG 9	- 15	INDEX	AUG 16	- 22
PLANTING DATE APR 5 - 25	9.7	1.00		9.0	.86		8.0		.66	7.7	
PLANTING DATE APR 26 - MAY 16	0.0	0.00		8.5	.76		7.0		.62	7.2	
INDEX	9.7	1.00		9.0	.86		8.0		.66	7.7	
INDEX	0.0	0.00		8.5	.76		7.0		.62	7.2	
OATS IN HHM10 ROTATION ON CLYMAN SOIL WITH CONTOUR CONVENT. TILLAGE											
INDEX = 1.00			BASE YIELD = 11.1			INDEX = 1.00			INDEX = .97		
HARVEST DATES	JULY 26	-AUG 1	INDEX	AUG 2	- 8	INDEX	AUG 9	- 15	INDEX	AUG 16	- 22
PLANTING DATE APR 5 - 25	9.9	1.00		9.2	.86		8.2		.66	7.8	
PLANTING DATE APR 26 - MAY 16	0.0	0.00		8.7	.76		8.0		.62	7.3	
INDEX	9.9	1.00		9.2	.86		8.2		.66	7.8	
INDEX	0.0	0.00		8.7	.76		8.0		.62	7.3	
OATS IN CCCOM ROTATION ON EHLEH SOIL WITH UPSDOWN CONVENT. TILLAGE											
INDEX = 1.00			BASE YIELD = 12.2			INDEX = .90			INDEX = 1.12		
HARVEST DATES	JULY 26	-AUG 1	INDEX	AUG 2	- 8	INDEX	AUG 9	- 15	INDEX	AUG 16	- 22
PLANTING DATE APR 5 - 25	11.3	1.00		10.5	.86		9.4		.66	9.0	
PLANTING DATE APR 26 - MAY 16	0.0	0.00		10.0	.76		9.2		.62	8.5	
INDEX	11.3	1.00		10.5	.86		9.4		.66	9.0	
INDEX	0.0	0.00		10.0	.76		9.2		.62	8.5	
OATS IN CCCOM ROTATION ON EHLEH SOIL WITH CONTOUR CONVENT. TILLAGE											
INDEX = 1.00			BASE YIELD = 12.2			INDEX = 1.00			INDEX = 1.12		
HARVEST DATES	JULY 26	-AUG 1	INDEX	AUG 2	- 8	INDEX	AUG 9	- 15	INDEX	AUG 16	- 22
PLANTING DATE APR 5 - 25	11.4	1.00		10.7	.86		9.6		.66	9.2	
PLANTING DATE APR 26 - MAY 16	0.0	0.00		10.1	.76		9.4		.62	8.6	
INDEX	11.4	1.00		10.7	.86		9.6		.66	9.2	
INDEX	0.0	0.00		10.1	.76		9.4		.62	8.6	
OATS IN CCOMH ROTATION ON EHLEH SOIL WITH UPSDOWN CONVENT. TILLAGE											
INDEX = 1.00			BASE YIELD = 12.2			INDEX = .90			INDEX = 1.12		
HARVEST DATES	JULY 26	-AUG 1	INDEX	AUG 2	- 8	INDEX	AUG 9	- 15	INDEX	AUG 16	- 22
PLANTING DATE APR 5 - 25	11.3	1.00		10.5	.86		9.4		.66	9.0	
PLANTING DATE APR 26 - MAY 16	0.0	0.00		10.0	.76		9.2		.62	8.5	
INDEX	11.3	1.00		10.5	.86		9.4		.66	9.0	
INDEX	0.0	0.00		10.0	.76		9.2		.62	8.5	
OATS IN CCOMH ROTATION ON EHLEH SOIL WITH CONTOUR CONVENT. TILLAGE											
INDEX = 1.00			BASE YIELD = 12.2			INDEX = 1.00			INDEX = 1.12		
HARVEST DATES	JULY 26	-AUG 1	INDEX	AUG 2	- 8	INDEX	AUG 9	- 15	INDEX	AUG 16	- 22
PLANTING DATE APR 5 - 25	11.4	1.00		10.7	.86		9.6		.66	9.2	
PLANTING DATE APR 26 - MAY 16	0.0	0.00		10.1	.76		9.4		.62	8.6	
INDEX	11.4	1.00		10.7	.86		9.6		.66	9.2	
INDEX	0.0	0.00		10.1	.76		9.4		.62	8.6	

WEIGHTS ARE (1) PLANT \$ HARVEST =1.000 (2) TILLAGE = .700 (3) ROTATION =0.000 (4) CONSERVATION = .300

OATS IN CCOMHH ROTATION ON EHLER SOIL WITH UP\$DOWN CONVENT. TILLAGE									
INDEX =1.00 BASE YIELD = 12.2 INDEX = .90 INDEX = 1.12									
JULY 26 -AUG 1 INDEX AUG 2 - 8 INDEX AUG 9 - 15 INDEX AUG 16 - 22 INDEX									
11.3 1.00 10.5 .86 9.4 .66 9.0 .59									
0.0 0.00 10.0 .76 9.2 .62 8.5 .49									
PLANTING DATE APR 5 - 25									
PLANTING DATE APR 26 - MAY 16									
OATS IN CCOMHH ROTATION ON EHLER SOIL WITH CONTOUR CONVENT. TILLAGE									
INDEX =1.00 BASE YIELD = 12.2 INDEX = 1.00 INDEX = 1.12									
JULY 26 -AUG 1 INDEX AUG 2 - 8 INDEX AUG 9 - 15 INDEX AUG 16 - 22 INDEX									
11.4 1.00 10.7 .86 9.6 .66 9.2 .59									
0.0 0.00 10.1 .76 9.4 .62 8.6 .49									
PLANTING DATE APR 5 - 25									
PLANTING DATE APR 26 - MAY 16									
OATS IN HHMH ROTATION ON EHLER SOIL WITH UP\$DOWN CONVENT. TILLAGE									
INDEX =1.00 BASE YIELD = 12.2 INDEX = .90 INDEX = 1.12									
JULY 26 -AUG 1 INDEX AUG 2 - 8 INDEX AUG 9 - 15 INDEX AUG 16 - 22 INDEX									
11.3 1.00 10.5 .86 9.4 .66 9.0 .59									
0.0 0.00 10.0 .76 9.2 .62 8.5 .49									
PLANTING DATE APR 5 - 25									
PLANTING DATE APR 26 - MAY 16									
OATS IN HHMH ROTATION ON EHLER SOIL WITH CONTOUR CONVENT. TILLAGE									
INDEX =1.00 BASE YIELD = 12.2 INDEX = 1.00 INDEX = 1.12									
JULY 26 -AUG 1 INDEX AUG 2 - 8 INDEX AUG 9 - 15 INDEX AUG 16 - 22 INDEX									
11.4 1.00 10.7 .86 9.6 .66 9.2 .59									
0.0 0.00 10.1 .76 9.4 .62 8.6 .49									
PLANTING DATE APR 5 - 25									
PLANTING DATE APR 26 - MAY 16									
OATS IN CCCJH ROTATION ON MIAMI SOIL WITH UP\$DOWN CONVENT. TILLAGE									
INDEX =1.00 BASE YIELD = 9.3 INDEX = .90 INDEX = .84									
JULY 26 -AUG 1 INDEX AUG 2 - 8 INDEX AUG 9 - 15 INDEX AUG 16 - 22 INDEX									
7.8 1.00 7.2 .86 6.4 .66 6.1 .59									
8.0 0.00 6.8 .76 6.2 .62 5.6 .49									
PLANTING DATE APR 5 - 25									
PLANTING DATE APR 26 - MAY 16									
OATS IN CCCJH ROTATION ON MIAMI SOIL WITH CONTOUR CONVENT. TILLAGE									
INDEX =1.00 BASE YIELD = 9.3 INDEX = 1.00 INDEX = .84									
JULY 26 -AUG 1 INDEX AUG 2 - 8 INDEX AUG 9 - 15 INDEX AUG 16 - 22 INDEX									
7.9 1.00 7.3 .86 6.5 .66 6.2 .59									
8.0 0.00 6.9 .76 6.3 .62 5.8 .49									
PLANTING DATE APR 5 - 25									
PLANTING DATE APR 26 - MAY 16									
OATS IN CCOHH ROTATION ON MIAMI SOIL WITH UP\$DOWN CONVENT. TILLAGE									
INDEX =1.00 BASE YIELD = 9.3 INDEX = .90 INDEX = .84									
JULY 26 -AUG 1 INDEX AUG 2 - 8 INDEX AUG 9 - 15 INDEX AUG 16 - 22 INDEX									
7.8 1.00 7.2 .86 6.4 .66 6.1 .59									
8.0 0.00 6.8 .76 6.2 .62 5.6 .49									
PLANTING DATE APR 5 - 25									
PLANTING DATE APR 26 - MAY 16									

WEIGHTS ARE (1) PLANT \$ HARVEST =1.000 (2) TILLAGE = .700 (3) ROTATION =0.000 (4) CONSERVATION = .300

OATS IN CCOHH ROTATION ON MIAMI SOIL WITH CONTOUR CONVENT. TILLAGE														
INDEX =1.00 BASE YIELD = 9.3 INDEX = 1.00 INDEX = .04														
HARVEST DATES	JULY 26	-AUG 1	INDEX	AUG 2	- 8	INDEX	AUG 9	- 15	INDEX	AUG 16	- 22	INDEX		
PLANTING DATE APR 5 - 25			7.9	1.00		7.3	.86		6.5	.66		6.2	.59	
PLANTING DATE APR 26 - MAY 16			0.0	0.00		6.9	.76		6.3	.62		5.6	.49	
OATS IN CCOHH ROTATION ON MIAMI SOIL WITH UPDOWN CONVENT. TILLAGE														
INDEX =1.00 BASE YIELD = 9.3 INDEX = .90 INDEX = .04														
HARVEST DATES	JULY 26	-AUG 1	INDEX	AUG 2	- 8	INDEX	AUG 9	- 15	INDEX	AUG 16	- 22	INDEX		
PLANTING DATE APR 5 - 25			7.8	1.00		7.2	.86		6.4	.66		6.1	.59	
PLANTING DATE APR 26 - MAY 16			0.0	0.00		6.8	.76		6.2	.62		5.6	.49	
OATS IN CCOHH ROTATION ON MIAMI SOIL WITH CONTOUR CONVENT. TILLAGE														
INDEX =1.00 BASE YIELD = 9.3 INDEX = 1.00 INDEX = .04														
HARVEST DATES	JULY 26	-AUG 1	INDEX	AUG 2	- 8	INDEX	AUG 9	- 15	INDEX	AUG 16	- 22	INDEX		
PLANTING DATE APR 5 - 25			7.9	1.00		7.3	.86		6.5	.66		6.2	.59	
PLANTING DATE APR 26 - MAY 16			0.0	0.00		6.9	.76		6.3	.62		5.8	.49	
OATS IN HHMO ROTATION ON MIAMI SOIL WITH UPDOWN CONVENT. TILLAGE														
INDEX =1.00 BASE YIELD = 9.3 INDEX = .90 INDEX = .04														
HARVEST DATES	JULY 26	-AUG 1	INDEX	AUG 2	- 8	INDEX	AUG 9	- 15	INDEX	AUG 16	- 22	INDEX		
PLANTING DATE APR 5 - 25			7.8	1.00		7.2	.86		6.4	.66		6.1	.59	
PLANTING DATE APR 26 - MAY 16			0.0	0.00		6.8	.76		6.2	.62		5.6	.49	
OATS IN HHMO ROTATION ON MIAMI SOIL WITH CONTOUR CONVENT. TILLAGE														
INDEX =1.00 BASE YIELD = 9.3 INDEX = 1.00 INDEX = .04														
HARVEST DATES	JULY 26	-AUG 1	INDEX	AUG 2	- 8	INDEX	AUG 9	- 15	INDEX	AUG 16	- 22	INDEX		
PLANTING DATE APR 5 - 25			7.9	1.00		7.3	.86		6.5	.66		6.2	.59	
PLANTING DATE APR 26 - MAY 16			0.0	0.00		6.9	.76		6.3	.62		5.8	.49	

ALFALFA ON ELBA SOIL YIELD INDEX = 1.04									
(1)		(2)		(3)		(4)		(5)	
DATES	YIELD	INDEX	DATES	YIELD	INDEX	DATES	YIELD	INDEX	TOTAL
CUTTING DATE MAY 24 - 30	1.33	1.50	JULY 12 - 18	1.41	1.60	AUG 28 - 29	1.34	1.50	4.07
CUTTING DATE MAY 24 - 30	1.33	1.50	JULY 19 - 25	1.33	1.50	AUG 30 - SEPT 5	1.33	1.50	3.98
CUTTING DATE MAY 31 - JUNE 6	1.68	1.90	JULY 19 - 25	1.33	1.50	AUG 30 - SEPT 5	1.33	1.50	4.51
CUTTING DATE MAY 31 - JUNE 6	1.68	1.90	JULY 26 - AUG 1	1.24	1.40	SEPT 6 - 12	1.39	1.70	4.42
CUTTING DATE JUNE 7 - 13	1.86	2.10	JULY 19 - 25	1.33	1.50	AUG 30 - SEPT 5	1.34	1.40	4.24
CUTTING DATE JUNE 7 - 13	1.86	2.10	AUG 2 - 8	1.06	1.20	SEPT 6 - 12	1.34	1.50	4.24
ALFALFA ON CALAMUS SOIL YIELD INDEX = .87									
(1)		(2)		(3)		(4)		(5)	
DATES	YIELD	INDEX	DATES	YIELD	INDEX	DATES	YIELD	INDEX	TOTAL
CUTTING DATE MAY 24 - 30	1.11	1.50	JULY 12 - 18	1.10	1.60	AUG 29 - 29	1.12	1.30	3.48
CUTTING DATE MAY 24 - 30	1.11	1.50	JULY 19 - 25	1.11	1.50	AUG 30 - SEPT 5	1.12	1.30	3.33
CUTTING DATE MAY 31 - JUNE 6	1.41	1.90	JULY 19 - 25	1.11	1.50	AUG 30 - SEPT 5	1.12	1.30	3.77
CUTTING DATE MAY 31 - JUNE 6	1.41	1.90	JULY 26 - AUG 1	1.04	1.40	SEPT 6 - 12	1.26	1.70	3.78
CUTTING DATE JUNE 7 - 13	1.55	2.10	JULY 19 - 25	.96	1.30	AUG 30 - SEPT 5	1.04	1.40	3.55
CUTTING DATE JUNE 7 - 13	1.55	2.10	AUG 2 - 8	.89	1.20	SEPT 6 - 12	1.12	1.50	3.55
ALFALFA ON CLYMAN SOIL YIELD INDEX = 1.00									
(1)		(2)		(3)		(4)		(5)	
DATES	YIELD	INDEX	DATES	YIELD	INDEX	DATES	YIELD	INDEX	TOTAL
CUTTING DATE MAY 24 - 30	1.27	1.50	JULY 12 - 18	1.36	1.60	AUG 29 - 29	1.22	1.50	3.91
CUTTING DATE MAY 24 - 30	1.27	1.50	JULY 19 - 25	1.27	1.50	AUG 30 - SEPT 5	1.22	1.50	3.82
CUTTING DATE MAY 31 - JUNE 6	1.61	1.90	JULY 19 - 25	1.27	1.50	AUG 30 - SEPT 5	1.22	1.50	4.33
CUTTING DATE MAY 31 - JUNE 6	1.61	1.90	JULY 26 - AUG 1	1.19	1.40	SEPT 6 - 12	1.25	1.70	4.25
CUTTING DATE JUNE 7 - 13	1.78	2.10	JULY 19 - 25	1.10	1.30	AUG 30 - SEPT 5	1.19	1.40	4.00
CUTTING DATE JUNE 7 - 13	1.78	2.10	AUG 2 - 8	1.02	1.20	SEPT 6 - 12	1.22	1.50	4.08
ALFALFA ON EHLEN SOIL YIELD INDEX = 1.09									
(1)		(2)		(3)		(4)		(5)	
DATES	YIELD	INDEX	DATES	YIELD	INDEX	DATES	YIELD	INDEX	TOTAL
CUTTING DATE MAY 24 - 30	1.39	1.50	JULY 12 - 18	1.48	1.60	AUG 29 - 29	1.39	1.50	4.26
CUTTING DATE MAY 24 - 30	1.39	1.50	JULY 19 - 25	1.39	1.50	AUG 30 - SEPT 5	1.39	1.50	4.37
CUTTING DATE MAY 31 - JUNE 6	1.76	1.90	JULY 19 - 25	1.39	1.50	AUG 30 - SEPT 5	1.39	1.50	4.78
CUTTING DATE MAY 31 - JUNE 6	1.76	1.90	JULY 26 - AUG 1	1.30	1.40	SEPT 6 - 12	1.38	1.70	4.63
CUTTING DATE JUNE 7 - 13	1.95	2.10	JULY 19 - 25	1.20	1.30	AUG 30 - SEPT 5	1.39	1.40	4.45
CUTTING DATE JUNE 7 - 13	1.95	2.10	AUG 2 - 8	1.11	1.20	SEPT 6 - 12	1.39	1.50	4.45
ALFALFA ON MIAHI SOIL YIELD INDEX = .84									
(1)		(2)		(3)		(4)		(5)	
DATES	YIELD	INDEX	DATES	YIELD	INDEX	DATES	YIELD	INDEX	TOTAL
CUTTING DATE MAY 24 - 30	1.07	1.50	JULY 12 - 18	1.14	1.60	AUG 29 - 29	1.07	1.50	3.28
CUTTING DATE MAY 24 - 30	1.07	1.50	JULY 19 - 25	1.07	1.50	AUG 30 - SEPT 5	1.07	1.50	3.21
CUTTING DATE MAY 31 - JUNE 6	1.36	1.90	JULY 19 - 25	1.07	1.50	AUG 30 - SEPT 5	1.21	1.70	3.64
CUTTING DATE MAY 31 - JUNE 6	1.36	1.90	JULY 26 - AUG 1	1.00	1.40	SEPT 6 - 12	1.21	1.70	3.57
CUTTING DATE JUNE 7 - 13	1.58	2.10	JULY 19 - 25	.93	1.30	AUG 30 - SEPT 5	1.08	1.40	3.43
CUTTING DATE JUNE 7 - 13	1.58	2.10	AUG 2 - 8	.84	1.20	SEPT 6 - 12	1.07	1.50	3.43

Table 1. (continued)

FIELD 6		RKLS = 34.69		FIELD 12		RKLS = 13.87			
Tillage	Rotation	Conservation Up & Down	Practice Contour	Values	Tillage	Rotation	Conservation Up & Down	Practice Contour	"C" Value
COOHH									
Conventional		3.50	1.75	.101		COOHH	1.40	0.70	.101
Minimum		2.04	1.02	.059		Conventional	0.82	0.41	.059
No Tillage		1.56	0.78	.045		Minimum	0.62	0.31	.045
OOC									
Conventional		12.14	6.07	.350		OOC	4.85	2.42	.350
Minimum		6.24	3.12	.180		Conventional	2.49	1.24	.180
No Tillage		4.16	2.08	.120		Minimum	1.66	0.83	.120
OOOOH									
Conventional		6.03	3.01	.174		OOOOH	2.41	1.20	.174
Minimum		3.22	1.61	.093		Conventional	1.29	0.64	.093
No Tillage		2.63	1.31	.076		Minimum	1.05	0.53	.076
COOHHH									
Conventional		3.01	1.50	.087		COOHHH	1.20	0.60	.087
Minimum		1.73	0.87	.050		Conventional	0.69	0.35	.050
No Tillage		1.31	0.66	.038		Minimum	0.53	0.26	.038
HHHO									
Conventional		0.31	0.15	.009		HHHO	0.12	0.06	.009
Minimum		0.28	0.14	.008		Conventional	0.11	0.06	.008
No Tillage				0		Minimum			0

APPENDIX 4. MACHINERY BUDGETS

Table 1. Corn Conventional Tillage, 2 Tractors (50 & 70 ph), Up and Down Slope.¹

Operations	Width	Speed	Efficiency	Acres/ Mach.hr.	Man hrs./ Acre	Equip. Cost	Operat. ² Cost/Acre	Variable Cost/Hour
Shred Stalks	120	4.0	85	4.08	.272 ^{1.11} ⁴	730	.28	
Spread P & K, some N (4 tons spreader)				4.00	.310 ^{1.25}	1,500	.26	
Plow 5-16"	80	4.5	77	2.77	.370 ^{1.02}	2,000	.54	1.49
Disk & Spring Tooth	192	4.5	80	6.91	.156 ^{1.08}	2,340	.113	.78
Plant + N (pop up) + insecticide & herbicide banded 6 rows ³	168	4.0	60	4.03	.298 ^{1.20}	2,570	.37	1.49
Cultivate (6 rows) ³	168	3.0	85	4.28	.243 ^{1.04}	1,200	.113	.49
Pick Corn ³	56	3.0	65	1.09	1.020 ^{1.11}	10,400	1.79	1.96
Haul to Crib Wagon	75 bu.				1.020	575	.350	
Tractors 50 & 70 hp.						13,500		
TOTAL				3.70		34,815	3.82	

Table 1. Footnotes

1. References for budgetary information include: (1) Michigan Farm Management Handbook 1971, Agricultural Economics Report No. 191, Department of Agricultural Economics, Michigan State University, May 1971; (2) Willet, G. S., et al., "Cost of Farm Machinery," Revised Extension Circular 589, Department of Agricultural Economics, University of Wisconsin, 1970; (3) Doster, D. H., Unpublished Budgets. "Field Time Labor and Machinery Cost Worksheets, 1972, Purdue University Agricultural Extension, Lafayette, Indiana; (4) Consultations with Ray Hoglund, Professor, Department of Agricultural Economics, Michigan State University.
2. Operating costs per acre include repairs, fuel and grease.
3. Assumes 28" rows.
4. Manhours as a per cent of power hours.

Table 2. Corn Conventional Tillage on the Contour, 2 Tractors (50 & 70 ph)^{1, 2}

Operations	Width	Speed	Efficiency	Acres/ Mach.hr.	Man hrs./ Acre	Operating Cost/Acre	Variable Cost/hour
	<u>Inches</u>	<u>MPH</u>	<u>Per cent</u>				
Shred Stalks 10'	120	4.0	80	3.84	.29	.30	
Spread P & K, Some N 4 ton				3.70	.34	.28	
Plow 5-16"	80	4.5	72	2.59	.39	.57	1.49
Disk & Spring Tooth	192	4.5	75	6.48	.16	.12	.78
Plant + N(pop up) + insecticide & herbi- cide banded (6 rows)	168	4.0	55	3.69	.32	.40	1.49
Cultivate (6 row)	168	3.0	80	4.03	.26	.122	.49
Pick Corn	56	3.0	60	1.00	1.11	1.960	1.96
Haul to Crib self unloading wagon	75 bu.				1.11	.350	
Tractors 50 & 70 hp.							
TOTAL					3.98	4.100	

1. Field efficiency was five per cent less than up and down the slope operations. See conventional tillage with no soil conservation for equipment and materials cost.

2. Refer to footnotes in Table 1.

Table 3. Corn Minimum Tillage, 2 Tractors (50 & 70 hp). Up and Down Slope.¹

Operations	Width	Speed	Efficiency	Acres/ Mach. hr.	Man hrs./ Acre	Equipment Cost	Operating Cost/Acre
	<u>Inches</u>	<u>MPH</u>	<u>Per cent</u>				
Shred stalks 10'	120	4.0	85	4.08	.272 ^{1.11}	730	.28
Spread P & K & some N (4 ton)				4.00	.310	1,500	.26
Chisel plow 12'	144	4.5	80	5.18	.200 ^{1.02}	1,160	.29
Plant + N + Insecticide (6 row)	168	3.5	65	3.82	.314 ^{1.20}	2,570	.39
Complete coverage herbicide 10' drawn	120	5.0	65	3.90	.270 ^{1.25}	520	.28
Cultivate (6 rows)	168	3.0	85	4.28	.243 ^{1.04}	1,200	.113
Pick Corn	56	3.0	65	1.09	1.020 ^{1.11}	10,400	1.79
Haul to Crib Wagon					1.020	575	.35
Tractors 50 & 70 hp.						13,500	
TOTAL					3.64	32,155	3.75

1. Refer to Table 1 footnotes.

Table 4. Corn Minimum Tillage on the Contour, 2 Tractors (50 & 70 hp.)¹

Operations	Width	Speed	Efficiency	Acres/ Mach.hr.	Man hrs./ Acre	Operating Cost/Acre
	<u>Inches</u>	<u>MPH</u>	<u>Per cent</u>			
Shred Stalks 10'	120	4.0	80	3.84	.29	.30
Spread P & K, Some N 4 tons						
Chisel plow 12'	144	4.5	75	3.70	.34	.28
Plant + N + insecticide (6 rows)	168	3.5	60	4.86	.21	.31
Complete coverage herbicide 10' drawn	120	5.0	60	3.52	.33	.40
Cultivate (6 rows)	168	3.0	80	3.60	.35	.31
Pick corn	56	3.0	60	4.03	.26	.122
Haul to crib, self-loading wagon				1.00	1.11	1.960
Tractors 50 & 70 hp.					1.11	.350
TOTAL					4.00	4.03

1. Refer to Table 1 footnotes.

Table 5. Corn No-Tillage, 2 Tractors (50 hp.), Up and Down Slope.¹

Operations	Width	Speed	Efficiency	Acres/ Mach.hr.	Man hrs./ Acre	Equipment Cost	Operating Cost/Acre
	<u>Inches</u>	<u>MPH</u>	<u>Per cent</u>				
Shred stalks 10'	120	4.0	85	4.08	.272 ^{1.11}	730	.28
Knife in NH ₃ 5 Knife				5.46	.198	1,200	.25
General herbicide (non selective killer)	120	5.0	65	3.90	.270 ^{1.25}	520	.27
Spread P & K (4 ton)				4.00	.310	1,500	.26
Plant + N + insecticide (AC no- till)	168	3.0	60	3.02	.397 ^{1.20}	4,000	.49
Pick corn (2 row, 28")	56	3.0	65	1.09	1.020 ^{1.11}	10,400	1.79
Haul to Crib Wagon					1.020	575	.35
Tractors (2-50 hp.)						11,200	
TOTAL					3.45	30,125	3.69

1. Refer to Table 1 footnotes.

Table 6. Corn No-Tillage on the Contour, 2 Tractors (50 hp.)¹

Operations	Width	Speed	Efficiency	Acres/ Mach.hr.	Man hrs./ Acre	Operating Cost/Acre
	<u>Inches</u>	<u>MPH</u>	<u>Per cent</u>			
Shred Stalks 10'	120	4.0	85	3.84	.29	.30
Knife in NH ₃ , 5 knife				5.20	.19	.26
General Herbicide (non-selective killer)	120	5.0	60	3.60	.35	.41
Spread P & K (6 row AC No-Till)				3.70	.34	.28
Plant + N + insecticide (6 row)	168	3.0	55	2.77	.43	.53
Pick corn 2 row-28"	56	3.0	60	1.00	1.11	1.96
Haul to Crib self unloading wagon					1.11	.35
Tractors 2-50 hp.						
TOTAL					3.82	4.09

1. Refer to Table 1 footnotes

Table 7. Oats Conventional Tillage, CCOOH, CCOHH, Up and Down Slope.^{1,2}

Operations	Width	Speed	Efficiency	Acres/ Mach.hr.	Man hrs./ Acre	Equip. Cost	Operating Cost/Acre	Variable Cost/hr.
	<u>Inches</u>	<u>MPH</u>	<u>Per cent</u>					
Shred Stalks 10'	: 120	4.0	85	4.08	.270 ^{1.11}	730	.28	
Spread P & K, N 4 ton	: 144			4.00	.310 ^{1.25}	1,500	.26	
Plow 5-16"	: 80	4.5	77	2.77	.370 ^{1.02}	2,000	.54	1.49
Disk & Spring Tooth 16"	: 192	4.5	80	6.91	.156 ^{1.08}	2,050	.113	.78
Drill 15' 7" oats & alfalfa	: 105	3.5	65	2.39	.500 ^{1.19}	1,100	.48	1.49
Spray insecticide 10' Drawn	: 120	5.0	65	3.90	.270 ^{1.05}	755	.27	1.04
Harvest oatlage SP 11' Windrower	: 132	4.5	75	4.95	.210 ^{1.02}	5,100	.40	1.98
Forage chopper w/for- age pickup	: 132	3.0	60	2.37	.468 ^{1.11}	3,100	.467	1.01
Self unloading wagon hauling	:				.238	1,700	.148	.62
Forage Blower	:				.238	900	.069	.29
TOTAL	:				3.030	18,935	3.030	

1. Tractor costs included in corn budgets.

2. Refer to Table 1 footnotes.

Table 8. Oats Conventional Tillage for Rotations OOOOH, OOOHH and OOOHHH on the Contour.¹

Operations	Width	Speed	Efficiency	Acres	Man hrs./Acre	Operating Cost/Acre	Variable Cost/hour
	<u>Inches</u>	<u>MPH</u>	<u>Per cent</u>				
Shred Stalks 10'	120	3.0	80	3.84	.29	.30	
Spread P & K, N, 4 tons	144			3.70	.34	.28	
Plow 5-16"	80	4.5	72	2.59	.39	.57	1.49
Disk & Spring Tooth 16"	192	4.5	75	6.48	.16	.12	.78
Drill 15' 7" oats & alf.	105	3.5	60	2.20	.54	.68	1.49
Spray insecticide 10' drawn	120	5.0	60	3.60	.29	.29	1.04
Harvest oatlage SP 11' Windrower	132	4.5	75	4.45	.23	.40	1.98
Forage chopper w/ forage pickup	132	3.0	55	2.18	.509 ^{1.11}	.46	1.01
Self unloading wagon hauling					.254	.157	.62
Forage blower					.254	.074	.29
TOTAL					3.26	3.33	

1. Refer to Table 1 footnotes.

Table 9. Alfalfa Up and Down.¹

Operations	Width	Speed	Efficiency	Acres/ Mach.hr.	Man hrs./ Acre	Equipment Cost	Operating Cost/Acre
	<u>Inches</u>	<u>MPH</u>	<u>Per cent</u>				
Plant with Oats							
Spray insecticide 10' drawn	120	5.0	65	3.90	.27 ^{1.05}	520	.28
Spread P & K				4.00	.31	1,500	.26
Harvest 3 cutting							
Windrower 11' SP	132	5.0	80	5.28	.19	5,100	.44
TOTAL					.77	7,120	.98
Bale and stack custom hire	Bale \$.10-12	+ .05 hauling and stacking, assuming 80 lb. bales cost/ton =					
\$3.75 to \$4.25 ton.							

1. Refer to Table 1 footnotes.

Table 10. Alfalfa on the Contour.¹

Operations	Width	Speed	Efficiency	Acres/ Mach.hr.	Man hrs./ Acre	Operating Cost/Acre	Variable Cost/Hour
	<u>Inches</u>	<u>MPH</u>	<u>Per cent</u>				
Plant With Oats							
Spray insecticide 10' drawn	120	5.0	60	3.60	.29	.29	1.04
Spread P & K				3.70	.34	.28	
Harvest 3 cutting Windrower 11' SP	132	5.0	75	4.95	.21	.40	1.98
TOTAL					.84	.97	
Bale & Stack Custom hire Bale \$.10-.12 + .05 hauling & stacking, assuming 80 lb. bales cost/ton = \$3.75 to \$4.25.							

1. Refer to Table 1 footnotes.

APPENDIX 5. FERTILIZER, HERBICIDE, SEED, AND INSECTICIDE COSTS PER ACRE

Table 1. Average Fertilizer Cost per Acre by Rotation and Tillage System.^{1,2,3.}

Tillage	Rotation OOOHH		Rotation OOOHH	
	/5	Price/Lb	/5	Price/Lb.
		Total		Total
<u>Conventional</u>				
N	72	.088	44	.088
K ₂ O	95	.212	135	.212
P ₂ O ₅	50	.052	57	.052
TOTAL		\$29.08		\$35.45
<u>Minimum</u>				
N	72.8	.088	44.8	.088
K ₂ O	96	.212	136.2	.212
P ₂ O ₅	50.8	.052	57.8	.052
TOTAL		\$29.40		\$35.81
<u>No-Tillage</u>				
N	74	.088	46	.088
K ₂ O	98	.212	138	.212
P ₂ O ₅	52	.052	59	.052
TOTAL		\$29.99		\$36.38

CONTINUED...

Table 1 (continued)

Tillage	Rotation /3 Price/Lb.	Total	Rotation /5 Price/Lb.	Total	Rotation /6 Price/Lb.	Total
<u>Conventional</u>						
N	140	\$12.32	8	.088	37	.088
K ₂ O	60	12.72	215	.212	156	.212
P ₂ O ₅	40	2.08	71	.052	60	.052
TOTAL		\$27.12				
				\$49.97		\$39.45
<u>Minimum</u>						
N	140	12.32	8	.088	37.3	.088
K ₂ O	60	12.72	220.2	.212	156.8	.212
P ₂ O ₅	40	2.08	72.5	.052	60.6	.052
TOTAL		\$27.12				
				\$51.15		\$39.67
<u>No-Tillage</u>						
N	140	12.32	8	.088	38.3	.088
K ₂ O	60	12.72	228	.212	158.3	.212
P ₂ O ₅	40	2.08	74.7	.052	61.6	.052
TOTAL		\$27.12				
				\$52.92		\$40.13

1. For minimum tillage and no-tillage 10 and 25 per cent more fertilizer, respectively, were used in the year following sod.
2. Fertilizer recommendations were taken from the Ohio Agronomy Guide 1972-73. Yield levels assumed by crop are: corn: 100-130 bu.; oatlage: 9.3-12.2 tons; and alfalfa 4.5-6 tons per acre.
3. The procedure for calculating fertilizer cost per acre is illustrated below.* Requirements for nitrogen, potassium and phosphorus were determined for each crop and converted to a rotation according to the following example for conventional tillage.

Table 1. (Continuation of Footnote 3.)

<u>Pounds by Element</u>	<u>C</u>	<u>C</u>	<u>C</u>	<u>O</u>	<u>H</u>	<u>/5</u>	<u>Price/Lb.</u>	<u>Average Cost/Acre</u>
N	40	140	140	40	0	360	.088	\$ 6.34
K ₂ O	60	60	60	35	260	475	.212	20.14
P ₂ O ₅	40	40	40	55	75	250	.052	<u>2.60</u>
							<u>TOTAL</u>	<u>\$ 29.08</u>

Table 2. Herbicides.¹

Crop	:	Herbicide	
	:	Amount per Acre	Cost per Acre
	:	:	:
Conventional Tillage Corn	:	3 lbs. Atrazine	\$ 6.25
Minimum Tillage Corn	:	2 lbs. Atrazine	\$10.50
	:	2 qts. Lasso	
No-Tillage Corn	:	1 pt. Paraquat	\$10.75
	:	0.2 oz. X77	
	:	2 lbs. Atrazine	
Oats (legume sown)	:	2-4 D Amine	\$.34
	:		

1. Reference: Warren Cook, Eaton County Michigan Extension Director, July 10, 1973.

Table 3. Seed Costs per Acre for Corn, Oats, and Alfalfa.

	CORN		OATS		ALFALFA	
	Conventional Tillage	Minimum No- Tillage	Conventional Tillage	Rotation	Conventional 2, 3. Tillage	
Lbs. seed (56 lb. bu)	10	11	12	OOOOH	10	cost/ acre
				OOHH	10	\$ 6.95
				OOHHH	10	3.47
Cost/Lb.	\$.215	\$.215	\$.215	OOHHH	10	2.32
Seed Cost/ Acre	\$2.15	\$2.36	\$2.58	HHH	10	2.32

1. Assume: 16,000 plants per acre, 15% germination loss; hence 18,400 seeds/acre @ 1,800 seeds/lb.

18,400/1,800 = 10.2 lbs./acre Conventional Tillage
 11 lbs./acre Minimum Tillage + .075%
 12 lbs./acre No-Tillage + .15%

2. Seed cost/lb. \$.695, Michigan Farm Management Handbook, 1971 Agricultural Economic Report No. 191, pg. 45.

3. Higher seeding rates will not make up for poor seedbed preparation.

References: "Seeding Practices for Michigan Crops," Extension Bulletin 489, Cooperative Extension Service, Michigan State University, March 1965.

"Seeding Rates of Alfalfa," M. B. Tesar, Department of Crop and Soil Sciences, Michigan State University, File 22.215, March 14, 1972.

Table 4. Insecticide.¹

Crop/Insect	Chemical	Application Rate/Acre	Cost/Acre
Com ²			
Rootworm	FURADAN (Granules)	1.07	\$ 4.83
Alfalfa			
Weevil	METHOXYCHLOR (Spray)	1.25	\$ 2.22
Oats			
Cereal Leaf Beetle	MELATHION (Spray)	1.00	\$ 1.54

1. Reference: Robert F. Ruppel, "Insecticide Costs for Alfalfa Weevil, Cereal Leaf Beetle and Com Rootworm Control in Michigan," Department of Entomology, Michigan State University, June 16, 1972.

2. 28" Rows.

APPENDIX 6. FEED REQUIREMENTS

Table 1. Dairy Feed Requirements.

	Number of Head	Feed Require- ments	Alfalfa Ration	Alfalfa tons/yr.	Oatlage Ration	Oats ton/yr.	Corn Cob Mean Ration	Corn Cob Meal
		lbs./day	per cent	tons/yr.	per cent	ton/yr.	per cent	tons
<u>Milking Cows</u>								
41 lbs milk/day	78	44.5	68	360	0	0	32	169
47 lbs milk/day	78	47.6	56	317	0	0	44	249
54 lbs milk/day	78	50.2	47	281	0	0	54	322
90 days dry	78	38.8	84	114	0	0	16	21
<u>Replacement Heifers</u>								
1,000 lbs heifers	12	31.2	43	29	20	14	37	25
750 lbs heifers	15	27.6	23	17	20	15	57	43
350 lbs heifers	10	11.8	0	0	23	5.0	77	16

1. Feed requirements by class are calculated as follows:

(No. head) x (feed req'ts./day) x (% feed X) x (No. days) / 2,000 = tons feed/ period/ class;

Bu. Corn Cob Meal = tons (2,000)/70.