AN ECONOMIC EVALUATION OF SOIL TILLAGE TECHNOLOGIES

SUMMARY REPORT

Prepared for:

Agriculture Canada

By:

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EXECUTIVE SUMMARY

This report summarizes the key issues, findings and conclusions of the economic evaluation of soil tillage technologies. Details of the findings reported here are presented in six supporting documents.

It has been demonstrated that soil conserving tillage technologies are profitable to use from both a farm field and watershed level. In addition to these farm related benefits, downstream activities (e.g. water conveyance) would be positively impacted with a reduction in soil loss, ranging from $3.00 to $12.00 per hectare of cropped farm land.

This report examines issues and options for promoting greater farmer adoption rates of reduced tillage technologies.

1.0 INTRODUCTION

Agricultural production is undergoing fundamental changes in an effort to comply with new policy directives regarding *sustainable agricultural development.* This means that farmers are faced with the task of managing Canada's agricultural resources (i.e. soil and water) with two inter-related objectives in mind:

1) To obtain abundant and high quality yields, and

2) To assure continuing sustainable ecological benefits from soil and water.

Although the concept of sustainable agriculture is not new to farmers, there is a sense of urgency driving the adoption of new farming techniques/practices which conserve soil and prevent the degradation of watercourses. To this end, a five year program was initiated by Agriculture Canada to investigate strategies and technologies for reducing soil loss and phosphate run-off in Southwestern Ontario, known as the *Southwestern Ontario Soil and Water Environmental Enhancement Program (SWEEP).* This program is near completion and is comprised of two sub-programs:

- Technology Evaluation and Development (TED), and
- Pilot Watershed Study (PWS).

The purpose of the TED sub-program is to develop and test a range of soil conserving and water quality enhancement technologies that could be used throughout Ontario in various cropping situations. Experiments conducted under this sub-program were based on small plots and were highly technical in nature.

The purpose of the Pilot Watershed Study (PWS) sub-program was to implement a variety of appropriate soil conserving technologies on all fields within three test watersheds and compare the soil movement and run-off from these watersheds to three nearby control watersheds (i.e. watersheds where soil conserving technologies were not applied). The focus of this sub-program was to provide a demonstration of how the adoption of soil conserving technologies work in achieving their goal in terms of reduction in soil loss and enhancement of water quality.

Previous to the PWS program, the Ontario Ministry of Agriculture and Food (OMAF) as part of SWEEP was involved in testing and demonstrating alternative tillage practices in a series of side-by-side experiments on selected participating farmers' fields. This program, called Tillage 2000, compared conventional tillage practices to reduced and no-till field operations.

Deloitte & Touche Management Consultants (formerly Deloitte Haskins & Sells)was asked to assess the economic implications of adopting soil conserving technologies based on the results of both the PWS and Tillage 2000 programs. The economic evaluation was to provide an assessment of the economic impact on participating farmers (at both a field and watershed level) and to assess the downstream macro-economic impact associated with reduced soil loss.

The rationale for the economic evaluation was three-fold:

1) To provide a source of information from which farmers can evaluate the potential economic benefits from adopting alternative cropping practices in their farming situation;

2) To provide background information for researchers, extension personnel and other organizations in evaluating and presenting the merits of soil and water conserving technology adoption to the farming and general public; and

3) To provide background management information to program administrators within all levels of government who are responsible for agricultural production policies and the determination of assistance programs to farmers to facilitate the adoption process of soil and water conserving technologies, where needed.

1.1 PURPOSE OF THE STUDY

The overall purpose of this study was to provide an economic evaluation of soil tillage technologies tested within the SWEEP program. To this end a number of specific questions were addressed as follows:

- Does it pay to use soil conserving tillage technologies from a farmer's perspective, considering field cropping activities only?
- Does it pay to use soil conserving tillage technologies from a watershed perspective, considering the whole farm impact?
- What is the financial risk associated with alternative tillage technologies and other soil conserving techniques?
- What is the tradeoff between net farm income and soil loss?
- What is the possible downstream impact associated with reduced soil loss and phosphorus loading at the watershed level?
- How are farm-related sectors impacted following the introduction of soil conserving technologies:
    - Farm input suppliers
    - Crop or livestock processors

- ! What is the impact of soil conservation tillage practices on local communities within close proximity to sub-watersheds, and on respective whole watershed basins?
- ! What are possible policy implications for introducing soil conservation tillage technologies?
- ! What is the distribution of costs and benefits between producers, consumers, taxpayers and society generally? and
- ! What are possible incentives or compensation plans for stimulating the adoption of appropriate soil and water conserving technologies?

1.2 SCOPE OF STUDY

This study deals with the economic benefits associated with the introduction of soil conserving tillage technologies on three pilot demonstration watersheds in southwestern Ontario, located in the Kettle Creek, Pittock, and Essex watershed areas. Each watershed was divided into two areas. In one area soil and water conserving technologies were applied on all fields while in the other area conventional cropping practices were maintained. Field input and output data were monitored for each of the paired watersheds covering three cropping years, 1989 to 1991.

This study investigates the impact of alternative tillage practices. It also assesses the economic consequences of other soil and/or water conservation technologies such as the introduction of field structures (e.g. grassed waterways).

In addition to the PDW watersheds, results of the Tillage 2000 program, conducted by OMAF from 1986 to 1990, were incorporated into the field level economic analysis.

With respect to the downstream macro-economic impact assessment, this study discusses the impact from a conceptual perspective only. Soil loss measures used in the three paired demonstration watersheds do not provide any estimate about soil loss or phosphorous loading within the whole watershed basins contained in southern Ontario. The downstream impact associated with soil loss is a function of two elements:

- The degree of change in tillage practices with the associated impact on soil loss within micro-basins, and

- The size of the total area affected.

1.3 ORGANIZATION OF REPORTING

The results and discussion of this study are presented in seven volumes. Volume one (this document) is a summary report which provides an overview of the salient issues, results and discussion associated with the introduction of soil conserving tillage technologies in southwestern Ontario. Volumes two through seven are technical documents which describe all models used, details all simulation results, and provides background data and information required to support the discussion and conclusions presented in the summary document(volume one).

This summary report is comprised of six sections, as illustrated in Figure 1.1. The first major section (Section 2.0) provides an overview of the approach and methodology for each of the analytical components. This section describes the relationship among changes in the field, watershed and downstream that are associated with soil conserving tillage technologies, and illustrates how these various sets of information are used in assessing the net social impact and subsequent policy implications. This section concludes with a discussion of the field data used for this study, and in particular the data derived from the PWS program.

Section 3.0 presents an overview of the field level economic analysis, comparing conventional, reduced tillage and no-tillage cropping practices. The purpose is to report on whether soil conserving tillage technologies generate higher net returns relative to conventional practices, and whether the financial risk associated with conservation practices is more variable. This section of the report relates only to field level comparisons.

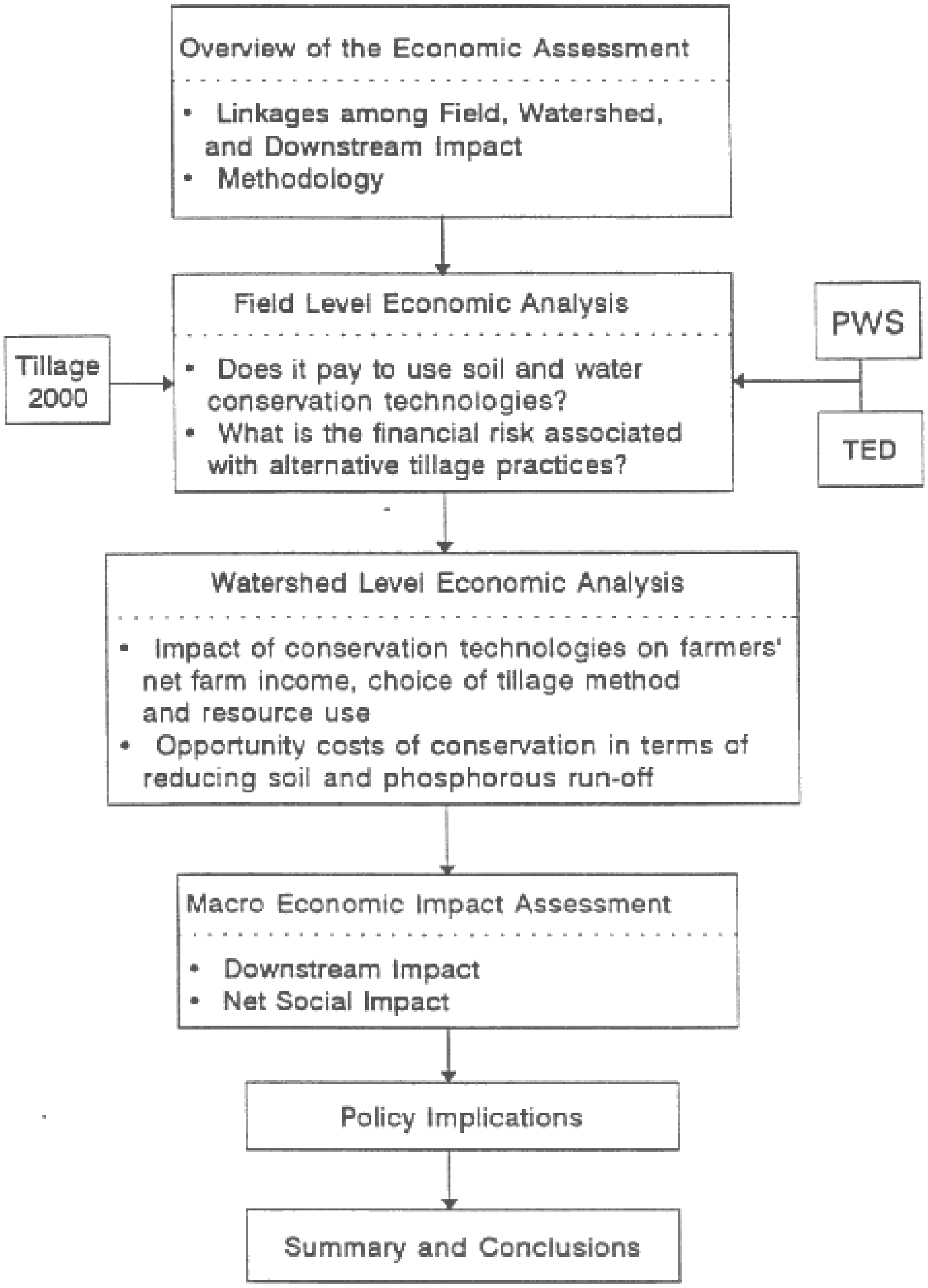
The optimization of farming practices and associated economic implications at the watershed level are presented in Section 4.0. The analysis and discussion addresses the trade-off between soil loss and net farm income at this aggregate level. Two issues are discussed in this regard:

! The impact of conservation tillage technologies on farmers' net farm income, choice of tillage method and resource use, and

! The opportunity cost of conservation in terms of reducing soil and phosphorus run-off.

Section 5.0 provides a conceptual overview of the macro-economic impact from a number of perspectives:

Figure 1.1 Outline of the Report and Issues Addressed



- The impact on the farm input supply sector resulting from the adoption of soil conservation tillage practices at a watershed level;

- The impact on commodity output sectors resulting from prospective changes in crop rotations, crop output, and livestock output levels at a watershed level;

- The impact of soil conservation tillage practices on:

    - Local communities within or surrounding the study watershed, and
    - The "conservation authority" in general; and

- The impact on downstream activities affected by reduced soil and/or phosphorus loading.

This section concludes by drawing together the economic information from previous chapters to determine the net social cost or benefit from introducing soil conserving tillage technologies. The policy implications associated with the above economic analysis are the topic of Section 6.0. A recommended strategy for increasing the adoption of soil conservation tillage practices is outlined in section 7.0. The final section (8.0) provides a general summary and conclusion.

Within each of the above sections, references will be made to specific technical reports contained in the volumes two through seven of this series. Each of these technical reports (presented as independent volumes) detail the methodology and results of respective analyses. The order of presentation for the technical reports will be as follows:

Volume Two: Collection and Analysis of Field Data From PWS

Volume Three: Field Level Economic Analysis of Changing Tillage Practices in Southwestern Ontario

Volume Four: An Economic Evaluation of the Tillage 2000 Program in Ontario

Volume Five: An Economic Assessment of the Technology Evaluation Development (TED) Program

Volume Six: Watershed Level Economic Analysis of Tillage Practices in Southwestern Ontario

Volume Seven: Macro-Economic Impact Associated With Soil Conserving Technologies

2.0 APPROACH AND METHODS

This chapter outlines the steps involved in assessing the economics of soil and water conservation technologies conducted under the SWEEP program. A general description of the overall methodology is presented.

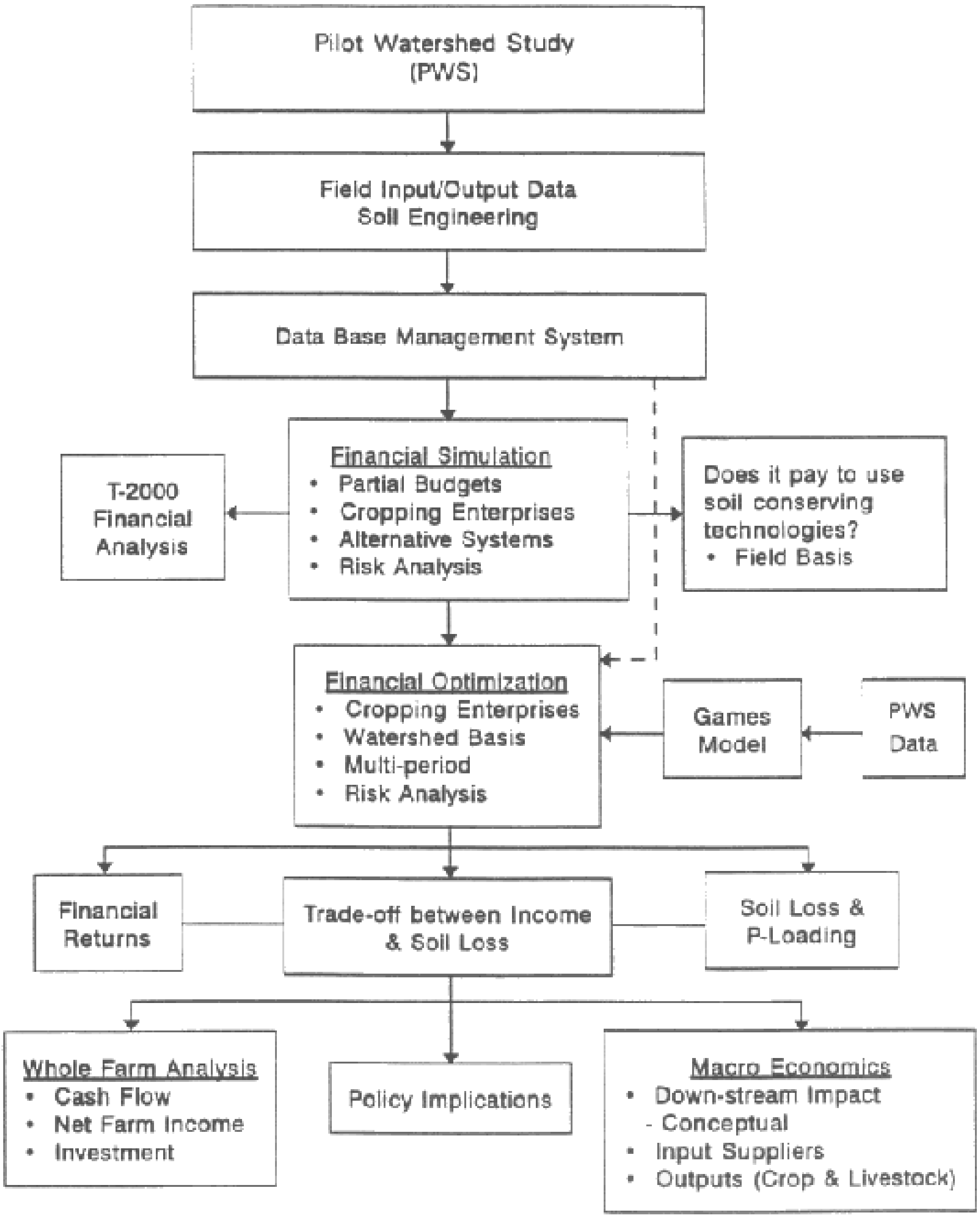
2.1 DEVELOPMENT OF THE OVERALL METHODOLOGY

The methodology for this assignment was originally planned according to the format presented in Figure 2.1. Our approach to the assignment was driven by our expectations of what would be generated from the field input/output data within the pilot watershed study (PWS) program. Essentially, this field data was to provide information regarding cropping practices (e.g. crop rotations, types of operations performed), inputs (e.g. labour, materials, equipment), and outputs (i.e. yields), by field within each of the three paired watersheds. This information was collected and organized/synthesized within a data base management program (DBase IV).

Output of the data base would be used directly in the field level economic assessment (financial simulation) to determine the net returns to alternative conservative technologies/practices. The data base would also be used indirectly to support the watershed level economic assessment (financial optimization).

Both the financial simulation and financial optimization components provide necessary information in determining the trade-off between net farm income and soil loss. Policy implications relating to the adoption of conservation practices could then be assessed in light of the preceding results.

Figure 2.1 Initial Methodology for Assessing the Economics of Soil and Water Quality Conservation Technologies



An integral component of the economic analysis involved an assessment of the broader social impact as related to: downstream impact, input suppliers, and farm outputs.

The main driver of the entire analysis was the PWS field input/output data. However, as the data were being organized and put in the data base management system, it became evident that some portions of the PWS data were inaccurate or missing, and could not be verified with the PDW contractor or the cooperating farmers. Specifically, it was not possible to determine the number of operations performed, the inputs used, or the yields within each of the paired watersheds. Details of how the data were organized, analyzed and evaluated are discussed later in this chapter. The important issue was that we could not rely solely on the PWS data base for our economic analysis.

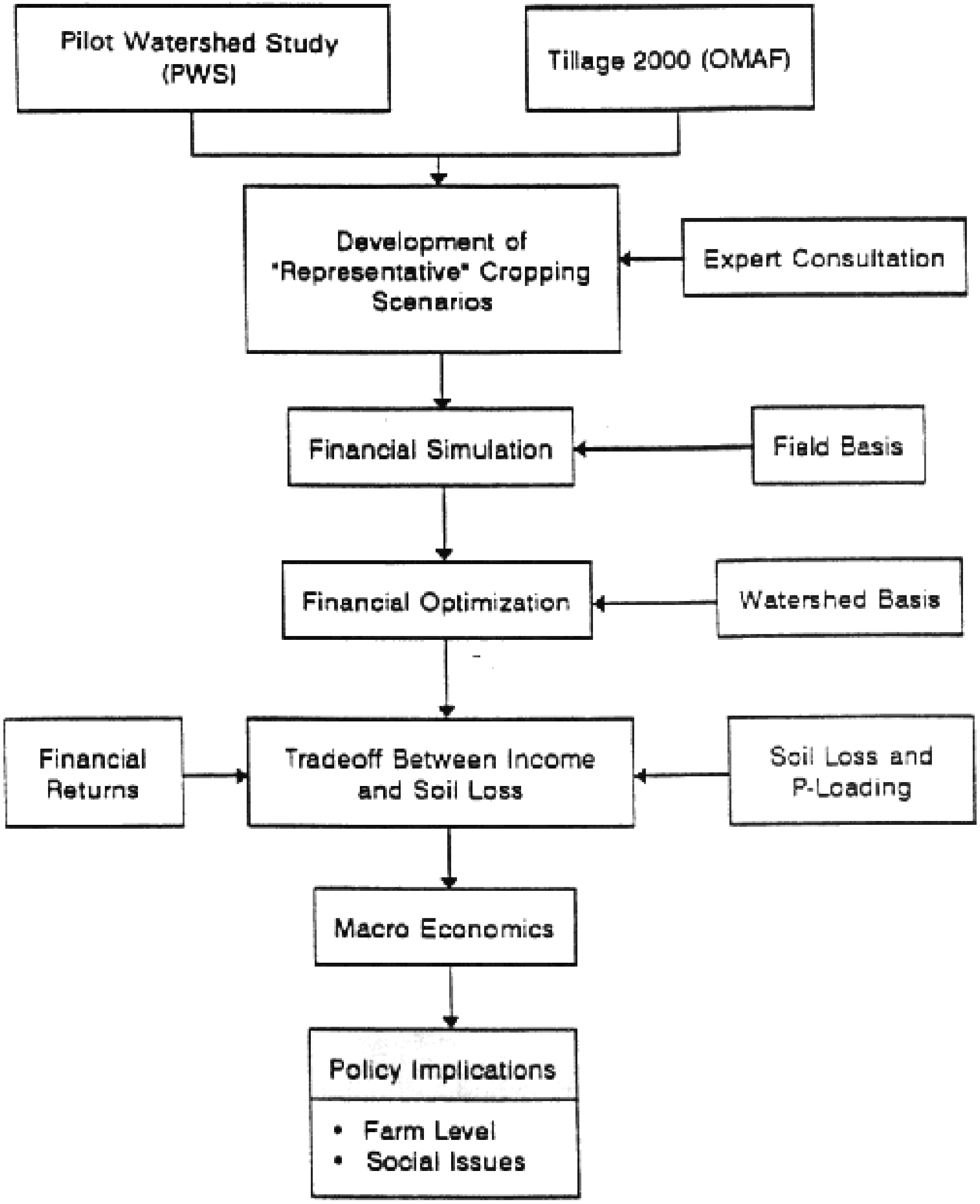
Consequently, the methodological approach was revised (Figure 2.2). Essentially, we opted to develop "representative" cropping scenarios for each of the following three tillage practices/systems:

- Conventional tillage,
- Reduced tillage, and
- No-Tillage.

Cropping scenarios were also delineated for four crop rotations and specific to the characteristics of each watershed:

- Corn following corn,
- Corn following "other" crops,
- Soybeans following corn, and
- Wheat following soybeans.

Figure 2.2 Revised Methodology for Assessing the Economics of Soil and Water Quality Conservation Technologies



In total, eleven representative cropping scenarios were developed (a corn following corn rotation was not developed for the Essex watershed), which included details of:

- Operations performed,
- Materials used,
- Time to complete operations, and
- Yields.

The development of the cropping scenarios was based on a combination of three information sources:

- Output from the PWS data base,
- Input/output data and results of Tillage 2000, and
- Consultations with selected experts involved in each of the above programs.

Details of representative cropping scenarios developed for this study are discussed in Section 3.0. Given that the analysis is driven by representative case scenarios, all subsequent components of the analysis could proceed as previously planned. The specific methodologies used in analysis are highlighted in the following sections.

2.2 FINANCIAL SIMULATION - FIELD LEVEL ANALYSIS

The financial simulation of the field level impact associated with alternative tillage practices was conducted using a partial budgeting approach within a spreadsheet framework. The objective of the partial budget was to estimate the net revenue (revenue minus total costs of production), the operating margin(revenue minus material costs only), and the opportunity cost of labour - alternatively the net return to labour (net revenue divided by the total hours for all operations).

Costs of conducting specific operations were based on the average custom farm work rates in Ontario published by OMAF (1991). The use of average custom rates was necessitated by the lack of comparable data from the PWS data base.

Estimates of the time required to complete various field operations were derived from the Tillage 2000 data base (see Volume 4 of this report series).

The list of materials used and the associated average rates of application within operations were derived from the PWS data base, as was the basic description of field operations for selected PWS participants [1].

Crop yield data were derived from a combination of three sources:

- Tillage 2000,
- Weersink et al. (Forthcoming), and
- OMAF Publication 20 (1991).

A risk analysis associated with expected variations in crop yields was previously conducted utilizing the Tillage 2000 data base (Volume IV - An Economic Evaluation of the Tillage 2000 Program). The results of this analysis for corn are presented in the next chapter. The financial risk assessment involved the use of a Monte Carlo simulation approach for estimating the 90 percent confidence range of expected net returns per hectare under each of the three

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[1] Data drawn from the PWS data base were derived from cooperators evaluated by watershed technicians as having the highest reliability in completing data input sheets with the greatest accuracy.

tillage practices. The analysis was conducted separately from the above financial simulation exercise.

2.3 FINANCIAL OPTIMIZATION - WATERSHED LEVEL ANALYSIS

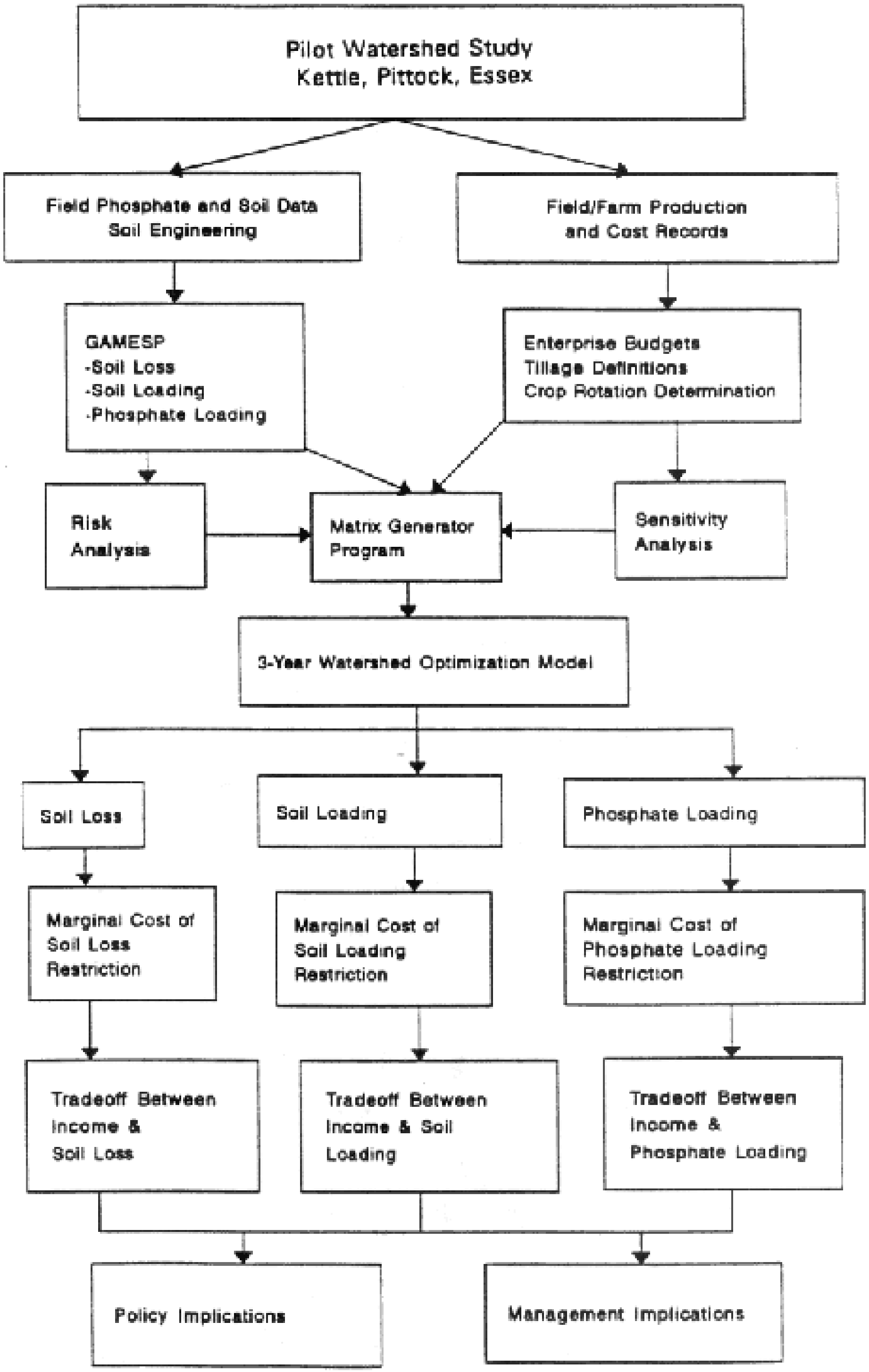
The method of analysis for the financial optimization involves two steps (Figure 2.3). The first step obtains primary data for each of the three paired watersheds. These data include soil engineering data and production/economic data; as well as estimates of soil loading, soil loss, and phosphate loading, which were obtained using GAMESP, a simulation model. The second step is to optimize among competing tillage technologies and crop rotations under various environmental quality constraints using a multi-period linear program.

Data requirements are broken down into 2 categories. Economic data relate to prices, yields and costs of alternative tillage practices and crop rotations (derived from the output of the field level financial simulation), while engineering and environmental data relate to the input requirements for the GAMESP simulation model, and the watershed linear program.

2.3.1 GamesP Simulation

For simulating soil and phosphorous loading and soil loss each watershed was broken down into 365 field size cells each with a unique slope and erosion factor. The average cell size within watersheds is about 1.3 hectares. Soil loading quantities (tonnes/ha.), phosphate loading quantities (kg/ha.) and soil loss quantities (tonnes/ha.) were obtained from the GAMESP Model (Guelph Model for Evaluating Effects of Agricultural Management Systems on erosion and sedimentation with phosphorous component) which describes and predicts soil loss by fluvial erosion and the delivery of soil and phosphates from field to stream using the universal soil loss equation (USLE). The USLE computes soil loss per unit area

Figure 2.3 Methodology for Assessing the Watershed Level Economic Impact



over a specified time. Estimates of soil and phosphate loading into surface water are obtained using a delivery ratio function. Soil loss is predicted on rainfall, soil erosion factors, steepness of the slope in the field and length of slope, crop grown, and crop management (i.e. tillage) practice. In this study all factors except the crop 'C' factor and Manning's 'N' for tillage practice are held constant for each cell in the watershed. The USLE 'C' factors and Manning's 'N' were determined specifically for this exercise. The USLE rainfall factor was 95. In addition, GAMESP simulations were run for USLE rainfall factors of 85 and 105, to measure the result's sensitivity to weather risk.

2.3.2 Linear Program

A 3-period profit maximizing linear program was constructed using the economic data and the simulated GAMESP results. The objective was to maximize the 3-year profits subject to environmental quality constraints. The decision variables were to choose either of 4 rotations under a conventional or no-till technology. Each cell in the watershed was treated as a separate field so that any solution was available to it. However, once a rotation was selected in year 1 there was no recourse in changing rotations for subsequent periods. For example, if a particular cell was planted to soybeans in the first year of a corn-soybean-corn rotation then corn would have to be grown on that same area in period 2 and soybeans again in period 3. Since corn was included in each rotation it was assumed in all cases that the crop preceding the choice of rotation in year 1 was corn. Furthermore since optimization permitted growing any crop or rotation on each cell, the procedure permitted a remedial targeting strategy to be investigated. Remedial targeting implies that conservation practices are applied first to the most erosive areas in the watershed.

From the optimum solution, restrictions were imposed on each of the 3 environmental factors by reducing the amount of effluent in increments of 5%, to a minimum total effluent discharge equal to 40% of the unconstrained maximum. This assumes mutually exclusive restrictions on the environmental quality constraints. However, it may be that multiple restrictions are imposed on tillage practices. For example phosphate loading and soil loss may be treated by different legislations with one limiting phosphate loading and the other limiting soil loss: The policies are not mutually exclusive and as a consequence marginal costs may increase due to multiple constraints.

To investigate these joint relationships the optimization model was run for multiple restrictions by holding 2 constraints constant while varying the third in parametric progression. Soil loss, and soil and phosphate loading were investigated through successive parameterization of the constraint limits from 100% to 40% in increments of 10%. In all, 216 additional linear programs covering all combinations of constraints (6x6x6) were run. In essence the marginal cost structure of contiguous environmental policies obey the law of the minimum whereby the greatest opportunity costs accrue to the most restrictive constraint: Restrictions on 1 level of effluent become passive as increased restrictions on another level of effluent emerge and becomes most limiting. These results suggest that multiple goal strategies for single watersheds may not be effective. Rather, establishing a single standard for the effluent deemed most important in terms of social costs would likely be the more effective policy. In targeting a single effluent, (e.g. soil loss, or soil/phosphate loading) the results from this research indicate that the remaining effluents would also be incrementally reduced.

2.4 THE PWS DATA BASE

The focus of the PWS data collection activity and analysis is the field diary book, which was designed to capture the details of every operation conducted by farm cooperators within each of the paired watersheds. Deloitte & Touche was not responsible for the data collection activity. We provided advice on data needs for the economic analysis.

Farm cooperators were asked to complete a separate field book for each of their fields in the test and control watersheds. Generally, cooperators understood what was required of them in this regard and completed their field books. However, the quality of the data supplied was poor in most cases. A sample of problems associated with the PWS data base is as follows:

! Some cooperators attempted to convey information regarding six or more operations on one data sheet that was designed for one operation at a time - this lead to great difficulty in sorting out operations by date and matching them with appropriate machinery and materials;

! Many indicated the materials used, but no estimate for the rate of application was provided;

! While a particular field operation was indicated, there was nothing in their machinery list to indicate what tractor or implement was used;

! Some operations were reported to have occurred on the same day in the same field which makes no sense. For example, it is not logical that a row cultivation would be performed in the same field as crop seeding on the same day, or the mix of operations in the same field was clearly delineated; and

! There were many other missing pieces of data from virtually all field records.

Although Deloitte & Touche undertook an exhaustive data entry and cleaning exercise in an effort to rectify these and other data shortcomings, the general results of the PWS data base remained very unreliable. In a large number of cases, the person entering the data had exercised judgements that injected an element of subjectivity into the data. This was impossible to avoid because the data entry process for this analysis was so isolated from the data recording process in the field. Those entering data had access to the farm cooperators only through field technicians. Slow turn-around of completed booklets made it impossible to identify problems and get back to cooperators in a reasonable length of time, when corrections could be made. In addition, there was no opportunity to print out detailed reports and return them to cooperators for verification. If this were done, many of the problems cited above could have been avoided. Details of the PWS data recording and analysis are presented in Volume two.

As previously described, these problems with the PWS data base prompted us to revise our initial approach and establish "representative" cropping scenarios upon which the economic analysis could be based.

3.0 FIELD LEVEL ECONOMIC ANALYSIS

This section discusses the economics of alternative tillage practices as tested in southwestern Ontario under a combination of programs conducted within SWEEP and Tillage 2000, from a field level perspective only. The results of this analysis clearly indicates that the net financial returns from soil conserving technologies are higher than from conventional tillage practices for corn and wheat, and potentially soybeans. In addition, the financial risk (i.e. variability in crop yield response) associated with soil conservation is equivalent to conventional tillage practices, based on a detailed analysis of corn production. This section describes the categories of tillage practices tested, and reports on results for each of the three watersheds within the pilot watershed study (PWS) program of SWEEP.

This section is intended to highlight key issues and findings, which are detailed in two separate volumes:

- ! Volume 3 Field Level Economic Analysis of Alternative Tillage Practices in Southwestern Ontario, and
- ! Volume 4 An Economic Evaluation of the Tillage 2000 Program in Ontario (1986-89).

3.1 FIELD OPERATIONS

Field operations utilizing various regimes of tillage were classified under one of the following three general practices:

! Conventional Tillage ! Reduced Tillage ! No-Tillage

Tillage practices are generally differentiated by primary tillage operations and crop residue. Conventional tillage typically involves mouldboard ploughing, which completely overturns the soil leaving little crop residue. Conservation tillage methods only partially overturn the soil leaving some degree of crop residue and include reduced and no-tillage practices. No-till practices, as the name implies, involves no primary or secondary tillage, leaving the maximum amount of crop residue. Reduced tillage systems typically involve chisel ploughing, but was defined as a "catch-all" category in this analysis encompassing everything between the two extremes of conventional and no-till.

Typical sets of operations for each of these three tillage practices were identified for each of the PWS watersheds. Field operations within four crop rotations were finalized through consultation with selected OMAF and PWS personnel. The field operations determined to best typify practices under each tillage practice are identified in Table 3.1 for each watershed.

3.2 FINANCIAL RETURNS TO ALTERNATIVE TILLAGE PRACTICES

The analysis of net returns per hectare was conducted separately using yield data derived from three sources, namely; Tillage 2000, Weersink et al. (forthcoming), and OMAF (1992). The financial results using Tillage 2000 unpaired data are presented in this summary, while, the results using other yield estimates are detailed in volume two Chapter B. These yield data were considered appropriate for this analysis because the data were derived from the same regions as the PWS watersheds and represent average yields over 5 years.

Table 3.1 Description of Typical Field Operations in the Kettle, Pittock and Essex Watersheds

OPERATIONS FOR VARIOUS ROTATIONS FOR KETTLE CREEK WATERSHED						
ROTATION	TILLAGE METHOD					
	CONVENTIONAL		REDUCED		NO-TILL.-	
Corn after corn	Fall:	Moldboard plow	Fall:	Chiselplow	Fall:	
	Spring:	2 Cultivations Plant Spray Fertilize Row cultivate Combine	Spring:	2 Cultivations Plant Spray Fertilize Row cultivate Combine	Spring:	Spray No-Till planter Spray Fertilize Combine
Corn after other	Fall:	Moldboard plow	Fall	Chisel plow	Fall:	
	Spring:	Cultivate Incorporate Plant Spray Fertilize Row cultivate Combine	Spring:	Cultivate Incorporate Plant Spray Fertilize Row cultivate Combine	Spring:	Spray No-Till planter Spray Fertilize Combine
Soy after corn	Fall:	Moldboard plow	Fall	Chisel plow	Fall:	
	Spring:	Cultivate Incorporate Plant Spray Fertilize Row cultivate Combine	Spring:	Cultivate Incorporate Plant Spray Fertilize Row cultivate Combine	Spring:	Spray No-Till planter Spray Combine
Wheat after soy	Fall:	2 cultivations Plant	Fall:	Cultivate Plant	Fall:	No-till drill
	Spring:	Fertilize w/ clover Combine	Spring:	Fertilize w/ clover Combine	Spring:	Fertilize w/ clover Combine

OPERATIONS FOR VARIOUS ROTATIONS FOR PITTOCK WATERSHED						
ROTATION	TILLAGE METHOD					
	CONVENTIONAL		REDUCED		NO-TILL	
Corn after corn	Fall:	Moldlboard plow	Fall:		Fall:	
	Spring:	Cultivate Spray/Fertilize Cultivate Plant Spray Combine	Spring:	Cultivate Spray/Fertilize Cultivate Plant Spray Combine	Spring:	Spray No-till planter Spray Fertilize Combine
Corn after other	Fall:	Moldlboard plow	Fall:		Fall:	
	Spring:	Cultivate Spray/Fertilize Cultivate Plant Spray Row cultivate Combine	Spring:	Cultivate Spray/Fertilize Cultivate Plant Spray Row cultivate Combine	Spring:	Spray No-till planter Spray Fertilize Combine
Soy after corn	Fall:	Moldlboard plow	Fall:		Fall:	
	Spring:	Disc Cultivate Incorporate Plant Spray Row cultivate Combine	Spring:	Disc Cultivate Incorporate Plant Spray Row cultivate Combine	Spring:	Spray Spray No-till planter Spray Combine
Wheat after soy	Fall:	Moldlboard plow Cultivate Plant	Fall:	Chisel plow Cultivate Plant	Fall:	No-till drill
	Spring:	Fertilize w/ clover Combine	Spring:	Fertilize w/ clover Combine	Spring:	Fertilize w/ clover Combine

OPERATIONS FOR VARIOUS ROTATIONS FOR ESSEX WATERSHED						
	TILL.AGE METHOD					
ROTATION	CONVENTIONAL		REDUCED		NO- TILL	
Corn after other	Fall:	Moldboard plow	Fall:	Disc	Fall:	
	Spring:	Cultivate Incorporate Plant Fertilize Row cultivate Combine	Spring:	Cultivate Incorporate Plant Fertilize Row cultivate Combine	Spring:	Spray No-till planter Spray Fertilize Combine
Soy after other	Fall:	Moldlboard plow	Fall	Chisel plow	Fall:	
	Spring:	Disc Cultivate Incorporate Plant Spray Row cultivate Combine	Spring:	Cultivate Incorporate Plant Spray Row cultivate Combine	Spring:	Spray Spray No-till planter Spray Combine
Wheat after soy	Fall:	Disc Fertilize Cultivate Plant	Fall:	Fertilize Cultivate Plant	Fall:	Fertilize No-till drill
	Spring:	Fertilize w/ clover Combine	Spring:	Fertilize w/ clover Combine	Spring:	Fertilize w/ clover Combine

3.2.1 Net Returns Per Hectare/Per Hour

The results of the analysis of net financial returns per hectare and per labour hour for conventional, reduced and no-tillage practices within three watershedsare summarized in Table 3.2, and graphically illustrated in Figure 3.1.

Corn Following Corn

For this rotation, the net returns per hectare from either reduced or no-tillage systems are roughly equivalent to the returns from conventional tillage practices (Figure 3a). However, when considering the net returns to labour, both reduced and no-tillage practices exceed conventional practices, by between $20 to $80 in the Kettle and Pittock watersheds. Continuous corn rotations are not common in the Essex watershed.

Corn Following Other

No-tillage practices generate marginally higher net returns per hectare relative to either reduced or conventional practices, by between $20 to $40 per hectare (Figure 3b). When considering the net returns to labour, both reduced and no-tillage practices were higher compared to conventional tillage practices by a wide margin ranging from $20 to $110, across all three watersheds.

Soybeans Following Corn

Conventional tillage practices in this rotation generate the highest net returns per hectare. Net returns, however, are only a small margin higher in both the Pittock and Essex watersheds, where soybean production is more predominate (Figure 3c). When considering the net returns to labour, all three tillage practices are roughly equivalent across all three watersheds, which makes the use of soil conserving technologies very competitive in this rotation.

Table 3.2 Net Returns From Alternative Tillage Systems in Southwestern Ontario

Crop Rotation & Cost/Return Categories	($/Hectare) Watershed								
	Kettle			Pittock			Essex		
	A	B	*C*	A	B	*C*	A	B	C
Corn Following Corn:									
Costs:									
Field Operations	237	229	170	220	181	178			
Materials	301	301	334	326	326	329			
Yield[1] (t/Ha)	8.3	7.9	8.0	8.4	8.0	8.1	N.A.	N.A.	N.A.
Net Return	365	335	369	366	366	375			
Net Return/Hour ($/Hr)	109	128	194	109	140	197			
Corn Following Other:									
Costs:									
Field Operations	241	233	170	234	195	178	226	209	170
Materials	282	282	277	283	283	287	270	270	263
Yield	8.2	7.9	8.0	8.4	8.0	8.1	8.2	7.8	7.9
Net Return	380	350	427	395	395	418	394	374	428
Net Return/Hour	113	134	225	117	151	220	117	143	225
Soy Following Corn:									
Costs:									
Field Operations	215	207	144	251	212	175	238	207	160
Materials	167	167	184	191	191	224	197	197	230
Yield	2.7	2.5	2.2	2.8	2.6	2.3	2.7	2.5	2.2
Net Return	242	203	187	214	205	142	187	172	124
Net Return/Hour	81	72	92	72	73	70	63	61	61
Wheat Following Soy:									
Costs:									
Field Operations	144	123	121	160	156	117	158	135	133
Materials	127	127	127	126	126	126	171	171	171
Yield	3.9	4.0	3.7	4.1	4.2	3.9	3.9	4.0	3.7
Net Return	241	280	237	250	273	266	181	223	179
Net Return/Hour	85	118	145	89	115	163	64	94	110

1) Yield data is derived from Tillage 2000 results, 1986-1989.

A = Conventional tillage

B = Reduced tillage

C = No-till

Figure 3.1a Comparison of Net Returns Per Hectare and Net Returns Per Hour From Alternative Tillage Systems in Continuous Corn Rotations

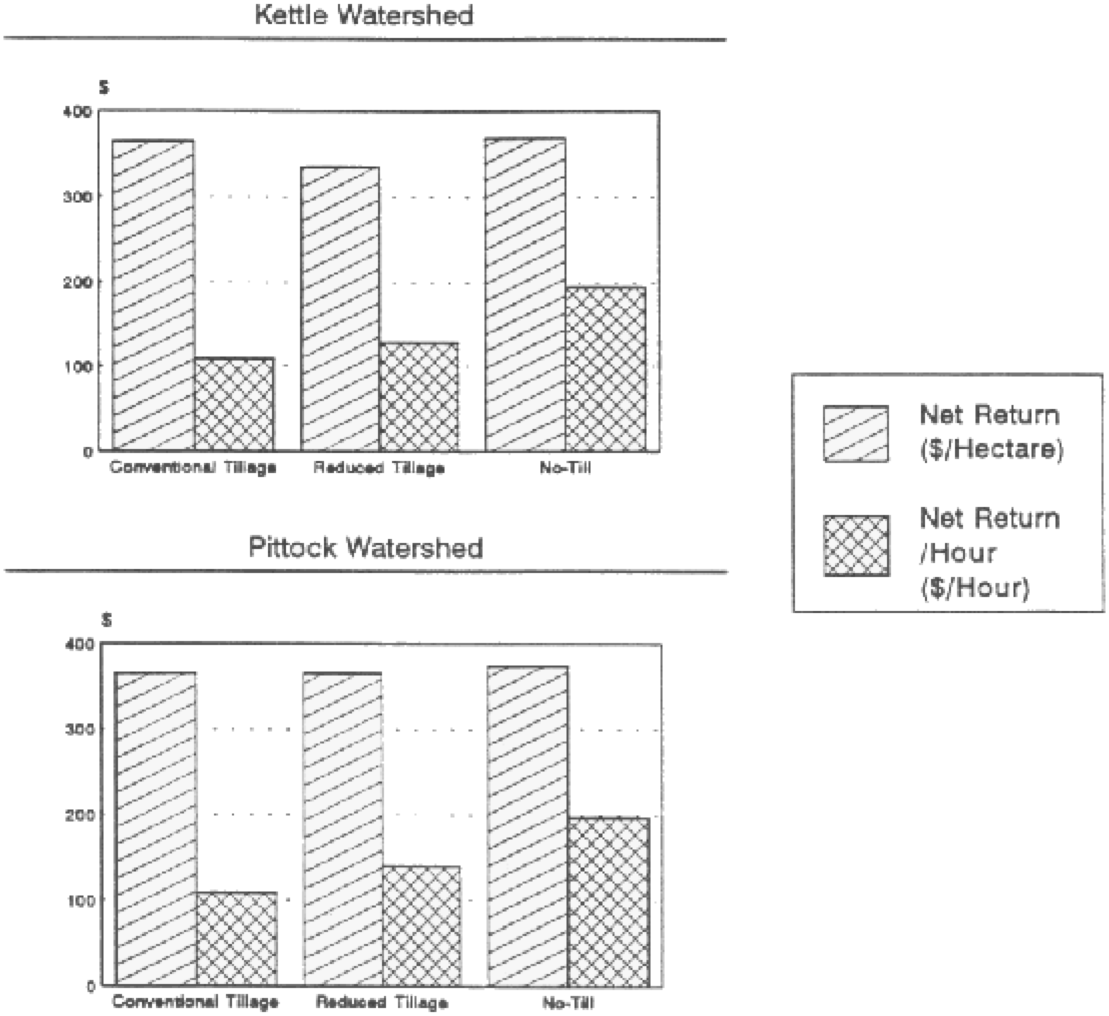


Figure 3.1b Comparison of Net Returns Per Hectare and Net Returns Per Hour From Alternative Tillage Systems in Corn Following Other Crops

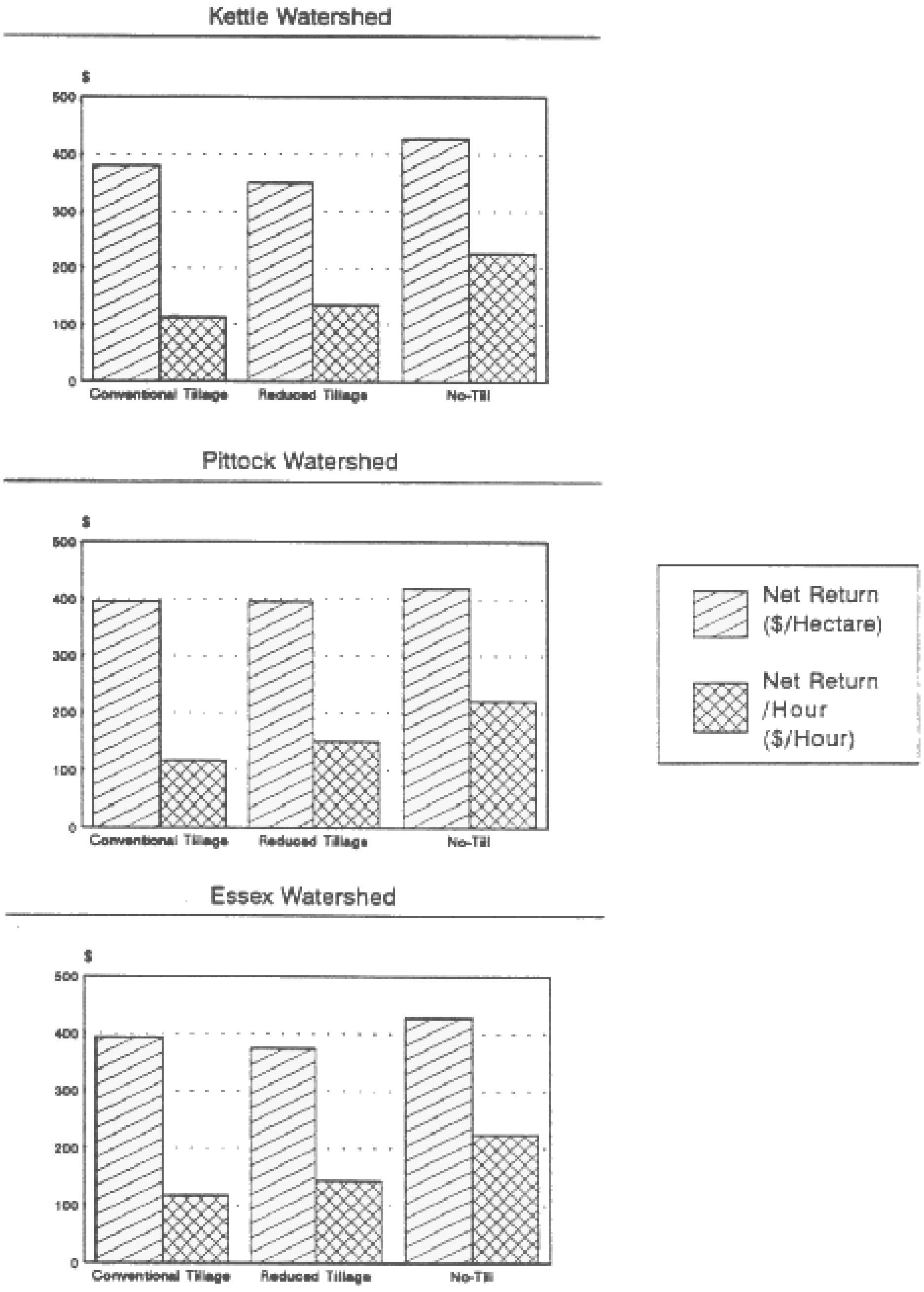


Figure 3.1c Comparison of Net Returns Per Hectare and Net Returns Per Hour From Alternative Tillage Systems in Soybeans Following Corn

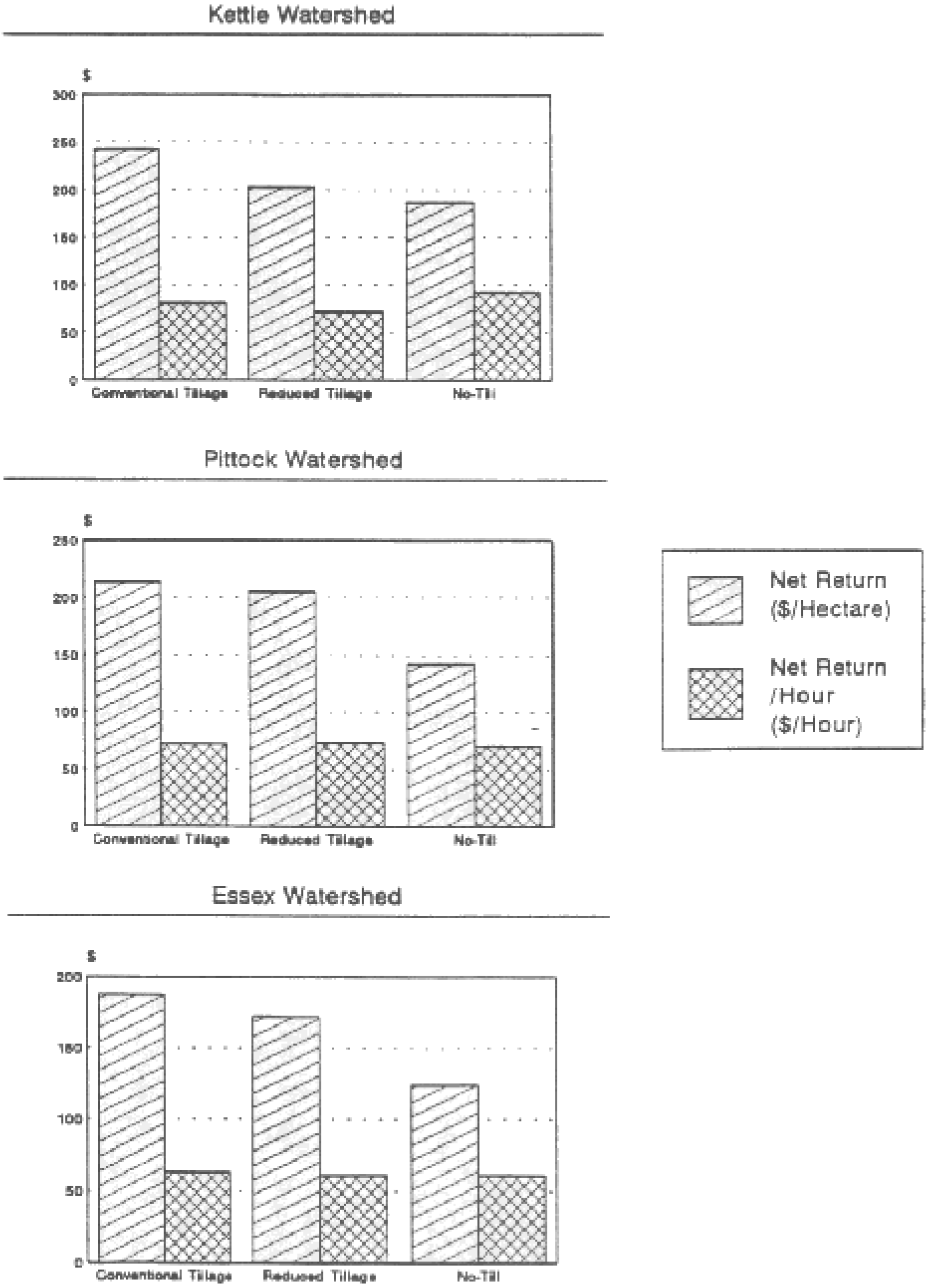
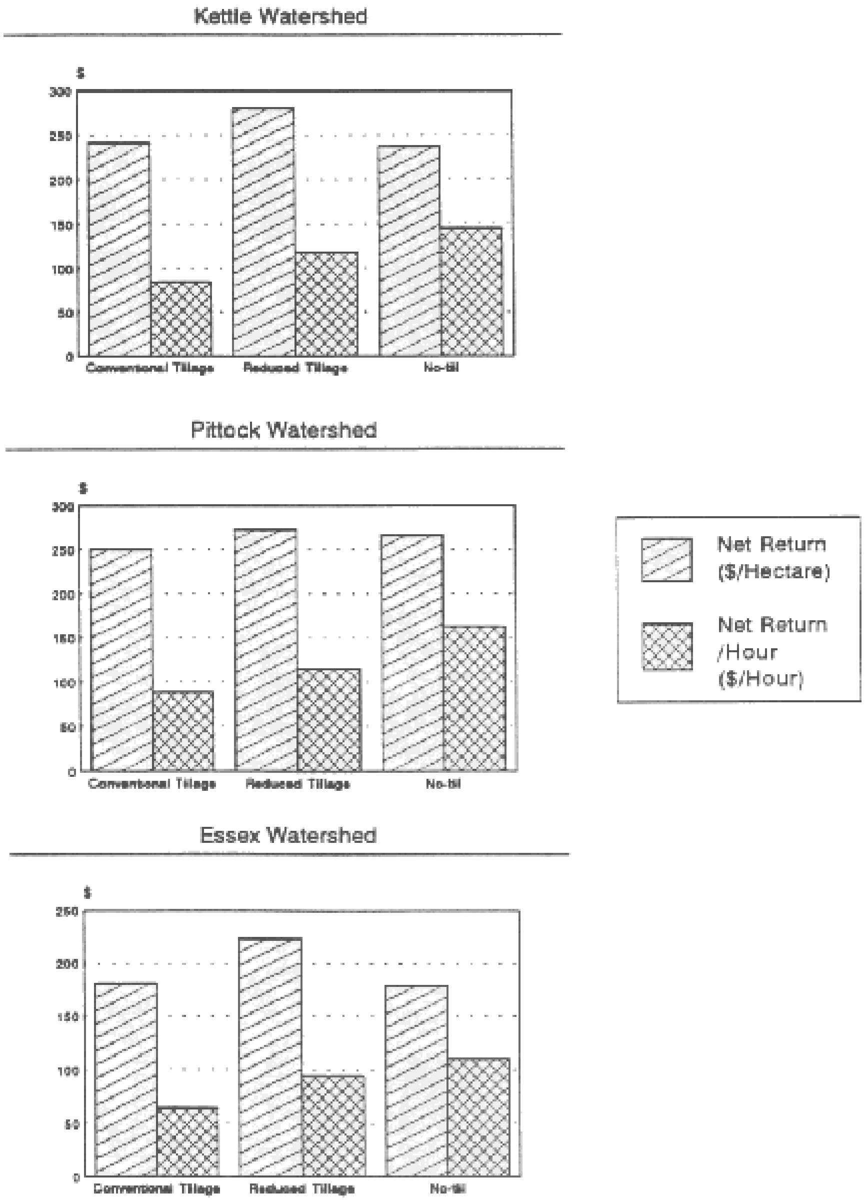


Figure 3.1d Comparison of Net Returns Per Hectare and Net Returns Per Hour From Alternative Tillage Systems in Wheat Following Soybeans



Data compiled by Weersink et al. (forthcoming) indicates that the yield of soybeans under reduced tillage practices is greater than yields under conventional tillage practices, and are roughly equivalent between no-till and conventional. In this situation, the net returns to soil conservation practices greatly exceed the net returns to conventional tillage practices, (see volume two - Chapter B for more detail).

Wheat Following Soybeans

The net returns per hectare are highest under reduced tillage practices, by between $20 to $40, and are roughly equivalent with no-tillage (Figure 4d). However, if considering the net returns to labour, both reduced and no-tillage practices significantly exceed the benefits of conventional tillage practices by up to $60 per hour.

3.2.2 Implication of Net Financial Results

Given the foregoing results, it is clear that the benefits of soil conservation practices (i.e. reduced or no-tillage practices) can exceed the net returns to conventional tillage practices. The benefit of soil conservation is particularly large when considering the net return to labour. This is of great significance to farmers who have high opportunity costs to labour, particularly in the spring and fall seasons.

3.3 ANALYSIS OF FINANCIAL RISK

An important consideration for farmers is whether the net returns to soil conservation practices are more or less variable relative to expected net returns under conventional practices. This issue is important because there is a natural tendency to avoid opportunities for greater net returns if the expected outcomes are perceived to be "riskier" relative to current practices.

Consequently, a risk assessment of corn production was conducted using the Tillage 2000 data over the period of 1986 to 1989. This analysis investigated the variability associated with material costs and yields for each tillage practice. From this, the 90 percent confidence range for net returns for corn were calculated (Table 3.3).

Results indicate that the lower and upper bounds of the confidence intervals between no-till and conventional tillage practices are not significantly different for net returns per hectare. Although, the confidence interval boundaries for reduced tillage on corn are lower than both conventional and no-till. This suggests that no-tillage systems are not any "riskier" compared to conventional tillage practices. Moreover, risk expectations of conservation tillage should not be an impediment to adoption.

When considering returns to labour, the spread between boundaries of no-till exceed both the reduced and conventional tillage systems. However, the boundaries for no-till are significantly higher (statistically different), making this a superior tillage practice from a risk perspective.

Table 3.3 **Confidence Intervals of Average Annual Production Costs and Net returns for Alternative Tillage Practices on Corn in Ontario Using Tillage 2000 Data**

Net Returns	Tillage Practice on Grain Corn		
	Conventional	Reduced	No-Till
	(90% Confidence Interval)		
Net Returns Per Hectare ($/Ha)			
Lower Bound	344	318	335
Upper Bound	503	469	504
Net Returns to Labour ($/HR)			
Lower Bound	103	124	160
Upper Bound	150	182	234

4.0 WATERSHED LEVEL ECONOMIC ANALYSIS

This section first outlines the impact of conservation tillage on a watershed net income basis, optimum choice of tillage method, and resource use. An evaluation of the opportunity costs of soil/phosphorus conservation limits is then presented. The analysis is based on a watershed modelling exercise which simulates the terrain and cropping dynamics for each of the three test pilot watersheds under SWEEP. Details of this model and its results are presented in Volume six of this report series.

4.1 BACKGROUND

The linkage between environmental quality and agricultural production has been well established (Canadian Agricultural Economics and Farm Management Society ad hoc Committee on Sustainable Agriculture, 1990). Policy guidelines call for an overall reduction in soil and phosphate loading in surface water within ten years, as part of our commitment to environmental stewardship. Farming practices and their relationship to soil and water quality are the focal point in this effort.

It was demonstrated in the previous chapter that the use of soil conservation practices/systems (i.e. reduced or no-tillage) offer the greatest potential for net returns from a field level perspective. It is important, however, to extend the analysis to whole farm cropping enterprises in an effort to assess the impact on crop rotations, resource use, and net farm income as it relates to various constraint levels on soil and phosphorous loading. These considerations are important to farmers and government in making the transition to more sustainable cropping practices.

The importance of this information is twofold:

A) It will indicate which tillage technologies/systems and crop rotations available to Kettle, Pittock and Essex watershed farmers provide the most benefits in terms of farm profitability and soil/effluent reduction; and

B) Given the above results and quantification of the downstream (macroeconomic) impact, which is the topic of Section 5.0, it will be possible to assess options/policies which will best stimulate greater adoption of soil/water conservation technologies, which is the topic of Section 6.0.

4.2 FARM PROFITABILITY IN THE KETTLE CREEK WATERSHED - NO ENVIRONMENTAL CONSTRAINTS

The optimum solution to the 3-year multi-period linear program, without environmental constraints is to grow 412 hectares (total area of watershed crop land) of continuous corn using soil conservation tillage methods. The total three year watershed profit is equal to $456,000. The model chooses a continuous corn rotation because price (and revenue) is highest for corn in this period. Crop prices are based on the average of the past five years. The crop selection could change if relative prices were different or if other farming enterprises such as livestock operations with feed requirements were considered. Inclusion of feed requirements as constraints would not likely affect the overall result. Consequently, it is less important which crops are selected by the model in this hypothetical case, compared to the selection of tillage practices. No sensitivity analysis around crop prices was conducted.

The immediate environmental impact associated with this cropping activity over three years, based on output from the GAMESP model, is as follows:

Environmental Impact With Continuous Corn Under Conservation Tillage

Soil Loading = 40 tonnes
Phosphate Loading = 63 kilograms
Soil Loss = 9,281 tonnes

Soil loading and phosphate loading is the rate at which soil particulate matter and phosphate, respectively, reaches a watercourse. Soil loss refers to movement of soil off a field and does not necessarily relate to loading.

Most farmers in Ontario are not currently practising soil/water conservation toany significant extent. By constraining the model to conventional tillage practices only, the solution was to still grow continuous corn on all 412 hectares as before. However, the three-year farm profits associated with this practice were $450,000, which is about $6,000 less than the optimum solution. In addition, the immediate environmental impact is significantly greater, as follows:

Environmental Impact With Continuous Corn Under Conventional Tillage

Soil Loading = 152 tonnes
Phosphate Loading = 211 kilograms
Soil Loss = 16,947 tonnes

This result clearly shows that there is both a financial incentive and an environmental impact incentive to grow crops under conservation practices in this watershed. Moreover, if one considers the long-term decrease in soil productivity associated with conventional practices, yields will likely decline and further increase the spread in profitability between conventional and conservation tillage practices.

4.3 FARM PROFITABILITY IN THE KETTLE CREEK WATERSHED - WITH ENVIRONMENTAL CONSTRAINTS

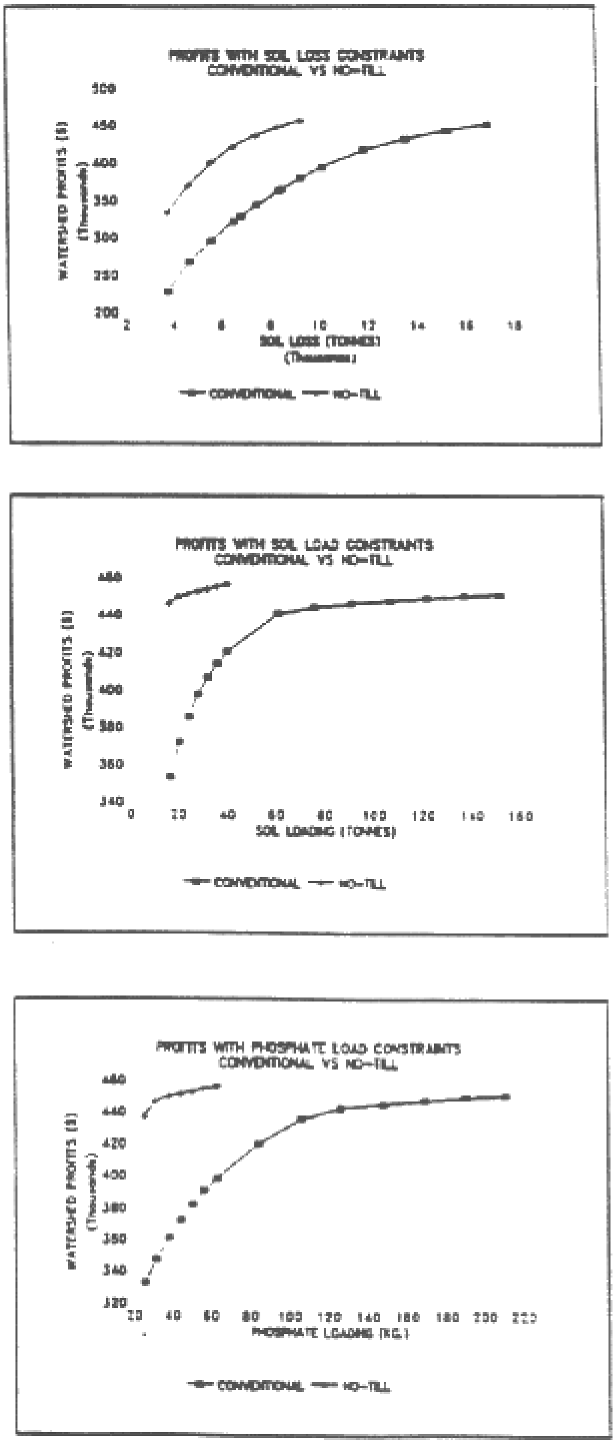
Incremental restrictions were placed on soil loss, soil loading and phosphorous loading for both conventional and no-tillage systems on continuous corn in increments of 10% to a minimum total effluent discharge equal to 40% of the unconstrained maximums described previously. The overall results of this analysis are illustrated in Figure 4.1.

Results indicate that the most profitable alternative for watershed farmers is to adopt no-till strategies at all effluent restriction levels. For conventionally cultivated land to produce the same amount of soil loss as the optimal no-till solution, farmers would have to set aside about 65 hectares of land (i.e. grow only 347 hectares of continuous corn) and accept profits of $379,247 which is about $77,000 less than the optimum solution under conservation tillage. More important, by simply using conservation tillage soil loss could be reduced by 45%.

As indicated in Figure 4.1, the relationship between effluent reduction and profitability holds regardless of whether the environmental quality constraint is on soil loss, soil loading or phosphate loading. Specifically, as effluent reduction levels increase, profitability declines.

Adding incremental effluent restrictions on either conventional or no-tillage systems requires that some land be set aside for non-crop activities. However, less land would need to be set aside if conservation tillage systems were used.

Figure 4.1 Comparison of Profits and Effluent Levels Between Conventional and No-Tillage in Kettle Watershed



4.3.1 Opportunity Cost of Effluent Restrictions

Imposing effluent restrictions on the model resulted in land being removed from production and sitting idle, which would be used any combination of grassed waterways or grassed knolls within fields. It was this idle land which established the opportunity costs of the environmental quality constraints.

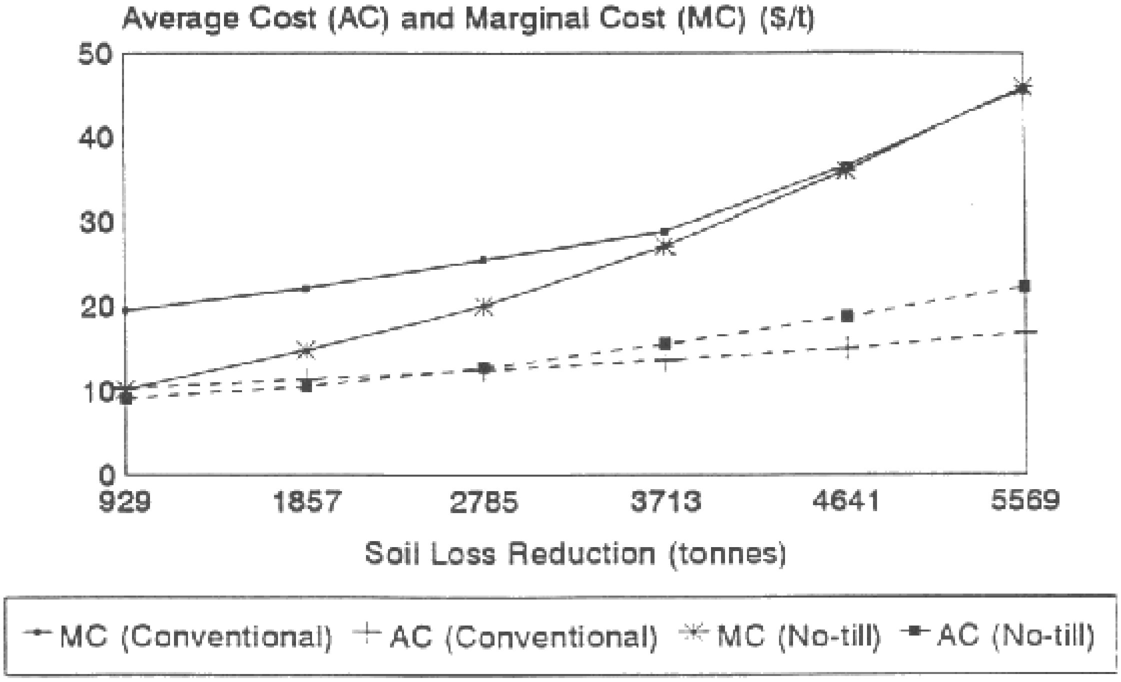
The opportunity cost of effluent restrictions is embodied in the measures of the marginal and average costs. Specifically, marginal cost is the *incremental* reduction in profits resulting from each additional tonne or kilogram reduction in effluent while average cost is defined as the *total* reduction in profits per unit of effluent reduction. The average cost (AC) and marginal cost (MC) associated with soil loss restrictions for both conventional and no-tillage are displayed graphically in Figure 4.2. The results from similar restrictions on soil loading and phosphate loading are discussed in volume six of this report series.

Imposing effluent restrictions on the model reveals two important results:

1) Marginal costs are consistently higher than average costs (Figure 4.2), indicating that inefficiencies exist under environmental quality constraints and hence, a departure from the profit-maximizing solution.

2) Marginal costs of production tend to be higher for conventional tillage than no-till (Figure 4.2), meaning that increasing environmental constraints will result in a larger incremental profit loss under conventional tillage systems compared to no-till.

Figure 4.2 Comparison of Average and Marginal Costs Between Conventional and No-Tillage in Kettle Watershed



4.4 FARM PROFITABILITY IN THE PITTOCK WATERSHED - NO ENVIRONMENTAL CONSTRAINTS

In the Pittock watershed the optimum selection of crop rotation and tillage system is very similar to the Kettle watershed, which is to grow continuous corn on all 359 hectares using zero tillage. In this case, the total three year profit is $403,312. In contrast, if we constrain the model to select only conventional tillage practices, continuous corn would be selected but the net income falls to $393,627. Although there is a profit difference, the most important result is that the use of conventional tillage systems on the watershed brings about significantly higher levels of soil and phosphate loading and soil loss, as illustrated below:

<u>Environmental Impact With Continuous Corn Under Conservation Tillage</u>

Soil Loading = 83 tonnes
Phosphate Loading = 169 kilograms
Soil Loss = 4,508 tonnes

<u>Environmental Impact With Continuous Corn Under Conventional Tillage</u>

Soil Loading = 256 tonnes
Phosphate Loading = 404 kilograms
Soil Loss = 8,231 tonnes

As in the Kettle watershed, there is both a financial and environmental incentive to grow corn under conservation tillage practices.

4.5 FARM PROFITABILITY IN THE PITTOCK WATERSHED - WITH ENVIRONMENTAL CONSTRAINTS

By placing incremental restrictions on soil loss, soil loading, and/or phosphate loading, it is clear that the use of conservation tillage practices is the most profitable strategy, as illustrated in Figure 4.3. For example, for conventionally tilled land to produce the same amount of soil loss as the optimum no-till solution, farmers would have to set aside about 132 hectares, with net farm profit at $250,000, which is 38% less than the optimum solution under conservation tillage. By simply using conservation tillage on all land, soil loss could be reduced by 45%.

The relationship between effluent reduction and profitability is the same regardless of whether the environmental constraint is associated with soil loss, soil loading, or phosphate loading. Increasing the effluent restrictions on both conventional and no-tillage systems results in the idling of some land, however, a lower cropping restriction will occur under the soil conservation system.

The general relationship regarding the opportunity cost of effluent restrictions for the Kettle watershed (Figure 4.2) holds for the Pittock watershed as well.

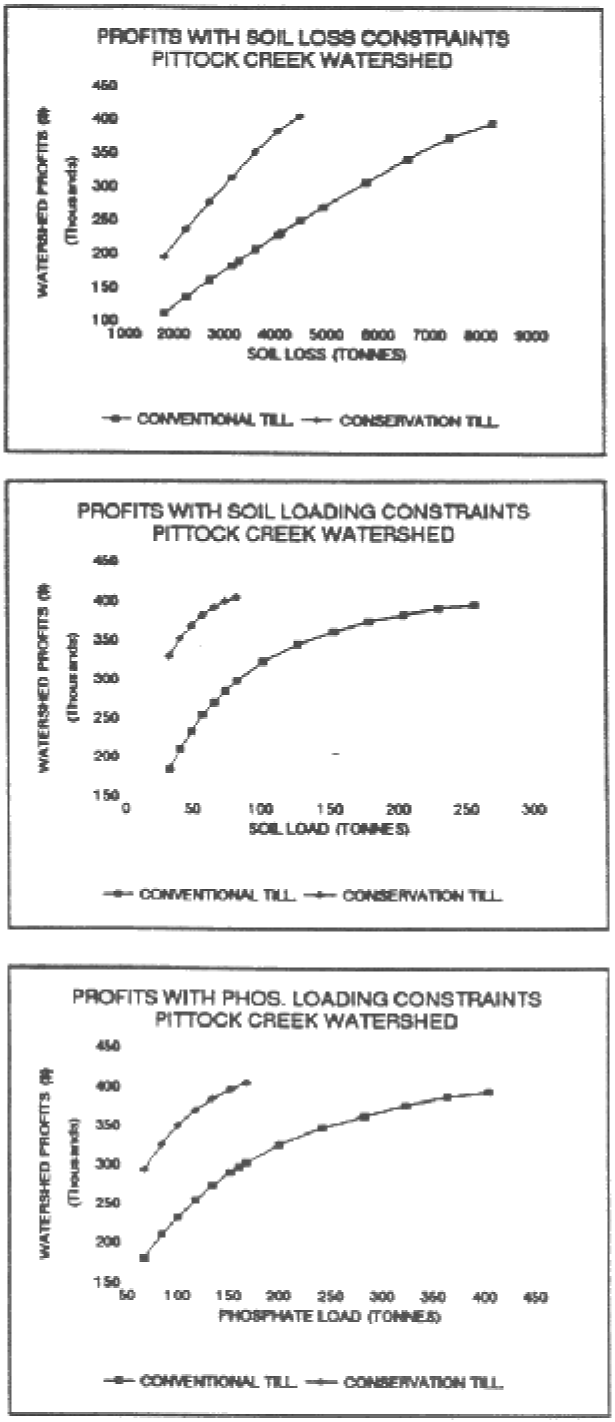
4.6 FARM PROFITABILITY IN THE ESSEX WATERSHED - NO ENVIRONMENTAL CONSTRAINTS

The optimum solution in the Essex watershed is unique relative to the Kettle and Pittock watersheds. Specifically, the optimum solution is to grow soybeans in rotation with corn using conventional tillage practices, generating a 3-year profit of $334,699 and with the following effluent discharges:

<u>Environmental Impact With Continuous Corn Under Conventional Tillage</u>

Soil Loading = 3,383 tonnes
Phosphate Loading = 3,710 kilograms
Soil Loss = 3,783 tonnes

Figure 4.3 Comparison of Profits and Effluent Levels Between Conventional and No-Tillage in Pittock Watershed



This solution is not surprising given that the Essex watershed is very flat relative to the other watersheds and has far less soil loss under conventional tillage systems.

4.7 FARM PROFITABILITY IN THE ESSEX WATERSHED - WITH ENVIRONMENTAL CONSTRAINTS

If soil loss restrictions are placed on this watershed, it is evident that the optimum solution is to incorporate conservation tillage and alter the crop rotation. For example, consider a 10 and 40% soil loss restriction on "constrained" and "unconstrained" solutions, where a constrained solution limits cropping to conventional tillage, and unconstrained solutions allow the model to select either conventional or conservation tillage practices (Table 4.1).

Table 4.1 Comparison of Profits and Soil Loss in Constrained and Unconstrained Solutions in Essex Watershed

Soil Loss Restriction	Constrained to Conventional Tillage Practices			Unconstrained Selection of Tillage Practices		
	Crop Rotation	Hectares	Watershed Profit	Crop Rotation	Hectares	Watershed Profit
10%	SCS [1]	339	$306,674	SCS [1] SWC [2]	325 110	$330,545
40%	SCS [1]	282	$216,524	SWC [2]	402	$294,141

1 = conventional tillage

2 = no-tillage

SCS = soybeans/corn/soybeans

SWC = soybeans/wheat/corn

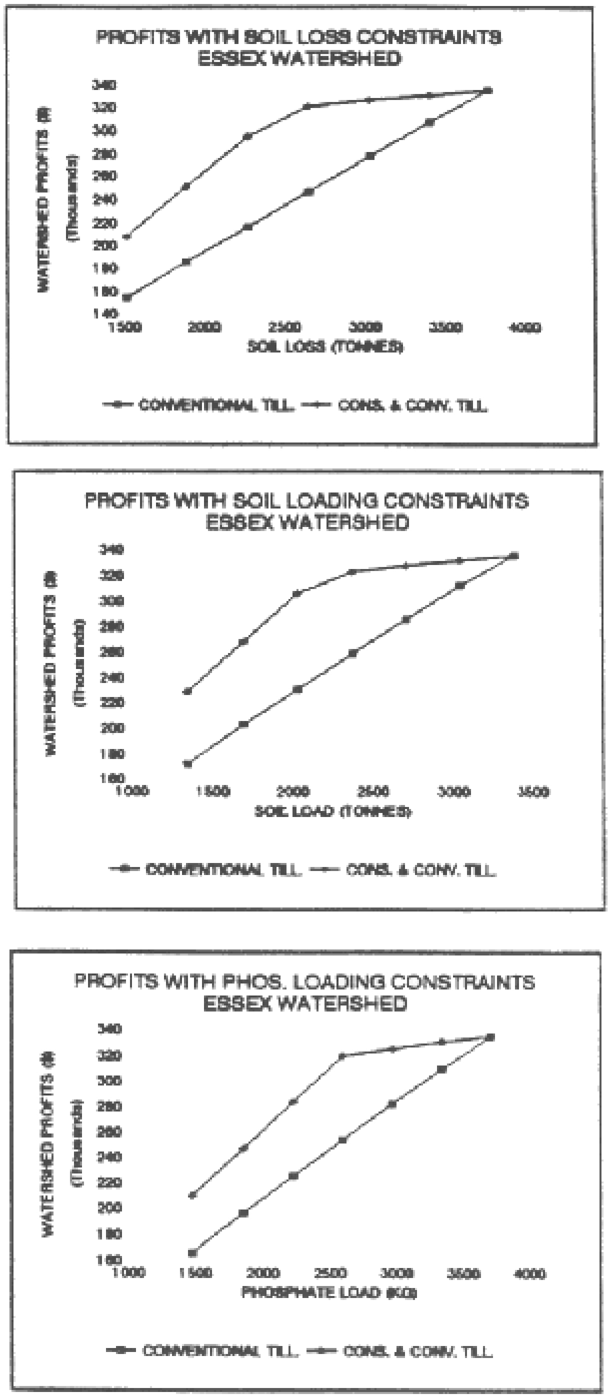
In either soil loss restriction level, net profits are lower than the previous optimum solution of $334,699. However, given that some level of soil loss restrictions are desirable, the optimum solution is to utilize soil conserving tillage practices. The 10% soil loss restriction is optimized growing a soybean-wheat-corn (SWC) rotation under no-till on about one third of the watershed, resulting in higher net profits of about $23,000 relative to conventional tillage soybean-corn-soybean rotations. With a 40% restriction on soil loss, only no-till SWC rotations are selected and grown on 402 hectares. The spread in net profits between tillage systems and crop rotations is approximately $78,000. The general relationship between effluent restrictions and profits in the Essex watershed is illustrated in Figure 4.4.

4.8 SUMMARY OF WATERSHED LEVEL IMPACT

The results of the watershed economic analyses indicate that in the Kettle and Pittock watersheds the optimum solution is to select conservation tillage practices in growing continuous corn. In the Essex watershed, the optimum solution is to select conventional tillage in growing a soybean-corn-soybean rotation. Despite these two different starting points, if there is a general desire to reduce the levels of soil loss, soil loading and/or phosphorous loading, then the optimum solution is to utilize conservation tillage practices. In addition to this, it would be optimal in the Essex watershed to alter the crop rotation.

It is important to note that the exclusive use of conservation tillage practices in the Kettle and Pittock watersheds could reduce soil loss by as much as 45%, relative to conventional tillage, without having to set aside land or lose profits. If further soil loss restrictions are required in these two watersheds, the opportunity cost to farmers is lower using conservation tillage systems. This means that the cost of soil loss restrictions (i.e. reduced profitability) is lower under conservation tillage systems compared to conventional tillage systems.

Figure 4.4 Comparison of Profit and Effluent Levels Between Constrained and Unconstrained Tillage Systems In Essex Watershed



The same impact is true in the Essex watershed. By imposing limits on soil loss in the Essex watershed, farmers will experience less cost using a combination of conservation tillage and alternative crop rotations.

It is important to note, however, that the foregoing analysis does not consider any adjustment costs for farmers switching from conventional to conservation tillage systems. In reality, farmers with conventional tillage equipment would find that their salvage value is relatively low and that the cost of new conservation equipment is high. The implications of this cost consideration are discussed in more detail in Chapter 6.0.

5.0 MACRO-ECONOMIC ANALYSIS

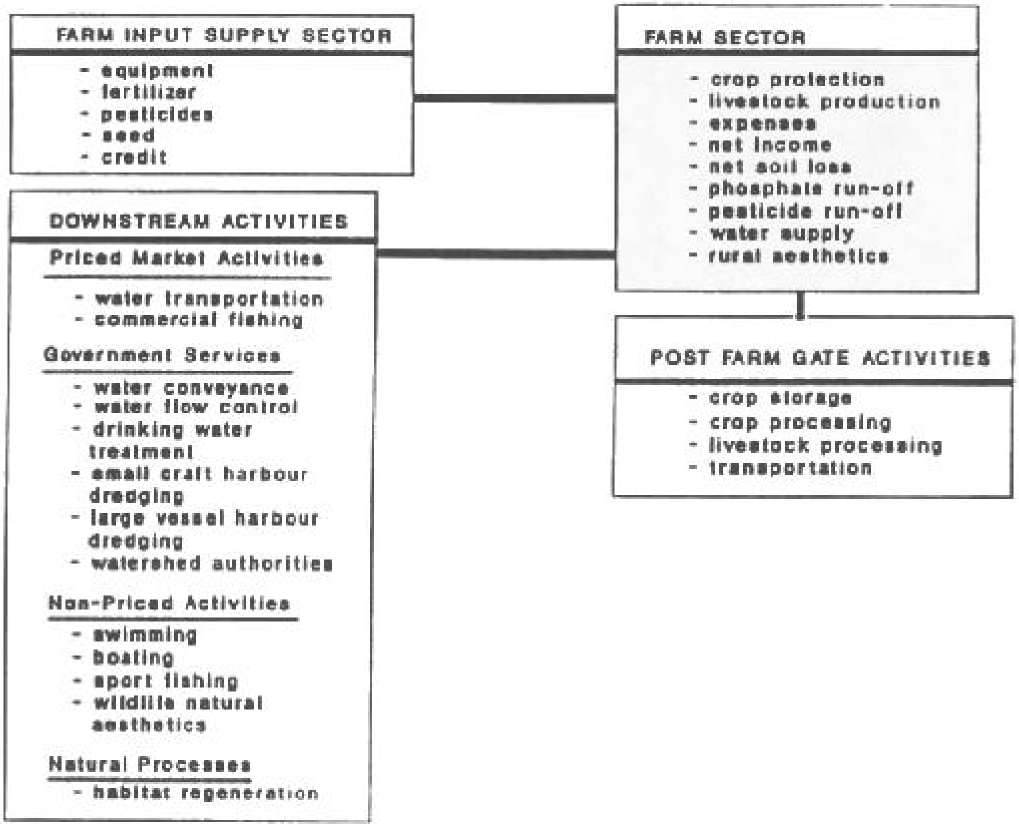
This section summarizes the possible off-farm consequences of soil and water conservation on three impact areas: the input supply sector, the commodity output sector, and downstream activities such as government services, fishing, and recreational/aesthetic activities. The potential areas of impact at the watershed level are highlighted in Figure 5.1. The major areas of impact include water transportation and flow, fishing, and recreational activities.

The analytical focus of this section is on the downstream impact which could occur given a reduction in sediment and phosphorus runoff. Results indicate that a 10 percent reduction in soil erosion lowers annual downstream costs by $3 per cropland hectare and a 40 percent reduction lowers annual downstream costs by $12 per cropland hectare. Details of the methodology and results are presented in volume seven.

5.1 BACKGROUND

While the linkage between environmental quality and agricultural production has been well established, the off-site damages from water-induced soil erosion have not been treated as a farm production cost since the negative affects of erosion to downstream activities do not directly influence farming practices. The failure to account for off-site damages may lead to under-investment in soil conservation. Therefore it is necessary to evaluate both the on-farm and the off-farm financial impact to determine the true cost of erosion.

Figure 5.1 Impact of Conservation Activities at the Watershed Level



Results from previous sections indicate that the use of conservation tillage practices is economically and environmentally superior at both the field and watershed level. It is important to incorporate the non-farm sector in this analysis in order to provide farmers, government and the public with a better sense of the benefits of conservation tillage and the costs of agricultural erosion.

5.2 FARM INPUT SUPPLY SECTOR

We contacted selected farm equipment dealers in each of the three pilot watershed areas to assess the potential impact that a greater adoption of conservation tillage would have on their business. The equipment dealers contacted include:

Pittock - Zehr Brothers and Lovey's Farm Equipment;
Essex - Carlton McGuire and Jacob's Farm Equipment;
Kettle Creek - Vanden Brink Farm Equipment and Van-Cross John Deere.

There was common consensus regarding the following issues:

- A large supply of used conventional equipment would flood the market. Although much of this equipment would be in good shape, it would be practically worthless with little or no salvage value.

- Fewer tractors would be sold as well as fewer parts and repairs due to lower usage rates under conservation systems.

- There would also be less (and different) equipment sold and fewer replacement parts. Leasing of conservation equipment could increase since the new equipment is high-tech, high-quality, and high priced with a lower amount of annual use.

- There would be a negative impact on fuel sales with demand occurring only at seeding and harvest times if no-till became prevalent. There would also be a corresponding reduction in government tax revenue.

- More attention would be directed to service and parts and less to sales (after the initial transition from conventional to conservation tillage systems).

- One area experiencing increased sales could be sprayer equipment.

The implication of this impact is that farm equipment suppliers must adjust their sales and services to reflect the derived demand for new equipment and other services. Although the derived demand for new equipment may decline, there is some opportunity for providing new innovative services relating to the adoption and execution of conservation tillage systems across Ontario.

5.3 COMMODITY OUTPUT SECTOR

The commodity output sector would be affected by changes in either the mix of output or the quantity/quality of output (or both). The mix of output would change if conservation tillage practices resulted in a shift in production to different crops than grown under conventional methods. Results from the last section indicate that the optimal profit maximizing solution was to grow continuous corn under conservation tillage (i.e. no-till) in the Pittock and Kettle watersheds. In the Essex watershed, the optimal solution was to grow soybeans in rotation with corn using conventional tillage practices.

It is important to understand that these results could change given a change in commodity prices or considering feed requirements and other variables that affect production decisions. This report does not suggest that continuous corn is optimal.

Rather, the important issue is that conservation tillage practices are optimal, particularly in cases where soil loss restrictions are imposed.

Although original estimates predicted a decrease in crop yields under conservation tillage, more recent results indicate that crop yields should not differ significantly once farmers have gained experience with the new tillage methods and have progressed up the "learning/experience curve". Until definite results have been demonstrated, it is not possible to quantify any impact on the commodity output sector. Currently, there is no reason to expect that the mix of crops will change substantially as farmers move to a greater use of conservation tillage practices.

5.4 DOWNSTREAM ACTIVITIES

Two scenarios were developed to assess the impact of a change in the delivery of sediment from the stream to the lake. In one scenario (Scenario A), 90 percent of the sediment and sediment bound phosphorous that enters the stream from a field is assumed to progress to each successive level of waterway (such is the case in fast flowing streams). In the second scenario (Scenario B), more settling in the stream bed occurs (such as in the case of slower flowing streams) whereby 60 percent of the sediment that enters the stream travels to each successive level in the system. Phosphorous is divided into two types, phosphorous in the water and phosphorous in sediment. It is assumed that 60% of phosphorous is absorbed by sediment and the other 40%is soluble (in the water). The following subsections trace the impact of each scenario (which have similar results) and the imposition of 10 and 40 percent restrictions on soil loss entering the stream. Results from section 4.0 indicate that reductions in the order of 50% are very likely, simply by utilizing conservation tillage practices on all acreages modeled.

5.4.1 Priced Market Activities

The priced downstream market activities such as water transportation and commercial fishing have a clearly quantifiable and measurable value. For example, it is estimated that total harbour dredging costs in Ontario are $8.2 million per year, of which 30% (approximately $2.5 million) is attributed to cropland erosion. The agricultural area assessed to be contributing to dredging problems is 1.68 million hectares, resulting in a cost per hectare of $1.46 per dredging. Similarly, the cost to commercial fish landings in Ontario is calculated as the potential increase in value in sediment-sensitive fish landings expected from the elimination of excessive sediment from waterways. The potential increase in fishing value due to the elimination of sedimentation from cropland is about $26 million resulting in a cost of over $15 per hectare.

Both levels of sediment delivery that brought about reductions in farm soil erosion of either 10 or 40 percent yielded equivalent dollar savings (Table 5.1). For example, the benefits (cost reductions) of a 40% reduction in sediment and phosphorous yields to water transportation (dredging) is 59 cents per hectare. The benefits to commercial fishing under the same scenario is $2.49/ha ($2.36/ha for the sediment reduction and $0.13/ha for the phosphorous reduction). The changes in downstream sediment delivery are measured as percentage changes from assumed baseline values. Since different sediment delivery rates do not affect the percentage changes in sedimentation, the reported benefits do not vary significantly between scenarios A and B. (See volume seven for a full explanation of the derivation of the numbers in Table 5.1.) However, since the absolute volume of soil loading is greatest in scenario A, the total cost of remediation programs would be significantly higher in this case, based on the large number of hectares in type A water systems.

Table 5.1 Dollar Savings Created By Reductions in Farm Soil Erosion

	(Dollars per Hectare)			
Activity	Soil Loss 10%		Soil Loss 40%	
	A Sediment	B Phosphorus	A Sediment	B Phosphorus
Water Transport	0.15	0	0.59	0
Commercial Fishing	0.59	0.031	2.36	0.13
Water Conveyance	0.10	0	0.40	0
Water Flow Control	0.27	0	1.09	0
Water Treatment	0.53	0.21	2.12	0.85
Swimming	0	0.03	0	0.11
Boating	unknown	unknown	unknown	unknown
Sport Fishing	0.95	0.025	3.79	0.40
Wildlife	unknown	unknown	unknown	unknown
Totals	$2.59	$0.30	$10.35	1.49
Total A&B	$2.89		$11.84	

5.4.2 Government Services

Curtailing the negative impact created by soil erosion and runoff would be very beneficial for the many services provided by local and provincial governments such as water conveyance, water flow control and drinking water treatment.

Water conveyance maintenance involves the removal of sediment that accumulates within drainage systems, both at farm field edges and further downstream. The total annual water-conveyance maintenance cost is $3.41 /ha. The relationship between sediment reduction and benefits is not linear. It is assumed that as we decrease sediment loading the cost to clean drains decreases by a factor of 1.5. The potential benefit of reducing soil erosion by 40% is 40 cents per hectare (Table 5.1).

Water flow control involves the construction of sediment control measures to reduce flooding. These costs were measured as the cost of storage depletion of reservoirs attributable to soil erosion from agricultural sources. Two alternatives for restoring storage capacity are dredging and building extra capacity. The average annual costs per reservoir associated with each alternative are $113,600 for dredging and $22,700 for new storage capacity.

The benefits associated with reducing soil erosion by 40% would be $1.09/ha for water flow control (Table 5.1).

To ensure that water is safe to drink, it must be purged of both sediment and other contaminants. Excessively turbid water can increase the cost of water treatment by up to 35 percent (Clark et al., 1985) as well as increase maintenance costs on the purifying equipment. It is estimated that 10% of the total treatment costs, or approximately 4 cents/thousand gallons, can be attributed to sediment and phosphorous loadings from cropland. The expected cost savings associated with a 40% decrease in sediment and phosphorous yields is $2.12/ha and $0.85/ha respectively (Table 5.1).

5.4.3 Non-Priced Activities

Phosphorous and sediment loading also has an impact on non-priced activities like swimming, boating, sport fishing, and wildlife aesthetics. Given the nature of these activities, it is difficult to assess the extent of the impact. Not only is little known about the overall magnitude of the biological impact on recreational fishing or swimming, there is also no commonly accepted method for estimating the costs. However, an attempt was made to estimate a cost for the above activities wherever possible.

To determine the economic cost associated with beach closure, the number of recreational users turned away due to sediment and phosphorous pollution was assessed. Assuming agricultural soil erosion accounts for around 50% of phosphorous loads, an effective solution to beach closures would be a combination of improved tillage practices to prevent soil erosion and improved control of waste effluent from milkhouses and industrial discharges. It is estimated that the benefits of improvements in phosphorous yields to recreational facilities could be approximately 11 cents per hectare (Table 5.1).

Excessive sediment results in a significant drop in fish and plant populations, with the most preferred sport fish being affected the most by excessive sediment. Reduced visibility also reduces the rate at which fish are caught since they are unable to see the lure from as great a distance. Unlike the commercial fishing industry where market values for fish can be determined, recreational sport fishing is usually measured by expenditures for fishing related activities, the economic value of fishing days, or "willingness to pay" estimates. These estimates represent the value fishermen receive from the fishing "experience" rather than the value of the fish itself.

An estimate of the total benefits resulting from the elimination of excess sediment from streams and lakes in Southern Ontario was calculated by combining the value of the potential increase in the number of fish caught and the value of the increase in angler days (see volume seven). Of the $35 million total value, 33% or $11.55 million was the cost to the recreational fishing industry associated with cropland sediment. The cost savings associated with a 40% reduction in sediment and phosphorous loading are $3.79/ha and $0.40/ha respectively (Table 5.1).

5.5 TOTAL BENEFITS

The macro-economic analysis indicates that the economic benefits obtained from a 10% reduction in soil erosion are around $2.89 per hectare. A 40% overall reduction in soil erosion would increase the estimated downstream benefits to $11.84/ha. These benefits are likely somewhat understated since a part of the impact was not quantifiable. For example, evaluations of the financial cost of soil erosion to wildlife, habitat regeneration, and natural aesthetics are unavailable, so the benefits of reduced sedimentation were not calculated. Given that these benefits may be one of the most important of the analysis, the downstream impact is likely much higher than that calculated in Table 5.1.

6.0 POLICY IMPLICATIONS

In this section the policy implications associated with soil and water conservation practices are addressed. This discussion commences with a review of the state of conservation adoption, a review of an adoption process model and the factors affecting adoption, and ends with approaches that can be used to influence the adoption of conservation practices.

6.1 SOIL AND WATER CONSERVATION PRACTICES

The economic analysis of alternative soil and water conservation practices indicates that the adoption of conservation tillage technologies results in a higher net farm income in all three watersheds examined, compared to conventional practices. Furthermore, the downstream social benefits of reduced soil loss from agricultural cropland is substantial.

Given these results, the best interest of farmers and society are served by ensuring that soil conserving tillage practices are utilized extensively. It is evident, however, that soil conserving technologies are not widely utilized despite extension efforts to the contrary. Consequently, it is important to explore some of the issues and rationale for this behaviour and to then suggest policies or programs that could be used to increase the adoption of soil conservation practices in Ontario.

6.1.1 Adoption of Soil Conservation in Canada

Results from the recent Census of Agriculture indicate that crop rotation (using clovers, alfalfa, etc.) was utilized by 37% of Canadian farmers to control soil erosion in 1990. Ontario farmers were the second highest users of crop rotation at 54% while only 17% of British

Columbia farmers employed crop rotations (Table 6.1). Prince Edward Island farmers were the highest users of crop rotation, at 64%.

Table 6.1 Percentage of Census Farms Reporting Soil Erosion Control Practices, 1990.

Province	Crop Rotation	Winter Cover Crops	Grassed Waterways	Strip-Cropping	Contour Cultivation	Other
NFLD	24	4	3	1	5	8
P.E.I.	64	8	10	4	9	14
N.S.	28	10	7	2	6	6
N.B.	35	8	7	4	7	7
Quebec	42	3	3	2	3	7
Ontario	54	18	14	4	6	18
Manitoba	32	6	11	4	12	34
Sask.	21	6	12	20	17	34
Alberta	38	6	15	8	10	26
B.C.	17	8	7	1	4	9
Canada	37	9	11	8	9	22

Source: Statistics Canada, 1992.

To control soil erosion, 18% of Ontario farmers used winter cover crops, 14% used grassed waterways, 4% used strip-cropping, and 6% used contour cultivation, in addition to crop rotation. The most frequently reported "other" practice was some form of conservation tillage.

With respect to tillage systems, Ontario farmers reported that 78% utilized conventional tillage systems, which we assume incorporated the use of ploughing, compared to 18% who used reduced tillage and 4% using no-till systems (Table 6.2). Clearly, the majority of tillage methods in Canada are based on conventional tillage methods, although the prairies tend to use conservation tillage methods most relative to other regions.

Table 6.2 Use of Alternative Tillage Systems in 1991

	(Percent)		
Province	Conventional Tillage	Reduced Tillage	No Tillage
Newfoundland	84.1	7.7	8.2
Prince Edward	91.2	7.9	0.9
Island	88.3	7.8	3.8
Nova Scotia	85.3	12.5	2.2
New Brunswick	85.2	12.3	2.5
Quebec	78.2	17.8	4.0
Ontario	66.3	28.7	5.0
Manitoba	63.9	25.7	10.4
Saskatchewan	72.6	24.3	3.1
Alberta	83.5	11.9	4.6
British Columbia			
Canada	68.9	24.4	6.7

Source: Statistics Canada, 1992

6.2 THE ADOPTION PROCESS AND CONSERVATION TECHNOLOGY

The rationale for the relatively low adoption of soil conservation technologies must first begin with a review of the adoption/innovation decision process (IDP)which was developed by sociologists to explain the adoption and diffusion of new technologies in agriculture. This model explains the mental processes through which a farmer passes from first knowledge of an innovation to a final decision to adopt or reject. The IDP model progresses through a series of five stages, as following:

STAGE ONE: AWARENESS

The individual learns of the existence of the new idea or innovation, but lacks complete information about it.

STAGE TWO: INTEREST

The individual develops interest in the innovation and seeks additional information about it.

STAGE THREE: EVALUATION

The individual makes mental application of the innovation to his present and anticipated future situation and decides whether or not to try the innovation.

STAGE FOUR: TRIAL

The individual actually tests the new innovation on a small scale in order to determine benefits to his own situation.

STAGE FIVE: ADOPTION

The individual uses the new innovation continuously on a full scale.

This model is useful for investigating the adoption of soil conservation technologies since it illustrates the steps that a potential adopter typically goes through, and as such can be a basis for identifying specific areas that should be addressed by policy. The model implies that adoption is not an automatic conclusion once a technology is developed. Rather, there is a time lag between awareness and adoption of new technologies. The length of this time lag will vary depending on the factors which most influence each stage. Consequently, the role for policy makers is to assess how best they can shorten the time tag by introducing measures which facilitate the IDP process.

Some common terminology that is used in discussions of adoption of technologies and practices is provided below:

ADOPTION	The conscious first use of a new technology or practice by an individual or institution.
ADOPTION PROCESS	The series of events an individual goes through in deciding to adopt or not to adopt a new technology.
INNOVATION	A new practice or technology or change in behaviour.
INNOVATOR	Those in the population that are first to adopt a particular technology. Others are defined sequentially as early adopters, early majority, late majority and laggards.
DIFFUSION	The process by which innovation spreads from its inventors/advocates/innovators to other users.
DIFFUSION LEVEL	The percent of the population adopting the new technology after its complete introduction into a sector. It defines the maximum adoption level possible, which in this case will be less than 100 percent of all crop area.
ADOPTION RATE	The percent of the population adopting the new technology in each time period after introduction. The rate of adoption does not have to be constant in each time period.

6.2.1 Factors Affecting Adoption Rates and Diffusion Levels

The diffusion level and the adoption rate are both influenced by many factors within the Adoption Innovation Decision Process (IDP). These factors include the following:

Relative Advantage: The advantage of the new innovation/technology relative to existing technologies is a strong determinant of successful adoption. In this regard, we have evaluated the economic benefits of soil conservation methods relative to conventional practices. There is a relative advantage provided by conservation practices.

Measurability: The probability of adoption is enhanced if the impact and benefit associated with adoption is easily measured. The benefit of conservation practices can be measured in controlled experiments and by researchers. However, it is much more difficult for crop producers to measure the yield benefits since many factors influence yield and they can not be controlled between years (or between farms). Other benefits also take time to be realized such as enhanced soil productivity. Consequently, the measurability of soil conservation practices has a dampening impact on the adoption rate and final adoption levels.

Compatibility: This factor relates to the extent the new technology is consistent with existing management practices and use of other inputs. The adoption of soil conserving technologies requires a fundamental shift in the philosophy and day-to-day management of cropping activities. It is not compatible with conventional tillage systems - it is a complete change in cropping management. Moreover, some soil conserving technologies may change the use of other inputs, such as herbicides and fertilizers, as well as impact on the decision of which crops to grow. Displaced conventional tillage equipment will also have little or no salvage value. Consequently, the adoption rate for soil conserving technologies will be slowed by this factor.

Complexity: New technologies and innovations and their consequences can be difficult or easy to understand. Less complex ideas are more quickly and widely adopted. The use of soil conserving technologies is very complex relative to other new farm technologies. The understanding and appropriate use of conservation technologies requires a long time period. Consequently, the adoption rate for many soil conserving technologies will be slowed by this factor.

Divisibility: This factor relates to the extent that an innovation can be applied on a limited scale within an enterprise to test the technology's attributes. The divisibility of soil conserving technologies is limited by the significant capital investment required. Unless rental of conservation equipment is available, this can limit the opportunity to test some soil conserving technologies on a trial basis and consequently slows the adoption process.

Reversibility: This factor relates to the ability to revert back to the old technology without significant consequences. Complete reversibility of a new technology encourages trial use, such as the case of BST and other animal health products. The use of soil conservation technologies is not reversible within the same growing season, except with significant cost. Moreover, reverting back to conventional tillage technologies, even the following season, will be costly given capital investment requirements.

Additive/Substitutes: Some products are additions (complements) to existing technology packages, while others are substitutes. Adoption of new technology is relatively easier when the new technology is an addition to current practices, since current capital equipment and inputs are not rendered redundant. Soil conserving technologies will substitute for "conventional" technologies and will displace conventional equipment and associated management programs. Such substitutions require considerable change by farmers, consequently, change can be slow for this reason.

Communicability: The knowledge and information concerning some technologies can be communicated to potential users more easily than others. This factor incorporates some dimensions of the complexity of an innovation/new technology as well as the measurability of benefits. The combination and implementation of soil conserving technologies can vary significantly between fields, let alone regions, depending on environmental conditions and crops grown. Consequently, there will not be any single conservation package that will fit all needs or conditions. Each site must be evaluated for specific needs and the appropriate mix of tillage systems and crop rotations must be developed site by site. This means that soil conserving technologies can not be easily communicated or demonstrated for all situations. This factor also contributes to a slower adoption rate.

Riskiness: Risk refers to the probability of failure with the new technology relative to existing practices. If farmers perceive that the risk associated with conservation practices is high, they will be very reluctant to adopt them without proof of significant net benefits.

Age of Innovation/Technology: Newer innovations and technologies are less likely to be adopted quickly by the majority of farmers than older innovations. This factor is in keeping with the philosophy of the IDP process which requires time to move from awareness to adoption. With the application of soil conserving technologies, this factor is somewhat complex since farmers may be required to implement a mix of technologies/innovations, some of which are relatively new and others older and better understood.

initial investment Required: A low initial investment will be more conducive to adoption than higher initial investments. "Investment" can be measured in terms of: (1) capital outlays, and (2) the time required to learn and best utilize the mix of soil conserving technologies to their optimum potential. This is closely related to the potential risk associated with the technologies and the opportunity cost of time and money. Soil conserving technologies require both significant initial capital investment and human capital investment, as well as costs associated with altering crop management practices.

In summary, there are many inter-related factors which constrain the adoption rate and ultimately the diffusion level of soil conserving (tillage) technologies. The following subsections identifies approaches to affecting change and outlines a number of policies and programs which could be used to offset some of the negative aspects of the above adoption factors.

6.3 PUBLIC POLICY AND RESOURCE USE

Public policy is interventionist in nature, and in the context of soil and water conservation, programs are designed to influence resource use and management practices. There are three general ways government can affect decision-making and hence resource use. These are programs which affect decision making and ultimately resource use through:

- direct impact on prices/costs (taxes, subsidies, credits) ;
- communication of information and extension activities; and
- enforceable regulations and standards.

These approaches are often referred to as the 3-Ps of economics -- pricing, preaching and policing.

Pricing programs include subsidizing the cost of conservation equipment through tax credits and rebates. It can also include taxes on equipment that is non-conservation in nature.

Communication and extension programs include providing scientific, technical and farm business management information on conservation. It also includes providing demonstration projects on conservation practices and equipment. Behaviour is modified through information and knowledge.

Regulations and standards is compliance driven. Examples include standards **on** permitted levels of sediment and phosphate loading. Compliance with environmental standards is difficult and expensive from both the cost of administration and compliance due to the need for extensive and reliable monitoring.

6.4 POTENTIAL POLICIES AND PROGRAMS FOR INCREASING ADOPTION OF CONSERVATION TILLAGE SYSTEMS

This section provides a number of policy or program options for enhancing the adoption rate of soil conserving technologies. These options are categorized on the basis of pricing, information and regulatory, and are not necessarily a comprehensive representation of all possible policies. Rather, the policies described in this section are presented for discussion only and should be considered a first step in challenging readers to think about alternative policies and programs which are practical and effective in this regard.

6.4.1 Pricing Programs

Provide Lower Cost Crop Insurance: One of the major constraints to the adoption of conservation technologies may be the perceived high financial risk associated with altering crop management approaches and utilizing new technologies. A specific concern is the uncertainty about crop yields associated with each tillage system. A program that would help to offset this particular uncertainty would be the introduction of lower cost crop insurance for crops produced by soil conservation technologies and methods. Another variant would be to modify the crop insurance program to provide a higher historic yield coverage factor.

Initiate Adjustment Assistance Programs: Given the factors of compatibility, substitution, complexity, and high investment costs, it may be necessary to introduce specific adjustment programs which address particular issues. Four examples of such programs are:

- Interest Free loans to farmers wishing to purchase new conservation equipment such as no-till planters or chisel ploughs;

- Tax Credits to farmers purchasing new conservation equipment and/or upon demonstrating crop management using soil conservation technologies;

- Rebates on Conservation Equipment; and/or

- Bonus Payments on crops grown under conservation systems, which would be based on volume of production grown under conservation. This would provide an incentive to maximize conservation benefits (yields).

Provide an Equipment Trade-in Program: As more farmers embrace the soil conservation philosophy and purchase new conservation equipment, the trade-in or salvage value of conventional tillage equipment will decline dramatically. Some farmers may have significant investment in conventional equipment and are unable to adopt conservation practices for this reason. A possible solution is to provide a program which supplements the trade-in of conventional equipment. This will increase the salvage value of conventional equipment and reduce the adjustment cost.

6.4.2 Information Programs

Make Conservation Equipment Available for Trial Use: The initial high cost of changing to conservation methods limits a farmers opportunity to experiment with specific conservation equipment for on-farm trials. An option is to make conservation equipment available, free of charge, for interested farmers wishing to explore the merits of selected technologies. Such a program would stimulate the trial stage of the IDP process and may lead to more full scale adoption of conservation practices.

Increase Extension Efforts: In an effort to address the issues identified under measurability, complexity and communicability factors, three possible programs and policies include:

! Continue/Expand Field Trials which demonstrate to farmers the merits and impact of soil conservation technologies and methods relative to conventional practices;

! Develop Site-Specific Decision Support Systems which will assist interested farmers in designing and selecting appropriate equipment and crop rotations for each field. This program may take the form of personalized counselling from OMAF or other innovators willing to share their experience and knowledge;

! Expand Educational Seminars/Innovator Testimonials which continue to report on successful results as well as help potential adopters to understand the strengths and weakness of various technologies and approaches to crop management; and

! Provide Farm Management Reports which outline the benefits of conservation practices. This would focus on the reduced costs, the yield impact and the environmental sustainability impact.

6.4.3 Regulatory Programs

Regulatory programs can be designed to result in the lower level of off-farm loadings. However, these are likely not practical given the costs of monitoring, and administration. A grower certification course on conservation practices is one idea worth considering since it would increase awareness and interest.

6.5 SUMMARY

Many of the programs outlined above may be more effective if implemented in combination with other programs. The details of each program and its execution requires more consideration. It would be desirable to do so within a structured consultation framework with farmers, industry leaders and government.

Each of the programs described above will have attendant costs as well as benefits. The macro-economic analysis clearly showed that there are positive downstream benefits from reducing soil loss. Consequently, it may be desirable for government, on behalf of taxpayers, to incur short term costs in assisting farmers to adopt soil conservation methods and technologies. Strategies to positively affect adoption of conservation practices are highlighted in the next section.

7.0 STRATEGIES TO ENHANCE CONSERVATION PRACTICES

Strategies used by the government to enhance soil and water conservation through the adoption of conservation practices should account for the adoption process model and the factors affecting adoption. This is the focus of this section.

7.1 IMPACT OF PROGRAMMING ON THE ADOPTION PROCESS

Government programming can directly influence the movement of producers from one stage of the adoption process to the next. Each programming approach has a different effect, as illustrated in Table 7.1.

Table 7.1 Impact of Programming Approaches on Adoption Process Stages

	Impact of Programming Approach on Adoption Stage		
Adoption Stage	Pricing	Information	Regulations
Awareness		X	X
Interest		X	X
Evaluation	X	X	X
Trial Use	X	X	X
Adoption	X		X

Pricing type programs, for example, do not increase awareness and interest. However, this type of programming is highly effective in moving an interested operator into the evaluation stage, or from the evaluation stage through to trial use or full scale adoption.

Information and extension programs are the only approach which directly impacts the first stages of the sequential adoption decision making process. Such programs enhance awareness and interest and can move an interested operator to the evaluation stage. Similarly, extension programs/field trials are effective methods to affect awareness through to trial use.

Regulatory programs can directly influence each stage of the adoption process.

7.2 IMPACT OF PROGRAMMING ON FACTORS CONSTRAINING ADOPTION

The discussion in the previous section described how the adoption of conservation practices can be hampered by many factors. Different programming approaches can have a differential impact on these constraining factors.

Table 7.2 is constructed to illustrate the importance of information and extension programming on reducing the negative effect of the many factors constraining adoption of conservation practices. This programming approach provides information to highlight the relative advantage, to improve on measurability of benefits by a grower, to reduce the potential complexity, to minimize the effect of divisibility, to improve the communicability of the benefits, to reduce the perceived risk, to offset the newness factor, and to reduce the investment time in understanding the new technology.

Table 7.2 Impact of Programming Approaches on Constraining Adoption Factors

	Impact of Programming Approach on Adoption Factors		
Adoption Factors	Pricing	Information	Regulations
Relative Advantage	X	X	
Measurability		X	
Compatibility	X		
Complexity		X	
Divisibility		X	
Reversibility			
Additive/Substitute			
Communicability		X	
Riskiness	X	X	
Age of Innovation		X	
Initial Investment	X	X	

Note: An "X" indicates the programming approach reduces the negative effect of the constraining adoption factor.

In contrast, pricing programs only have a direct effect on the relative advantage of conservation practices, compared to conventional technologies, the compatibility through reduced costs, a lowering of financial riskiness, and as an offset to the initial capital investment.

Regulatory programs do not appear to have a direct affect on these adoption factors.

7.3 PROGRAMMING MIX STRATEGY

The above suggests that the strategy could have the following elements:

(1) use information programs to enhance interest, awareness, evaluation and trial use, by reducing the negative impact of many of the factors affecting adoption;

(2) use pricing programs to move producers from the evaluation and trial use stages into full-scale adoption; and

(3) possible use of selected regulatory programs regarding minimum standards and which highlight the sustainability issues.

The challenge is to develop the appropriate program mix that is most cost-effective, and equitable and which is targeted to specific soil and water conservation issues in particular areas.

8.0 SUMMARY AND RECOMMENDATIONS

This report summarizes findings of an economic evaluation of soil tillage technologies tested within the SWEEP program. Several general conclusions regarding the results can be made:

- It pays to use soil conserving tillage technologies both from a field and watershed perspective. Specifically, the net benefits of reduced or no-tillage practices exceed the benefits of conventional tillage practices.

- The variability in field level results (i.e. yields) with conservation tillage is either equivalent to or less than the variability associated with conventional tillage practices. Consequently, the financial risk associated with conservation tillage is equivalent to and sometimes lower compared to conventional tillage.

- There is an inverse relationship between net watershed income and soil loss restrictions. However, the opportunity cost of soil loss restrictions is lower if farmers use soil conserving tillage technologies.

- There is likely very little impact that will accrue to farm input suppliers and processors as a consequence of greater adoption of soil conserving tillage practices.

- Significant cost savings to other "downstream" stakeholders will result from soil loss restrictions at the farm level. Consequently, the benefits of soil loss reductions are shared between many sectors of society (i.e. consumers, producers, taxpayers).

! There is a logical process for assessing the reasons for low adoption levels of soil conserving tillage technologies. It is necessary to better understand these issues and the critical linkages which affect adoption rates and levels.

! Several programs and strategies were presented for initiating some thought on how best to increase the adoption (uptake) of soil conserving tillage technologies.