

# NATIONAL SOIL CONSERVATION PROGRAM IN ONTARIO

## FINAL REPORT

### TABLE OF CONTENTS

|  | Page |
|--|------|
| 1. NSCP PROGRAM OVERVIEW .....                 | 1    |
| 2. DESCRIPTION OF THE FEDERAL PROGRAM .....    | 2    |
| 2.1 PERMANENT COVER PROGRAM .....              | 3    |
| 2.2 SOIL SURVEY SUB-PROGRAM OF NSCP .....      | 5    |
| 2.3 RESEARCH SUB-PROGRAM OF THE NSCP .....     | 6    |
| 2.4 MONITORING SUB-PROGRAM OF NSCP .....       | 8    |
| 2.5 AWARENESS SUB-PROGRAM OF NSCP .....        | 8    |
| 3. DESCRIPTION OF THE PROVINCIAL PROGRAM ..... | 9    |

## APPENDICES

### APPENDIX A

|                                  |    |
|----------------------------------|----|
| CANADA - ONTARIO AGREEMENT ..... | 15 |
|----------------------------------|----|

### APPENDIX B

|  |    |
|--|----|
| PERMANENT COVER BIDDING GUIDELINES AND DEMONSTRATION SITE<br>LANDOWNER AGREEMENT<br>GUIDELINES TAKEN FROM OSCIA IMPLEMENTATION AGREEMENT<br>TREE SERVICE MASTER CONTRACT: OMNR & OSCIA ..... | 16 |
|--|----|

### APPENDIX C

|  |    |
|--|----|
| PERMANENT COVER STATISTICAL<br>SUMMARY AND LIST OF DEMONSTRATION SITES ..... | 17 |
|--|----|

### APPENDIX D

|                                   |    |
|-----------------------------------|----|
| FINAL REPORT ON SOIL SURVEY ..... | 18 |
|-----------------------------------|----|

### APPENDIX E

|                                  |    |
|----------------------------------|----|
| FINAL REPORT ON MONITORING ..... | 19 |
|----------------------------------|----|

### APPENDIX F

|                                |    |
|--------------------------------|----|
| FINAL REPORT ON RESEARCH ..... | 20 |
|--------------------------------|----|

### APPENDIX G

|  |    |
|--|----|
| LAND STEWARDSHIP RESEARCH PROGRAM PROJECTS ..... | 21 |
|--|----|

## **1. NSCP PROGRAM OVERVIEW**

### **PURPOSE OF THE PROGRAM**

The overall purpose of the program was to encourage the implementation of appropriate soil resource management practices to maximize societal benefits and sustain the long-term productivity of the soil within practical economic limits and according to the soil's capability. Economic diversification was enhanced, where applicable, within the context of soil conservation activities.

In Ontario, the NSCP had several components. Permanent Cover Component was developed to assist in the implementation of on-farm conservation measures by providing financial incentives for farmers to retire sensitive land. The "awarenes" program fulfilled a much needed educational aspect. The research and monitoring provided a much needed feedback on the results of current practices and developmental methodologies to provide new ones.

### **ORIGIN**

This program was a national program resulting from an increased awareness of the necessity of a coordinated approach from all levels of government to coordinate activities pertaining to soil conservation.

This process resulted in an overall national review and consultations with provincial governments and farm organizations that was coordinated by the P.F.R.A. Programs were outlined on a provincial basis according to individual requirements.

### **CHRONOLOGY OF EVENTS**

A Treasury Board submission was accepted on September 15, 1988 and amended on August 23, 1989.

The Canada-Ontario Accord on Soil and Water Conservation was signed on October 12, 1989. This Accord was designed to act as an "umbrella" accord that would cover any type of soil and water activities jointly sponsored by Agriculture Canada and the Ontario Ministry of Agriculture and Food.

Funds expended by the Ontario Ministry of Agriculture and Food under the Land Stewardship Program prior to the signature of the Agreement were accepted as matching funds.

The Canada-Ontario Agreement was signed on April 9, 1990. (See Appendix A)

An implementation agreement was subsequently negotiated for the on-farm Permanent Cover Program with the Ontario Soil and Crop Improvement Association and signed on August 17, 1990. (See program guidelines in Appendix B)

The Canada/Ontario Environmental Sustainability Accord (COESA) was signed on October 27, 1992. The COESA Accord Committee assumed the responsibilities of Canada-Ontario Accord on Soil and Water Conservation Management Committee. The Implementation Committee reported to these Management Committees as required.

## 2. DESCRIPTION OF THE FEDERAL PROGRAM

The majority of the federal \$11.1 million budget focused on the protection of the agricultural lands most sensitive to erosion, using buffer strips along water courses and tree plantings on fragile land. This \$8.2 million "permanent cover" component was delivered by the Ontario Soil and Crop Improvement Association (OSCIA). In each of Ontario's 55 counties, OSCIA established a committee of local farmers to set local priorities and rule on applications and bids under the NSCP.

The remaining \$2.9 million was used for research, soil monitoring, and conservation awareness projects, which were being carried out by Agriculture Canada.

### AGREEMENT PROGRAMS AND PROJECTED EXPENDITURE

| Program Elements                     | Federal (\$000) | Provincial (\$000) |
|--------------------------------------|-----------------|--------------------|
| Permanent Cover Program              | 8,250           | 0                  |
| Monitoring, Research And Soil Survey | 2,400           | 0                  |
| Awareness                            | 450             | 0                  |
| Research                             | 0               | 750                |
| Extension                            | 0               | 500                |
| Financial Assistance                 |                 | 9,850              |
| Total                                | 11,100          | 11,100             |

### ACTUAL FEDERAL EXPENDITURES

| Activity                            | 1989-90 | 1990-91   | 1991-92   | 1992-93   | Total     |
|-------------------------------------|---------|-----------|-----------|-----------|-----------|
| Permanent Cover Program             | 0       | 791,750   | 2,644,195 | 3,366,523 | 6,802,468 |
| Monitoring Research And Soil Survey | 0       | 530,000   | 960,000   | 909,500   | 2,399,500 |
| Awareness                           | 39,600  | 33,970    | 41,650    | 52,960    | 168,180   |
| Sub-Total Federal                   | 39,600  | 1,355,720 | 3,645,845 | 4,328,983 | 9,370,148 |

## 2.1 PERMANENT COVER PROGRAM

The Permanent Cover Program of the National Soil Conservation Program (Ontario) was developed to assist in the implementation of on-farm conservation measures by funding buffer strips along water courses, tree plantings on fragile land, and retirement of flood plains.

There are three parts to this section of the program:

- a) Education through Demonstration Sites  
- **Original Allocation - \$605,000**
- b) Administration  
- **Original Allocation - \$2,060,000**
- c) Financial Incentives for Permanent Cover  
- **Original Allocation - \$5,585,000**, divided amongst counties on the basis of row crop acres.

### Administration

Agriculture Canada signed a contribution agreement with OSCIA to deliver the permanent cover portion of the program at the local level. Committees representative of the farm community were established in each county/district to review projects eligible for contributions under the permanent cover portion of the program. Project proposals were submitted on a bid/tendering basis to local committees of the Ontario Soil and Crop Improvement Association (OSCIA). Local OSCIA committees examined each applicant's proposal (bid), approving only those which offered highest value per dollar of contribution.

### PERMANENT COVER PROGRAM DESCRIPTION AND RESULTS

Up to \$10,000 per farmer was available under this three-year program. Producers could receive funds for retiring and protecting fragile land, especially farmland adjacent to streams and open ditches. This protected land will act as a shield from land that is under agricultural production and will help reduce erosion and chemical runoff. Eligible projects can include a number of program components, including 8 to 20 foot buffer strips with permanent grass and/or trees, enhanced buffers, block plantings of trees up to 20 acres on highly erodible and/or fragile land, and flood plains. Long-term agreements of 5, 10, 15 years were signed with recipients and over 90% of these were for 15 years. See Appendix C for details by project type and counties.

In total there were 1226 projects covering 5016 acres at an average cost of \$979/acre for a total expenditure of \$4,910,658.82. This represents 87.9% of the \$5.585 million originally allocated.

- Assuming a 16 foot (5 meter) width, over 1000 miles (1600 kilometres) of buffer strips were established.
- Of over 2,000 bids submitted, 1226 were approved.
- Flood plain retirement accounted for 74 projects on 570 acres (231 hectares)
- NSCP helped farmers plant 2.5 million trees on fragile farmland.
- NSCP helped establish 25 miles (42 kilometres) of windbreaks.

**Demonstration Sites**

Financial assistance was made available through the NSCP to establish demonstration sites. A maximum of \$20,000 per site, to a maximum of \$605,000 across Ontario was available. These demonstration sites focused on the retirement of fragile lands through permanent cover, targeted toward buffer zones adjacent to streams and watercourses, highly erodible sloping land and flood plains.

The OSCIA was responsible for reviewing and approving these demonstration site proposals. A Demonstration Site Approval Committee was established for this purpose. Applicants submitted a detailed project proposal including project plan, demonstration value, cost-benefit analysis and institutional involvement. Eligible applicants included Municipalities, Universities and Colleges, Conservation Authorities, government ministries, farm organizations and non-government agencies. See Appendix C for complete list of demonstration site locations.

- 31 projects were implemented with a total contribution of \$341,000
- 5 grass buffers, 5 grass and tree buffers, 10 highly erodible land, 5 floodplain, 5 enhanced buffers and one wetland buffer were established as demonstration sites.

**ONTARIO MINISTRY OF NATURAL RESOURCES CONTRIBUTION TO TREE PLANTINGS UNDER NSCP**

The tree plantings that occurred under NSCP were successful due to the cooperative approach taken by the Ontario Ministry of Natural Resources, the Ontario Ministry of Agriculture and Food, the OSCIA and Agriculture and Agri-Food Canada.

In 1990, the Ontario Ministry of Natural Resources (MNR) signed an agreement with the Ontario Soil and Crop Association (OSCIA) to supply nursery stock and the expertise to establish trees on fragile agricultural land. See Appendix B for details of master contract. The price to be paid for tree establishment service was based on the actual MNR costs incurred for tree planting on private land. Landowners paid for their Tree Service Contracts to OSCIA who in turn authorized MNR to establish the trees as outlined in the Tree Planting Plan. At the end of each planting season a summary of trees established was sent by MNR to OSCIA who then reimbursed the Minister. The price paid was \$0.85 per tree.

For this amount the Ministry carried out the following services:

1. Site visits were made to determine the tree requirements.
2. Suitable nursery stock was supplied.
3. Site preparation was carried out.
4. Trees were planted.
5. Vegetative competition was controlled.
6. Assessments were made to ensure establishment.

The tree handling, planting and tending standards adhered to were those in effect for regular MNR tree planting projects.

Tree establishment accomplishments under MNR were as follows:

| <b>Year</b> | <b>Trees</b> | <b>Dollars (+ GST)</b> |
|-------------|--------------|------------------------|
| 1992        | 445,166      | \$404,877              |
| 1993        | 297,575      | \$270,644              |
| 1994        | 11,400       | \$ 10,468              |
|             | 754,141      | \$685,889              |

**2.2 SOIL SURVEY SUB-PROGRAM OF NSCP**

**BACKGROUND**

The soil survey upgrade sub-component had a budget of \$ 200,000 and was administered by the head of the federal soil survey unit in Guelph. The purpose of the National Soil Conservation Program (NSCP) Soil Survey component was to promote a standard compilation of information on the quality, extent and location of agricultural lands in Ontario to provide standard reference data for policy, planning and extension initiatives. The soil survey upgrade sub-program was given a budget of \$ 200,000 over the three year duration of the program.

There were three areas of activity under this sub-program. The first was the development of an overall approach to soil survey information in the province. This included critical assessment of the requirements for the information and guidelines for upgrading surveys which were inadequate. This activity was carried out in-house with a great deal of consultation with associated agencies. The second activity consisted of several small projects conducted in-house to speed up the development of a generalized provincial level soil survey map for broad scale planning at regional, provincial and national levels. This activity also included a completion of data compilation for a detailed soil re-survey map and report. The third activity dealt with the need to upgrade substantial areas of the province for which the current soil survey information is inadequate. The requirements for additional information to bring the survey up to modern requirements were defined and developed into "statements of Work" which formed part of requests for proposals.

The following three proposals were funded for a total cost of \$125,000:

- 1) Application of Geographic Information Systems (GIS) for Soil Survey Upgrading in Ontario University of Guelph
- 2) Development, Evaluation and Demonstration of Soil Survey Upgrade ; Upper Thames River Conservation Authority
  - Phase 1:** Evaluate GIS and digital elevation technology compared to conventional air photo interpretation to assign slope classes and proportions to existing soil polygons in the Oxford County pilot study area
  - Phase 2:** Preparation of a multi-county digital soil map for Oxford and adjacent counties
- 3) **Unsolicited Proposal:** Research and Development of a Methodology for Soil Survey Upgrade and an Information System; Gregory Geoscience.

The remainder of the funds were used to support in-house projects to prepare generalized detailed maps and reports.

### **2.3 RESEARCH SUB-PROGRAM OF THE NSCP**

The purpose of the National Soil Conservation Program (NSCP) Research Component was to encourage research related to soil management practices toward the long term productivity of soil. The research sub-program was given a budget of \$1.1 million for the two year duration of the program. The Research component of the program was administered for Agriculture Canada by the Harrow Research Station. The key processes of land use, tillage practices and cropping systems that result in changes in soil quality were studied in terms of the sensitivity of soil to degradation, the conditions under which degradation occurs and its impact on productivity. A major task was research into changes in soil organic matter, nutrients, erosion, and pesticide levels related to land use, tillage practices and cropping systems for intensively cultivated land.

The initiation of the process to handle this component began in the fall of 1990. Dr. W. I. Findlay was appointed Scientific Authority for the solicitation of proposals for Soil Conservation Research. Through numerous committee meetings and with the assistance of individuals from the private sector, university, OMAF and Agriculture Canada, areas of concern were consolidated to issues which were subsequently developed into a "Statement of Work: which would be part of the Request for Proposals (RFP). Proposals totalling \$4.45 million were submitted for consideration against the \$1.1 million available. A rigorous review system, often involving out of province referees, was used with a preplanned evaluation criteria form. Twenty-nine referees were involved in the initial cut prior to committee prioritization. Six proposals were selected for contract, three for in-house support and two for contribution agreements. In addition, a literature search on buffer strips was supported. All of this effort was completed before Dr. Findlay announced his pending retirement in the late spring of 1991. His dedication and thoroughness as Scientific Authority set the stage and paved the way for the smooth running administration of these research projects.

Projects were carried out by Agriculture Canada, universities, colleges or other agencies.

#### **RESEARCH AREAS**

1. The following areas of research were considered for support:
  - (a) the development of soil management systems that protect fragile land and improve the environment, and are economically viable
  - (b) the development of indicators of degradation or conservation that can be used in monitoring the resource base
  - (c) development of methods to improve the transfer of conservation technology, e.g. "expert systems".
2. Preference was given to projects which were complementary to ongoing Federal and Provincial related research activities in soil and water conservation e.g. Soil and Water Environmental Enhancement Program (SWEEP), Great Lakes Water Quality Agreement and the Land Stewardship Program.

3. Preference was given to extend existing research projects, as compared to starting new research projects.
4. Preference was given to projects where there was good potential for commercial application of specific research results that had high potential for improvement of soil and environmental quality.

Out of 48 proposals seeking \$4.5 million, the available \$1.1 million, the following research was carried out and reported on:

**PART I - RESEARCH CONTRACTS THROUGH SSC**

## Project A

Soil Macropore Structures and Their Effect on solute Transport to Tile Drains

## Project B

Manure Management to Sustain Water Quality

## Project C

Prediction of Crop Responses to Changes in Soil Quality

## Project D

Influence of Soil Management Systems on Soil Quality

## Project E

Methodologies for Assessing Soil Structure (Degradation) in a Meaningful Way

## Project F

Open Category RFP under the NSCP Research Program  
The Effect of Soil Quality on Field Scale Runoff under Conventional and Conservation Tillage Systems  
Literature Review Pertaining to Buffer Strips

**PART II - IN-HOUSE RESEARCH**

## Project G

Soil Macropore Development as a Mechanism for Root Distribution and Solute Transport  
Rainfall simulator - Grid Lysimeter System for Preferential Solute Transport Studies Using Large, Intact Soil Blocks

## Project H

Composting Manure as a Means of Sustaining Air and Water Quality

## Project I

Prediction of Crop Seedling Responses to Changes in Soil Quality

## Project J

Soil Biota as Indicators of Soil Quality

## Project K

Methodologies for Assessing Soil Organic Matter Sustainability

## PART II - CONTRIBUTIONS TO ON-GOING PROJECTS

The Relationship between Landscape Position, Tillage Practices, and Soil Loss: Model Development  
Methodologies for Assessing Soil Structure and for Predicting Crop Response to Changes in Soil Quality

Additional information may be found in Appendix E

### 2.4 MONITORING SUB-PROGRAM OF NSCP

The Soil Quality Evaluation Program was initiated in 1989 in response to a requirement of NSCP to monitor soil and associated environmental quality for the agricultural soils in Canada. Considerable funding (\$1.1 million from Ontario) for the first three years of this program provided through the NSCP has allowed the Research Branch (CLBRR) the opportunity to more rapidly develop this program and to provide for its continuation beyond NSCP.

The first three years has seen the development of a conceptual framework for the evaluation of soil quality and a Geographic Information System (GIS) capability for regional and national assessments of soil and environmental quality. A primary focus of the program has been on assessing the susceptibility to change in soil quality through the development of improved capabilities to predict soil loss from wind and water erosion, change in the quality and quantity of soil organic matter, change to soil salinity and soil structure, and the impact of agricultural chemicals on soil and groundwater. A land use analysis capability has been established as a means for integrating farming practices and soil quality change and a network of soil quality benchmark sites provide a validation capability for the predictive systems. Finally, enhanced capabilities to evaluate the impact of soil quality change on soil productivity have been developed as a first step toward the evaluation of soil quality within the context of sustainable land management.

### 2.5 AWARENESS SUB-PROGRAM OF NSCP

Early in the awareness program approximately \$40,000 was transferred to headquarters for National Awareness activities. A contract was signed with Ginty Jocius and Associates. Awareness activities were then coordinated by Ginty Jocius and Associates and the OSCIA.

The following is an outline of Awareness activities:

#### 1. OSCIA Program Division Staff Training

# NSCP training for OSCIA Field Staff

#### 2. Program Description and Guidelines

# Pre-packaged kits available through OSCIA and local OMAF offices

# NSCP pamphlet available for wide distribution

# Available in English and French

#### 3. Provincial Promotion (orchestrated by Ginty Jocius and Associates)

# Media Release

# Print Advertisement in "Farm and Country", "Ontario Farmer" and "Agri-Comm". The major ad ran prior to each of the three submission deadlines.

- # NSCP letterhead provided for program correspondence
- # "Farm and Country" newspaper articles describing NSCP opportunities and typical achievements
- # 800 standard metal signs prepared to identify NSCP farm projects

#### 4. Local Promotion

- # NSCP was part of local Land Stewardship II workshops held in each county/district.
- # Standard slide set provided to each county/district
- # Colour overhead transparency set made available for sign-out by OSCIA Committees for local program promotion

#### 5. Demonstration Projects

- # Thirty-one farm demonstration projects established across the province with assistance provided by local partners. (e.g. Conservation Authorities, MNR, OMAF, County/District SCIA)
- # Demonstrations were highlighted in the booklet "Conservation Solutions on Fragile Agricultural Land". The booklet was used as resource material for the launch of the Permanent Cover II program.

### 3. DESCRIPTION OF THE PROVINCIAL PROGRAM

The Ontario Ministry of Agriculture and Food's (OMAF) contribution to the National Soil Conservation Program (NSCP) was stewardship practices funded by one year of the Land Stewardship Program (LSP). This program provided grants for the adoption of conservation farming practices that will enhance and sustain agricultural production and improve soil resources and water management by: reducing soil erosion and soil compaction, restoring soil organic matter levels and structure, and minimizing potential for environmental contamination from agricultural practices.

#### **OMAF provided:**

##### **I. Financial Assistance for Erosion Control**

Grants were provided to farmers to adopt conservation practices on Ontario farmland. These practices will enhance and sustain agricultural production as well as improve and protect soil and water resources.

Grants were available for:

- A. Soil Building
- B. Machinery and Equipment
- C. Education Courses

**PROVINCIAL FINANCIAL ASSISTANCE  
FOR EROSION CONTROL 1990-91**

|                         |  |             |
|-------------------------|--|-------------|
| Soil Building           | A-1 - Crop Rotation  | \$3,791,300 |
|                         | A-2 - Residue and Crop Cover                                 | 3,349,700   |
|                         | A-3 - Trees  | 152,000     |
|                         | A-4 - Stewardship Lease                                      | 493,100     |
| Machinery and Equipment | B-1 - Residue Management Equipment Rental                    | 179,400     |
|                         | B-2 - Residue Management Equipment Modification and Purchase | 1,030,300   |
| Education Courses       | C-1 - Conservation Training                                  | 25,900      |

## II. Research

Research projects relating to stewardship practices were solicited by OMAF and funded through the Agricultural Institute of Ontario. One third of the projects were OMAF's contribution to NSCP. (See Appendix G for details)

## III. Extension

Twelve new staff worked with 14 existing soil conservation advisors at OMAF field offices to counsel farmers on land stewardship practices, administer grants under the LSP and provide support for the NSCP.

## IV. Administration

An annual grant was given to the Ontario Soil and Crop Improvement Association (OSCIA) to cover costs to establish and administer committees in each county/district. These local committees reviewed and recommended projects for funding and hired part-time staff to assist in promoting and implementing the program.

## Terms

Projects were funded on a county/district basis by the OMAF. Expenditures were based on soil improvements and water quality enhancement as outlined in the applicants Land Stewardship Inventory and Action Plan, a farm profile accompanying the application.

Funds were allocated on a row crop acre basis. An applicant could apply for up to a grant maximum of \$30,000.

The Inventory and Action Plan detailed past land management practices, existing problems and planned future management practices that indicate a new and long term land stewardship approach is being adopted.

**ACTUAL PROVINCIAL EXPENDITURES**

| Activity                | 1989-90 | 1990-91    | 1991-92 | 1992-93 | TOTAL      |
|-------------------------|---------|------------|---------|---------|------------|
| Research                | 0       | 929,200    | 0       | 0       | 929,200    |
| Extension               | 0       | 468,700    | 100,000 | 100,000 | 668,700    |
| Financial Assistance    |         |            |         |         | 9,612,100  |
| Soil Building           | 0       | 7,786,100  | 0       | 0       |            |
| Machinery and Equipment | 0       | 1,209,700  | 0       | 0       |            |
| Education Courses       | 0       | 25,900     | 0       | 0       |            |
| Administration Costs    | 0       | 590,400    | 0       | 0       |            |
| Sub-Total Provincial    |         | 11,010,000 | 100,000 | 100,000 | 11,210,000 |

**I. FINANCIAL ASSISTANCE consisted of grants for:**

- A. Soil Building (Improvement and Maintenance)
- B. Conservation Machinery and Equipment
- C. Conservation Education (Technical Training)

**A-1 Crop Rotation**

To encourage the planting of forage grasses and legumes or plow down crops in rotation on soils showing signs of soil degradation and erosion, assistance was available to improve soil structure.

The same assistance was available to establish buffer strips on previously tilled land adjacent to streams, watercourses and field boundaries. Up to 30% of the applicants previously tilled acreage qualified. The grant rates for perennial and annual forage grasses, legumes and plow down crops are found in the county/district variable rate table.

**VARIABLE RATE TABLE**

| COUNTIES/DISTRICTS |   | RATES-DOLLARS PER ACRE |                |                   |        |    |                     |        |
|--------------------|---|------------------------|----------------|-------------------|--------|----|---------------------|--------|
|                    |   | Establishment Year     |                | No Off-Farm Sales |        | OR | With Off-Farm Sales |        |
|                    |   | Seeding                | Over-wintering | Year 1            | Year 2 |    | Year 1              | Year 2 |
| Group I            | Kent, Essex, Lambton, Elgin, Oxford, Middlesex  | \$15                   | \$15           | \$60              | \$70   | OR | \$25                | \$35   |
| Group II           | Huron, Perth, Brant, Haldimand-Norfolk, Hamilton-Wentworth, Niagara, Waterloo   | 15                     | 15             | 50                | 60     | OR | 20                  | 30     |
| Group III          | Peel, Stormont, Dundas, Glengarry, Bruce, Prescott, Ottawa-Carleton, Grenville, Durham, York, Halton, Victoria, Northumberland, Wellington, Russell   | 15                     | 15             | 40                | 50     | OR | 15                  | 25     |
| Group IV           | Peterborough, Simcoe, Frontenac, Lanark, Lennox-Addington, Grey, Leeds, Hastings, Dufferin, Renfrew, Prince Edward, Parry Sound, Sudbury, Rainy River, Temiskaming, Nipissing, Haliburton, Manitoulin, Cochrane, Thunder Bay, Muskoka, Kenora, Algoma | 15                     | 15             | 30                | 40     | OR | 15                  | 20     |

**A-2 Residue and Crop Cover**

To increase residue an applicant was paid a grant of \$20 per acre when 20% of the surface area for each acre is covered with residue from the previous crop immediately after planting. Up to 30% of the applicants tilled acreage from the previous year qualified.

**A-3 Trees**

To promote tree planting, grants were available to: retire fragile lands, encourage long term commitment to agri-forestry including intercropping of trees with commercial crops or to diversify crop production.

To reforest five or more tilled acres, a grant of up to \$220 per acre was available to cover costs of establishment of a forest species. A grant of \$100 per acre per year for the balance of the program was available to cover the cost of a well maintained planting.

For shelterbelts, windbreaks and plantings under five acres or intercropping with commercial crops, a rebate of purchase price and planting costs was spread over two years-65% during the planting year

and 35% in the second year for well maintained plantings. Maximum claim for stock and planting costs was not to exceed reasonable market value of planting 3 year old nursery stock.

#### **A-4 Stewardship Lease**

To encourage landlords to require tenants to farm their land under a land stewardship plan, a grant of \$10 per acre was paid to the landowner when the land was leased under an approved minimum land stewardship lease. The maximum grant available was \$3000 per applicant.

#### **B-1 Residue Management Equipment Rental**

To encourage the use and adoption of residue management equipment, grants of 80% of the 1987 rental or custom rates for residue management equipment were available. This covered up to a maximum of \$3000 per applicant.

#### **B-2 Residue Management Equipment Modification and Purchase**

To assist in modification of existing equipment to handle residue management or to purchase equipment for residue management, a grant of two-thirds of the cost to a maximum of \$3000 was available per applicant.

#### **C-1 Conservation Training Courses**

To support training, assistance was available for participants in conservation farming training courses as approved by OMAF.

A grant was available to cover up to 100% of tuition, 80% of travel costs and \$50 per day for the applicant's time upon successfully completing the course.

To ensure the proper set up and operation of conservation tillage equipment on an applicant's premises, assistance was available from a qualified farmer or technician.

The grant covers 90% of the cost up to \$200 per day for each type of equipment to a maximum two days per type of equipment to a maximum of six days per applicant.

A Land Stewardship Course Manual was produced that outlined the materials to be included in any educational course offered.

**II. RESEARCH was funded by OMAF through a Land Stewardship Research Fund administered by the Agricultural Research Institute of Ontario (ARIO).** The Land Stewardship Research Program is intended to assist in achieving the goals of the overall NSCP by adding to the current base of knowledge and by assisting extension staff with recommendations and farmers in the adoption of conservation practices. Total funds available over the three year period is \$2.8 million of which one-third is matching funds for NSCP i.e. \$929,200.

#### **RESEARCH AREAS consisted of the following:**

- a) Practical, cost-effective stewardship cropping systems to improve and maintain soil structure through crop rotation, crop cover during critical soil movement periods and residue management. Projects included practical cost-effective alternatives to monoculture through such practices as ground cover at appropriate periods of the year when there is potentially a high incidence of soil

movement/structure through crop and tillage selection and management practices, nutrient management and organic amendments for a wide range of soil types and climatic conditions.

- b) Options for Marginal and lowland areas to encourage farmers to take cropland (especially Classes III and IV) out of production and to return that land base to pasture and/or woodlot, and considering the length of time needed to establish the latter, the possibilities of wide-row spacing of hardwood species intercropped with cash crops could provide the best of both alternatives.

Many parcels of land in Ontario, characteristically dry in the summer months, are often too wet to provide optimum conditions for planting in spring.

Projects included the need to explore alternatives for improving productivity of such marginal areas and to study the economic and agronomic viability of such operations.

- c) Streambank stabilization and buffer strips to stabilize watercourse banks (e.g., permanent, intermittent, drainage ways) is of prime interest if we are to properly and adequately control soil erosion by water.

Projects included the study not only to the various vegetative species (e.g., grasses, shrubs, trees) but also such parameters as accessibility routes for watercourse maintenance, maintenance equipment and techniques and design criteria for the bank areas.

- d) Windbreaks and Shelterbelts to assess the various parameters of windbreak plantings, including economics, species, spacing, harvestability of shelterbeds (e.g., Christmas trees) and impact on wildlife habitat and crop productivity.

Projects included comparative documentation on the survival and growth rates of bare root seedlings versus container stock seedlings to determine if demand can be met by container stock.

**III. THE EXTENSION program consisted of the equivalent of 12 Soil Conservation Advisors** who were hired and with the existing Soils and Crops Specialists assisted in the delivery of the federal and provincial programs. Ontario provided field staff for erosion control, conservation cropping, soil quality monitoring and the stewardship ethic for the duration of the NSCP. These staff resources were distributed across the province to maximize their effectiveness in delivering the combined program.

**IV. The Ontario Soil and Crop Improvement Association administered the OMAF component of NSCP** through local committees in each count/district in the province. The committees reviewed and recommended projects for funding and worked with the Soil Conservation Advisors to promote and implement the program.

**APPENDIX A**

**CANADA - ONTARIO AGREEMENT**

**CANADA-ONTARIO  
AGREEMENT ON SOIL CONSERVATION**

This Agreement made this 9<sup>th</sup> day of April, 1990.

BETWEEN: Her Majesty the Queen in Right of Canada  
(referred to as "Canada") , represented by  
the Minister of Agriculture.  
OF THE FIRST PART

AND: Her Majesty the Queen in Right of the  
Province of Ontario (herein referred to  
as "Ontario"), represented by the Minister  
of Agriculture and Food.  
OF THE SECOND PART

WHEREAS the Parties have signed a Canada-Ontario Accord on Soil and Water Conservation and Development pursuant to the National Agriculture Strategy; and

WHEREAS the said Accord calls for agreements or other instruments to effect its implementation; and

WHEREAS the Governor-in-council, by Order-in-Council 1988-1/2211 of the 22nd day of September, 1988, has authorized the Minister of Agriculture to execute this Agreement on behalf of Canada; and

WHEREAS the Lieutenant Governor-in-Council, under the Land Stewardship Program being Order-in-Council O.C. 511/88 dated March 9, 1988, has authorized the funds required to be contributed by Ontario under this Agreement.

NOW THEREFORE the Parties hereto agree as follows:

Section 1 - Definitions

- 1.1 "Ministers" refers to the Federal and Provincial Ministers who are signatory to this Agreement.
- 1.2 "Federal Minister" means the Minister of Agriculture and includes any person authorized to act on the Minister's behalf.

- 1.3 "Provincial Minister" means the Minister of Agriculture and Food and includes any person authorized to act on the Minister's behalf.
- 1.4 "Management Committee" means the federal and provincial officers designated by the Federal and Provincial Ministers to manage this Agreement as established by Article 3.1 of this Agreement.
- 1.5 "Work Plan" means a multi-year plan that sets out the federal and provincial action plans and resources for any particular program initiative.
- 1.6 "Accord" means the agreement between the Government of Canada and the Government of the Province of Ontario dated October 12, 1989.

## SECTION 2 - PURPOSE AND OBJECTIVES

- 2.1 The goal of this agreement is to define the activities, coordination processes and resource commitments by Canada and Ontario in the areas of soil conservation as outlined in this document.
- 2.2 The overall purpose of these activities is to encourage the implementation of appropriate soil resource management practices to maximize societal benefits and sustain the long-term productivity of the soil within practical economic limits and according to the soil's capability. Economic diversification will be enhanced, where applicable, within the context of soil conservation activities.
- 2.3 The objectives of the initiative undertaken pursuant to this agreement shall be to:
- (a) Facilitate the reduction of soil degradation on individual farm units and effect land use changes in order to maintain or enhance the productivity of the soil resource and to reduce the off-farm impacts of degradation.
  - (b) Extend the knowledge of soil conservation technology, practice and soil quality trends and enhance the transfer of this information to the farming community.
  - (c) Increase the awareness and understanding among farmers of soil degradation and conservation, and encourage their early adoption of soil stewardship ethic and conservation practices.

- (d) Foster a long-term soil conservation ethic in society to obtain public understanding and support in the protection of the soil resource.
- (e) Enhance economic diversification, where applicable, within the context of effective soil conservation.

### SECTION 3 - IMPLEMENTATION AND MANAGEMENT

- 3.1 The parties agree forthwith upon the execution of this Agreement to establish a Management Committee which shall be composed of 2 officials designated by Canada and 2 officials designated by Ontario. Each party shall have the right to appoint one of its designated officials as Co-Chairperson of the Management Committee. The Management Committee shall implement the Accord and this Agreement and shall perform the duties listed in 3.2.
- 3.2 In addition to the duties defined in the above noted Accord, the Management Committee shall:
- (a) ensure that the intent and the terms and conditions of this Agreement are carried out;
  - (b) develop a Work Plan, as described in Section 4, required to implement the intent of this Agreement;
  - (c) jointly review the Work Plan on an annual basis including proposed expenditures for planning activities and amend as necessary;
  - (d) ensure that program visibility is consistent with the division of funding as defined in Section 6.2 and 6.4.3 of the Accord;
  - (e) coordinate activities with other departments, ministries, and agencies within their respective governments; and
  - (f) establish advisory and coordination committees, as required, or request the presence of representatives from other departments, ministries or agencies, including non-governmental bodies, where it is considered by the Management Committee that their presence would contribute to effective implementation.

## SECTION 4 - WORK PLANS

- 4.1 Canada and Ontario agree to undertake an ongoing work planning process for the implementation of this Agreement. A multi-year Work Plan shall be developed and reviewed annually and amended as required by the Management Committee.
- 4.2 The Work Plan, provided in Schedule "A", defines the principles, resource commitments, activities and delivery arrangements for this Agreement.
- 4.3 The Work Plan shall be reviewed annually to reflect changing priorities and cash flow requirements. Approval of the Work Plan shall be evidenced by the signatures of the Management Committee Co-chairpersons.
- 4.4 The Work Plan may include, but is not restricted to, details for each activity recognizing that a broad range of actions is necessary for a balanced and comprehensive soil conservation program. These activities may include: data collection monitoring, research, awareness, regulation, demonstration, education and assistance to producers. Information provided for each activity may include:
  - (a) a complete description;
  - (b) resource commitments by each party; and
  - (c) roles of each party and the responsibility for delivering services.
- 4.5 The Work Plan will be developed in consultation with relevant departments, ministries, agencies, and producer organizations as appropriate.
- 4.6 The Work Plan shall accommodate, to the extent possible, the goals and objectives of relevant departments, ministries, agencies, and producer organizations; and off-farm interests.

## SECTION 5 - FINANCIAL PROVISIONS

- 5.1 Subject to the Work Plan developed pursuant to this agreement, and subject to the funds being made available by the Parliament of Canada, the maximum contribution by Canada in respect of this Agreement shall not exceed \$11.1 million.

- 5.2 Subject to the work plan developed pursuant to this Agreement, and subject to funds being made available by the Legislature of Ontario, the maximum contribution by Ontario in respect of this Agreement shall not exceed \$11.1 million.
- 5.3 Provided that all other terms of this Agreement are complied with, the parties agree to match each others contribution under this Agreement.
- 5.4 Each party shall be responsible for financing its respective activities as defined in the Work Plan.
- 5.5 The financial provisions to be addressed in the Work Plan will include:
  - (a) the implementation responsibilities of each party and the resources to be committed by each party annually and
  - (b) clear identification of the costs which will be regarded as a contribution under this Agreement.
- 5.6 Organizations in Ontario will be designated by mutual agreement of the parties to receive and administer funds provided under this Agreement.
- 5.7 Each party may sign agreements or contracts with private or non-agricultural organizations, in order to carry out the intent of this Agreement.
- 5.8 Every effort will be made to harmonize federal and provincial procedures in dealing with local organizations.
- 5.9 Each party shall maintain detailed and accurate records of costs categorized as a contribution under this Agreement and will make the same available at all reasonable times for inspection and audit by the other party.
- 5.10 Notwithstanding the fact that both parties are represented by their respective Ministers, monies may be allocated from other departments, ministries and agencies to fulfil obligations under the Canada-Ontario Agreement on Soil Conservation. Such sources of funding and/or resources shall be duly identified in the Work Plan.

- 5.11 Each party agrees to obligate recipients of funds pursuant to this Agreement to repay overpayments, unspent balances and disallowed expenses and make a declaration that such amounts constitute debts due the Crown and to use its best efforts to collect all such sums.

## SECTION6 - PUBLIC INFORMATION AND PARTICIPATION

- 6.1 Canada and Ontario agree to cooperate in the development of public information programs respecting the implementation of this Agreement.
- 6.2 All public information activities undertaken in connection with this Agreement by either or both parties shall clearly make reference to this Agreement and fully and fairly reflect the contribution of each party.
- 6.3 Public information activities carried out under this Agreement will bear a joint logo and name, in size and place, to be agreed on.
- 6.4 All public information activities for jointly funded programs will be approved by both parties in advance. The use of both official languages shall be mandatory for information released to the general public under jointly funded programs. This does not apply to publications of a scientific or technical nature.
- 6.5 Major announcements will be approved by the Ministers, will give equal prominence to both parties and will be issued simultaneously.
- 6.6 The release of any information under this Agreement shall be subject to the Access to Information Act and the Privacy Act of Canada.

## SECTION7 - GENERAL PROVISIONS

- 7.1 No member of the House of Commons or the Senate shall be admitted to any share or part of any contract, agreement or commission made pursuant to this Agreement or to any benefit to arise therefrom.
- 7.2 Nothing in this Agreement is to be construed as authorizing one party to contract or to incur any obligation on behalf of the other.

- 7.3 In managing this Agreement, the Management Committee will recognize and adhere to the federal environmental assessment and review process and the provincial environmental acts, policies, and procedures.
- 7.4 This Agreement may be amended by written agreement of the Ministers, except for the financial limitations expressed in Section 5. Amendment of Section 5 may be made with the approval of the Governor-in-Council and the Lieutenant Governor-in-Council of Ontario.
- 7.5 All property, including patents, copyrights and other intellectual property and any revenue acquired through this Agreement which is attributable to Canada shall be disposed of in a fashion determined by the Federal Minister. All property, including patents, copyrights and other intellectual and any revenue acquired through this Agreement which is attributable to Ontario shall be disposed of in a fashion to be determined by the Provincial Minister.
- 7.6 Schedule "A" attached hereto forms a part of this Agreement.
- 7.7 This Agreement shall be construed in accordance with the law of Ontario.
- 7.8 If any dispute arises as to the interpretation or application of this Agreement in respect to any matter, if the matter in dispute cannot be resolved by the Ministers, the parties will by appropriate agreement submit the matter in dispute to the Federal Court of Canada for determination.

## SECTION 8 - DURATION

- 8.1 This Agreement shall remain in effect until March 31, 1993. Notwithstanding the foregoing either party may terminate this Agreement at the end of any fiscal year, by giving to the other party a full fiscal year's notice in writing of such termination.
- 8.2 No activity may be approved after the expiration date of this Agreement and no costs incurred later than March 31, 1994 may be considered as costs which will be regarded as a contribution under this Agreement.

IN WITNESS WHEREOF, this Agreement has been executed on behalf of Canada by the Minister of Agriculture and on behalf of Ontario by the Minister of Agriculture and Food.

IN THE PRESENCE OF

GOVERNMENT OF CANADA

---

Witness

---

Minister of Agriculture

Dated: April 9<sup>th</sup>, 1990

GOVERNMENT OF ONTARIO

---

Witness

---

Minister of Agriculture and Food

Dated: April 3<sup>rd</sup>, 1990

**SCHEDULE "A"**  
**CANADA-ONTARIO SOIL CONSERVATION WORK PLAN**

This Work Plan, signed pursuant to the Canada-Ontario Agreement on Soil Conservation, defines the activities and level of resource commitment by both levels of government to soil conservation. It covers a three year period, subject to Section 8.1 of the Agreement, and is intended to be updated as necessary.

**SECTION 1 - PRECEPTS AND UNDERSTANDINGS**

This Work Plan recognizes certain precepts and understandings:

- (a) Canada desires to emphasize its activities with respect to the long-term objectives of securing soil resources through the National Soil Conservation Program.
- (b) Ontario desires to continue its activity in the area of soil conservation and to affirm its leadership with respect to agricultural extension and land management.
- (c) The initiative under this Agreement will be a program including technical and financial assistance, awareness, education, soil conservation demonstrations, fragile land protection, monitoring and research.
- (d) Each party will provide up to a maximum of \$11.1 million in matching funds for the funding of activities under this Agreement.

**SECTION 2 - PURPOSE AND OBJECTIVES**

2.1 Canada will fund the following for the general purpose of conserving and managing soils in Ontario:

(a) Permanent Cover Program

An incentive program will be delivered to convert marginally productive or erosion susceptible land which is currently under annual cultivation into permanent cover, and to protect lands adjacent to streams or open ditches from adjoining intensive agricultural activities. The program will require the land to remain in permanent cover for a contracted number of years in order to receive compensation. A bid system is proposed which would involve the farmer bidding on the level of compensation required to remove the land from annual cropping. The maximum contribution is \$10,000 per farmer. Criteria will be established to define eligible acres and planting guidelines along streams and ditches.

The designated organization will receive bids and determine eligibility based on current use, soil erodibility and proposed compensation level. The Ontario Ministry of Natural Resources or Conservation Authorities may provide expertise and services in nursery production, tree planting and management.

(b) Services of Designated Organizations

The designated organization will be contracted to administer the bidding system for the Permanent Cover Program through its local committees. These committees may be either existing or new committees. These committees will consist of up to 6 people who will receive, evaluate and recommend bids for assistance to convert fragile lands to permanent cover.

(c) Monitoring and Research on Soil Quality

A program to monitor and evaluate soil quality will be established to provide a basis for determining present conditions, evaluating effectiveness of existing and new conservation programs and policies. The key processes of land use, tillage practices and cropping systems that result in changes in soil quality will be determined. Major soils of the province which have been affected by degradation will be studied in terms of their sensitivity to degradation, the conditions under which degradation occurs and its impact on productivity. Models will be developed which will predict changes in primary production, soil organic matter, nutrients, erosion, pesticide levels for intensively cultivated land based on projected change in land use, tillage practices and cropping systems.

The existing Tillage-2000 program and the Pilot Demonstration Watershed component of Soil and Water Environmental Enhancement Program (SWEET) provide a basis for the development of a program in soil quality monitoring. This would involve an increased number of soil/tillage/cropping systems and a comprehensive, uniform data set.

Projects will be carried out by Agriculture Canada, universities, colleges or other agencies.

(d) Survey and Information Systems

A program will be developed to assist with the application of soil inventory and related land resource information for the planning and implementation of soil conservation programs. A major part of the program will involve development of a cost effective method for upgrading older soil surveys to assist with soil conservation planning at the farm level. Lesser emphasis will be given to development of computer based Geographic Information Systems to facilitate access to and analysis of other land based information such as land use, drainage, climate and land ownership for conservation planning at regional and local levels.

The methodologies developed will be tested and applied in upgrading one county soil survey and the information utilized in the targeting and planning of soil conservation activities in that county.

(e) Awareness Activities

Various information transfer activities will be undertaken that complement, extend or directly support the impact of program elements delivered by Canada. As well, activities may be supported that promote awareness by the general public or by farmers particularly where these contribute to the consistent development of a national stewardship ethic or where interprovincial liaison could be beneficial. These activities will be carried out in cooperation with Ontario.

- (i) Some activities will emphasize awareness of the general public as to society's role in soil conservation. Examples include development of general brochures, displays, media releases and productions, audio-visual packages, support of National Soil Conservation Week, and other general efforts, and:
- (ii) Other activities could encourage general awareness by farmers as well as more detailed awareness by specific groups in society. Examples include production of more technically oriented bulletins, training/scientific workshops, field manual preparation, support services to general extension, school curriculum and study material development.

2.2 Ontario will fund the following programs for the general purpose of conserving and managing soils in Ontario:

(a) Financial Assistance for Erosion Control Structures

Ontario will provide assistance at a fixed rate and maximum per applicant for:

- soil building
- machinery and equipment
- education courses

(b) Extension Staff

To assist in the delivery of the federal and provincial programs, Ontario will provide field staff to provide technical assistance in the areas of soil conservation, erosion control, conservation cropping, soil quality monitoring and the stewardship ethic for the duration of the program. These staff resources will be distributed across the province to maximize their effectiveness in delivering the combined program.

(c) Provincial Research and Development

Ontario will provide the Land Stewardship Trust Fund of the Agricultural Research Institute of Ontario (ARIO) additional funds over the term of the program. These funds will be administered by the ARID for the purpose of funding research into land stewardship issues.

These funds will be directed toward projects that will develop or test new technologies or practices, or provide information pertinent to the development of new technologies and practices.

### SECTION 3 - PROGRAM DELIVERY

- 3.1 The objective of the current initiative is to substantially augment existing programs and provide an enhanced soil conservation program in the Province of Ontario. Coordination will be provided through an implementation committee as described in this Work Plan.
- 3.2 Local and provincial producer organizations shall be the preferred vehicle for the delivery of on-farm soil conservation programs.
- 3.3 Canada and Ontario each agree to administer and deliver the program activities which they are funding.

## SECTION 4 - PROGRAM IMPLEMENTATION AND CO-ORDINATION

- 4.1 The overall financial and technical administration will be provided by each level of government through an Implementation Committee reporting to the Management Committee and established to coordinate the activities of the two levels of governments.
- (a) The Implementation Committee shall include equal representation from:
    - (i) Ontario Ministry of Agriculture and Food
    - (ii) Agriculture Canada;
  - (b) The Implementation Committee can also include representation from the administrator and any other parties as deemed necessary by the Management Committee.
  - (c) The Implementation Committee will be co-chaired on a regular rotational basis by a federal and a provincial representative designated by the respective federal and provincial officers of the Management Committee;
    - (i) The Management Committee will ensure that the membership of the Implementation Committee is kept current and that the terms of reference are reviewed as necessary for the purposes of coordination and implementation of the Work Plan.
  - (d) Responsibilities of the Implementation Committee shall include:
    - (i) Review and recommend program terms and conditions;
    - (ii) Review and recommend program guidelines;
    - (iii) Monitoring and coordinating program delivery mechanism;
    - (iv) Preparing the annual Work Plan review.

4.2 Additional advisory committees and task forces may be established by the Implementation Committee as required.

APPROVED BY:

APPROVED BY:

\_\_\_\_\_  
Federal Management  
Committee Co-chair

\_\_\_\_\_  
Provincial Management  
Committee Co-chair

\_\_\_\_\_  
Date

\_\_\_\_\_  
Date

TABLE 1  
INITIAL FUNDING ALLOCATIONS\*  
(\$ X 1000)

| ACTIVITY                                    | CANADA        | ONTARIO       |
|---|---------------|---------------|
| 1. Permanent Cover Program                  | 8,250         |               |
| - incentives to farmers                     |               |               |
| - administration costs                      |               |               |
| 2. Monitoring, Research, and<br>Soil Survey | 2,400         |               |
| - monitoring                                |               |               |
| - research                                  |               |               |
| - survey                                    |               |               |
| 3. Awareness                                |               |               |
| - Ontario                                   | 378           |               |
| - National                                  | 72            |               |
| 4. Research                                 |               | 750           |
| 5. Extension                                |               | 500           |
| 6. Financial Assistance                     |               |               |
| - soil building                             |               | 9,850         |
| - machinery and equipment                   |               |               |
| - education courses                         |               |               |
| <b>TOTAL</b>                                | <b>11,100</b> | <b>11,100</b> |

TABLE 2  
BUDGET-CANADA 1989-1993  
(\$ X 1000)

| ACTIVITY                                   | FUNDING ALLOCATION |         |         |         |        |
|--|--------------------|---------|---------|---------|--------|
|  | 1989-90            | 1990-91 | 1991-92 | 1992-93 | TOTAL  |
| 1. Permanent Cover Program                 | 0                  | 800     | 5,600   | 1,850   | 8,250  |
| - incentives to farmers                    |                    |         |         |         |        |
| - Administration Costs                     |                    |         |         |         |        |
| 2. Monitoring, Research<br>and Soil Survey | 0                  | 800     | 1,000   | 600     | 2,400  |
| - monitoring                               |                    |         |         |         |        |
| - research                                 |                    |         |         |         |        |
| - survey                                   |                    |         |         |         |        |
| 3. Awareness                               | 0                  | 300     | 150     | 0       | 450    |
| - Ontario                                  |                    |         |         |         |        |
| - National                                 |                    |         |         |         |        |
| TOTAL                                      | 0                  | 1,900   | 6,750   | 2,450   | 11,100 |

TABLE 3  
BUDGET-ONTARIO 1989-1993  
(\$ X 1000)

| ACTIVITY                  | FUNDING ALLOCATION |               |            |            |               |
|---------------------------|--------------------|---------------|------------|------------|---------------|
|                           | 1989-90            | 1990-91       | 1991-92    | 1992-93    | TOTAL         |
| 1. Research               | 0                  | 750           | 0          | 0          | 750           |
| 2. Extension              | 0                  | 300           | 100        | 100        | 500           |
| 3 Financial Assistance    |                    |               |            |            |               |
| - soil building           | 0                  | 9,850         | 0          | 0          | 9,850         |
| - machinery and equipment |                    |               |            |            |               |
| - education courses       |                    |               |            |            |               |
| - administration costs    |                    |               |            |            |               |
| <b>TOTAL</b>              | <b>0</b>           | <b>10,900</b> | <b>100</b> | <b>100</b> | <b>11,100</b> |

**APPENDIX B**

**PERMANENT COVER BIDDING GUIDELINES AND DEMONSTRATION SITE  
LANDOWNER AGREEMENT  
GUIDELINES TAKEN FROM OSCIA IMPLEMENTATION AGREEMENT  
TREE SERVICE MASTER CONTRACT: OMNR & OSCIA**

## APPENDIX B

### BIDDING PROCEDURES

- # Bids are received by local committees.
- # Bids are reviewed by local committees and funding priorities are set based on the judgement of local committees.
- # Based on priorities established by the local committees, bids are sorted and prioritized according to the five program components as follows:
  - 1. Buffer Strips - Permanent Grass Species Only**
    - minimum buffer strip eligible is 8'
    - maximum buffer strip eligible is 20'
    - row crop acres only are eligible
    - permanent grass species, establishment and maintenance procedures must be identified
    - municipal drain regulations apply
  - 2. Buffer Strips - Trees**
    - minimum buffer strip eligible is an 8' grass strip and one row of trees
    - maximum buffer strip eligible is three rows of trees
    - a contract to purchase trees must be signed with one of the following approved contractors:
      - i) The Ontario Ministry of Natural Resources
      - ii) A Conservation Authority
      - iii) Others as approved by the Implementation Committee
    - municipal drain regulations apply
  - 3. Enhanced Buffers**
    - buffer zone that requires more than trees and grass
    - design, engineering, excavation, material and labour application
    - trees are an option (refer to component #2)
    - municipal drain regulations apply
  - 4. Highly Erodible/Fragile Land**
    - block areas retired (20 acre maximum per applicant in one or a combination of blocks)
      - row crop acres receive priority
      - must be planted to grass before application is submitted
      - trees are a requirement and rules of component #2 apply

## **NSCP ONTARIO FINAL REPORT**

---

### **5. Flood Plains**

- row crop acres receive priority
  - the appropriate Conservation Authority must be contacted if activity includes other than permanent grass
- # Successful bids are chosen, up to a maximum of the allocated funds to the recipient county.
- # Inspector is sent to examine the sites of the successful bid.

### **GENERAL CRITERIA FOR DEMONSTRATION SITES**

Demonstration sites must incorporate at least one of the program components. Preference will be given to sites which present a conservation system which, along with including at least one NSCP program component, integrates other soil and water conservation practices. Preference will also be given to projects established and operated as a joint venture.

**NATIONAL SOIL CONSERVATION PROGRAM  
CONTRIBUTION AGREEMENT AND LAND USE AGREEMENT  
ARTICLES OF AGREEMENT**

Agreement. made this \_\_\_\_\_ day of \_\_\_\_\_, 19\_\_.

**BETWEEN:**

Her Majesty the Queen in Right of Canada (referred to in this agreement as "Canada")  
represented by the Minister of Agriculture (referred to in this agreement as "the Minister"),

Her Majesty's Address: \_\_\_\_\_ (Name and Address)

Agriculture Canada,  
Agriculture Development Branch,       **AND**  
104-450 Speedvale Avenue West,  
Guelph, Ontario  
N1H 7Y7

\_\_\_\_\_ herein referred to as "Landowner".

**WHEREAS:**

- I. Canada is desirous of soil conservation for agricultural purposes and has to that purpose instituted the Permanent Cover Program under the National Soil Conservation Program; and
- II. The Landowner is desirous of participating in the Permanent Cover Program and is the owner in fee simple of the land (referred to herein as the "fragile land") described in the Application/Bid Form No. (referred to herein as the "Application/Bid Form");

Now therefore this Agreement witnesses that in consideration of mutual premises covenants and other good and valuable consideration, the parties agree as follows:

1. This Agreement shall commence on the date of these Articles of Agreement, and shall terminate when the number of years committed by the Landowner on the Application/Bid Form have elapsed.
2. Canada shall pay to the landowner a maximum of \$ \_\_\_\_\_, which represents the maximum amount to be contributed by Canada for the Landowner's work and commitment described on the Application/Bid Form. Payment is subject to satisfactory project completion as indicated by the signature of an authorized inspector on the "completion certificate" herein. In accordance with Section 40 of the Financial Administration Act, payment is subject to moneys having been appropriated by Parliament.
3. The LANDOWNER hereby covenants and agrees as follows:
  - a. To convert the fragile land to permanent cover by planting the agreed perennial vegetation, including any agreed trees, and to keep and maintain the fragile land in this permanent cover for the term indicated in the Application/Bid Form, protecting the permanent cover against livestock, fire, insects, disease and other perils.
  - b. To not return any part of the fragile land into cultivation of annual crops for the period of commitment except to periodically reseed and/or replant the fragile land to perennial vegetation and to notify Canada in writing prior to undertaking reseeding operations.
  - c. To permit and facilitate Canada, Her representatives, agents, servants, and employees or workers to enter the fragile Land to inspect and evaluate the condition of the land or the state of growth of perennial vegetation and for any other purpose which is conducive to the proper administration of the Permanent Cover Program throughout the period of commitment.
  - d. To notify Canada in Writing of any lease, transfer, sale, conveyance, transmission or other disposition of the fragile land.
  - e. To insert in any subsequent lease, transfer, sale, conveyance, transmission or other disposition of all or part of the fragile land, the same covenants as set forth in this Agreement including this clause but excluding paragraph 2 herein, and to require any lessee, successor or transferee or purchaser to covenant to observe the terms of the within Agreement, such covenant being so framed that the burden thereof

shall run with the land and with the intent that all such persons should be bound by the covenants herein contained.

4. In addition to any other remedy, upon default of the covenants contained in this Agreement, the LANDOWNER shall upon demand pay at least the following amount to Canada by way of liquidated damages: an amount representing the same proportion of the original contribution as the commitment years remaining in this agreement represent as a proportion of the total number of years originally committed.
5. Nothing contained in this agreement shall be considered or construed as creating the relationship of principal and agent, lessor and lessee or of employer and employee between the parties.
6. No amendment to this Agreement nor waiver of any terms and provisions shall be deemed valid unless effected by a written amendment with the consent of both parties.
7. This Agreement applies to the entire fragile land including any severed portions thereof. This Agreement shall enure to the benefit of and be binding upon the respective heirs, executors, administration, successors and assigns of the parties.
8. Any notice under this Agreement shall be sufficiently given by personal delivery or by registered letter, postage prepaid and mailed in a Canadian post office addressed to the respective parties as designated in these Articles of Agreement, or to any other address as may be designated in writing by the parties, and the date of receipt of any notice by mailing shall be deemed conclusively to be seven (7) days after the mailing.
9. This Agreement constitutes the only document concerning the relationship between the parties and supersedes all previous negotiations and documents relating thereto.
10. Agriculture Canada may, by notice in writing to the Landowner, terminate this Agreement if the Landowner becomes bankrupt or insolvent, or the Landowner is in breach of his obligations under this Agreement and has not remedied the situation after the time stipulated in the notice from Agriculture Canada in this respect.
11. No member of the House of Commons shall be admitted to any share or part of this Agreement nor to any benefit to arise therefrom.
12. For the purpose of the agreement, the Minister designates the Director, Agriculture Development Branch (Ontario) as the Departmental Representative.

In witness whereof the parties hereto have executed this agreement.

Her Majesty the Queen in Right of  
Canada, as represented by the  
Minister of Agriculture

\_\_\_\_\_  
Landowner

Per: \_\_\_\_\_  
Director, Agriculture Development  
Branch (Ontario)

\_\_\_\_\_  
Witness

**COMPLETION CERTIFICATE:**

Dated this \_\_\_\_\_ day of \_\_\_\_\_ 19\_\_

I hereby certify that the work described on the Application/Bid Form (#) has been completed, and/or the binding service contract for tree planting and/or maintenance described on the attached Application/Bid Form has been signed and paid for.

\_\_\_\_\_  
Authorized Inspector

\_\_\_\_\_  
Authorized Inspectors Signature

Distribution: 1st & 2nd Agriculture Canada; 3rd OSCIA Guelph; 4th OSCIA County/District; 5th Landowner.

---

**MEMORANDUM OF UNDERSTANDING made in duplicate this 10th day of  
May, 1991.**

BETWEEN:

HER MAJESTY THE QUEEN in right of the Province of  
Ontario as represented by the Minister of Natural  
Resources

(hereinafter referred to as the Ministry)

- and -

ONTARIO SOIL AND CROP IMPROVEMENT  
ASSOCIATION

(hereinafter referred to as OSCIA)

WHEREAS the Government of Canada and the Government of Ontario as represented by the Ministry of Agriculture and Food (OMAF) entered into an Agreement called the Canada-Ontario Agreement on Soil Conservation (the Canada-Ontario Agreement) to encourage the implementation of appropriate soil resource management practices;

AND WHEREAS the Ministry and OMAF wish to coordinate and integrate the provision of forestry services, to assist in soil conservation, particularly tree establishment, for the private land owners in Ontario;

AND WHEREAS the Canada-Ontario Agreement establishes the National Soil Conservation Program-Ontario Region under which the Permanent Cover Program (the Program) has been established;

AND WHEREAS OSCIA is an association designated under the Agricultural Associations Act whose objectives include the improvement of soil management and field crops in the Province of Ontario;

AND WHEREAS OSCIA has been designated under the Canada-Ontario Agreement to receive and administer funds for the Program;

AND WHEREAS OSCIA requires nursery stock and the services of a qualified forestry agency to ensure the successful implementation of the Program where tree establishment is appropriate;

NOW THEREFORE this Agreement witnesses that in consideration of the mutual provisions and covenants hereinafter set out, the Minister and OSCIA agree with each other as follows:

1. The Ministry agrees to:

1. (1) participate in OSCIA staff training sessions, county/district information meetings and applicant workshops;
2. (2) make available relevant fact sheets, brochures, technical bulletins and other documentation related to tree establishment which are currently available;
3. (3) carry out tree establishment services, which entails the site visit, planting plan, site preparation, supplying required tree seedlings, planting, tending, quality control and assessment.

The following maximum numbers of trees will be established:

spring 1992 - 1 million  
spring 1993 - 2 million  
spring 1994 - 2 million  
spring 1995 - 3 million

2. OSCIA agrees to:

1. provide the Ministry with a schedule of staff training sessions, county/district information meetings and applicant workshops with at least three weeks

- notice where possible;
- 2. distribute to the program applicants relevant fact sheets, brochures, technical bulletins and other documentation made available by the Ministry;
- 3. provide a list of approved program applicants on a regular basis to the Ministry to enable Ministry field staff to integrate services provided under this Program with the Ministry's regular programs;
- 4. provide a list of approved projects under this Program to the Ministry by October 1 of each year that this Agreement is in existence in order to ensure adequate opportunity for the planning of the operations under this Program;
- 5. administer the day-to-day operation of the Program including:
  - (a) ensuring completion of all required forms from applicants;
  - (b) determining eligibility of applicants;
  - (c) approving of applicants and of projects;
  - (d) handling appeals and complaints from applicants;
  - (e) processing of all accounts payable/receivable.

3.

- 1. The parties agree that the tree establishment services shall consist of those components described in Schedule 1 attached hereto and conform to current Ministry guidelines and standards.
- 2. Tree establishment will be provided on the minimum criteria of:
  - i) block planting areas of 1 hectare (2.5 acres) or more in size;
  - ii) linear planting areas (windbreak, buffers) of 1,000 trees or more.
- 3. OSCIA acknowledges and agrees that as the Ministry is not a party to the Tree Services contract with the landowner, OSCIA will use its best efforts to ensure that the landowner complies with those provisions in the Tree Service Contract relating to the Ministry. Failure of the landowner to comply with the said provisions will result in the termination of the Ministry's obligations and liabilities relating to the said landowner under this Agreement.

#### 4. FINANCIAL

- 1. The Ministry shall provide at no cost, the services described in 1. (1) and 1. (2).
- 2. The Ministry shall provide tree establishment services as described in 1. (3) at the cost of \$0.85 per tree over the period of this Agreement.
- 3. The Ministry will provide OSCIA a planting report by June 30 of each year outlining the number of trees planted under approved projects in the program.
- 4. OSCIA, subject to equivalent funding being provided by Agriculture Canada, will pay a one time charge of up to \$200,000 in the first year of this Agreement to secure tree seedlings for the program. This amount will be deducted from the subsequent tree establishment service charge and:

OSCIA, subject to funding provided under the Service Contract by landowners for trees established, will pay to the Treasurer of Ontario by July 31 of each year, the tree establishment costs under the Service Contract as stated in the planting report.

#### 5. REPRESENTATIVES

- 1. For the purpose of this Agreement, the designated representative of the Ministry is:

Alec J. Denys, Manager, Private Land Forestry Section, P. O. Box 1000, Sault Ste. Marie, Ontario, P6A 5N5, telephone (705) 945-6618,

and the designated representative of OSCIA is:

Harold Rudy, OSCIA, Guelph Agricultural Centre, P. O. Box 1030, Guelph, Ontario, NiH 6N1, telephone (519) 767-3241.

- 2. OSCIA agrees that the designated representative of the Ministry, for the purposes of carrying out the work referred to in Schedule 1, will be the District Manager who has jurisdiction in the area in which the services are to be performed.
- 3. The Ministry and OSCIA agree that they may designate a different representative by providing notice in writing.

6. From time to time during the period of this Agreement, the MNR and OSCIA will designate projects as being successful based on free-to-grow-status of areas with the minimum stocking required to meet the criteria of a "woodlot" as defined in the Trees Act.

In the event of disagreement on tree establishment success, a mutually agreed upon member of the Ontario Professional Foresters Association will be appointed and his decision will be final.

7. The parties hereto agree that time shall be deemed to be material and of the essence of this Agreement.

8. The parties hereto agree that this Agreement embodies the entire agreement between them, and OSCIA represents that in entering into this Agreement, the Ministry does not rely upon any previous oral or implied representation, inducement or understanding of any kind or nature.

9. OSCIA and the Ministry agree that the failure of either party to insist in one or more instances upon the performance by either party of any term or condition of this Agreement shall not be construed as a waiver of the future performance of any such term or condition and the obligations of each party with respect to such future performance shall continue in full force and effect.

10. The term of the Agreement is from April 1, 1991 to March 31, 1996, or such dates as may be agreed to in writing by OSCIA and the Ministry or when funding ceases. Projects approved and commitments made in writing prior to March 31, 1996 shall continue in force until completion.

11. Neither party shall be held responsible for events of force majeure such as acts of God, strikes, lock-outs, or other labour disturbances, civil disturbances, arrests and restraints by rulers and people, interruptions by government or court order, acts of the public enemy, wars, riots, sabotage, lightning, fire, storm, flood, explosion, and any other event or occurrence beyond the reasonable control of the Ministry and OSCIA.

12. OSCIA agrees to indemnify, keep indemnified and save harmless the Ministry and its officers, servants and agents from and against all claims, demands, costs, actions, causes of action, expenses, legal fees whatsoever which may be taken or made against them or any of them or incurred or become payable by them or any of them for any loss, damage or injury, including death, of any nature or kind whatsoever arising out of or in consequence of any act, neglect, or omission of OSCIA, its servants, agents or invitees.

IN WITNESS WHEREOF the Minister has hereunto subscribed his signature and affixed the seal of the Ministry of Natural Resources and OSCIA has hereunto set its corporate seal, attested by its proper officers duly authorized in that behalf.

SIGNED, SEALED and DELIVERED  
in the presence of

THE MINISTER OF NATURAL  
RESOURCES

\_\_\_\_\_  
Witness as to execution by J. F.  
Goodman, R.P.F.

\_\_\_\_\_  
J. F. Goodman, R.P.F.  
Assistant Deputy Minister  
Administration as  
authorized by the  
Minister of Natural  
Resources for the  
Province of Ontario

ONTARIO SOIL AND CROP  
IMPROVEMENT  
ASSOCIATION

## **SCHEDULE 1**

### **DESCRIPTION OF TREE ESTABLISHMENT SERVICES**

The following describes the components of the tree establishment services to be performed by the Ministry.

These services will be carried out only on projects approved by OSCIA under the Permanent Cover Program, or on applications at the request of OSCIA.

1. **SITE VISIT**

A site visit shall consist of a viewing of the approved project, discussing the objectives for permanent cover with the applicant, assessing the site for access, for . species and tree number requirement, determining the site preparation required, determining the possible need for vegetation control, and the planting technique.. These items will be included in a silvicultural prescription specific to that site.

2. **STOCK PRODUCTION**

Ensuring sufficient trees of a specified species are grown and available for the project.

3. **SITE PREPARATION**

Implementing the prescribed site preparation before tree planting.

4. **PLANTING**

Transporting, storage and the planting of the trees according to the prescription.

5. **TENDING**

Tending is the action of ensuring competing vegetation is controlled until the tree becomes established. The present technology often requires the use of herbicides. Without their use for vegetation control, tree establishment is not assured and the project may 'be refused by the Ministry of herbicide is not allowed by the applicant and an alternative method is not suitable. Tending may be carried out during or after the tree planting.

6. **QUALITY CONTROL AND ASSESSMENT**

Quality control consists of trained staff overseeing the various operations of tree establishment. Assessment is the measurement of success of the operations and the final tree establishment.

NOTE: Standards for tree establishment are set out in part in the following documents:

- 1) Standard MNR tree planting contract.
- 2) Publication, 1527, Windbreaks on the Farm
- 3) Stocking as defined in Trees Act to meet the criteria of a woodlot.
- 4) Nursery Stock Standards
- 5) OMAF Publication #75-Guide to Weed Control

**SCHEDULE 2  
TREE SERVICE CONTRACT**

THIS AGREEMENT MADE IN DUPLICATE THIS \_\_\_\_\_ DAY OF \_\_\_\_\_, 19\_\_\_, UNDER THE NATIONAL SOIL CONSERVATION PROGRAM

BETWEEN:                   ONTARIO SOIL AND CROP IMPROVEMENT ASSOCIATION  
                                  (Hereinafter referred to as "OSCIA")

AND

Address:  
Phone

(Hereinafter referred to as "Landowner")

This AGREEMENT WITNESSES that in consideration of the mutual provisions contained herein the parties hereto agree as follows:

1. The Landowner hereby agrees to provide a Total Payment\* of \$\_\_\_\_\_ to enter into a Service Contract with OSCIA who will ensure via a Memorandum of Understanding with the Ministry of Natural Resources (MNR), their agents or \_\_\_\_\_ contractors, that the services, as described in Schedule 1, will be carried out. The above sum represents trees at \$0.85 per tree plus 7% GST.

|                       |         |
|-----------------------|---------|
| # Trees _____ x \$.85 | = _____ |
| (add) 7% GST          | = _____ |
| * Total Payment       | = _____ |

2. The Landowner agrees to provide payment in full to OSCIA, Box 1030, Guelph, Ontario, N1H 6N1, as an advance to ensure the tree establishment service will be carried out as outlined in the Planting Plan and as described in Schedule 1. This amount must not exceed the approved allocation for trees as identified on the Bid Form referred to in Section 3 of this agreement.

Cheque must be made payable to: OSCIA - Tree Service Contract, and forwarded to the OSCIA Program Divisor via the local OSCIA County/District Committee.

3. The Landowner hereby agrees that OSCIA shall have no further obligations to the Landowner pursuant to this Agreement after the funds referred to in Section 1 of this Contract are forwarded to MNR by OSCIA.
4. The Landowner hereby gives leave and licence unto the OSCIA or MNR, their servants, agents and contractors to enter onto the land, described in Bid Form number for the services as described in Schedule 1 in establishing trees established under the National Soil Conservation Program.
5. The Landowner agrees that planting, tending and survival assessment may be conducted by MNR or its agents or contractors up to 5 years after establishment.
6. The Landowner agrees that representatives of OSCIA, MNR, or Agriculture Canada, their servants, agents or contractors, will have rights of access to the applicant's land for monitoring or inspection.

7. The Landowner agrees that no person shall sell or offer for sale or dispose of by gift or otherwise any nursery stock furnished under this program.
8. The Landowner agrees that this Agreement is endorsed in conjunction with the Agriculture Canada long-term Agreement known as the "Contribution Agreement and Land Use Agreement."
9. In the event that the Tree Establishment Services are not initiated, as described in Schedule 1 and the site plan, OSCIA will refund to the landowner the principle remaining in the landowner's account subject to proportional repayment to Agriculture Canada.
10. The owner agrees that the information pertaining to this project will be made available to OSCIA, MNR, Agriculture Canada, their agents and contractors for the purpose of providing the services as described in Schedule 1.

**SIGNATURES:**

\_\_\_\_\_  
LANDOWNER

\_\_\_\_\_  
OSCIA PROGRAM FIELD INSPECTOR  
(as witness)

\_\_\_\_\_  
DATE

\_\_\_\_\_  
DATE

\_\_\_\_\_  
OSCIA MANAGEMENT (GUELPH)

\*\*\*\*\*

PAYMENT RECEIVED FOR ABOVE TREE SERVICE CONTRACT: (Please attach Planting Plan provided by Ministry of Natural Resources)

|                 |          |         |
|-----------------|----------|---------|
| # Trees _____   | x \$0.85 | = _____ |
| (add) 7% GST    |          | = _____ |
| * Total Payment |          | = _____ |

\*OSCIA GST Registration Number is 8127536837

Received by:  
OSCIA Field Inspector

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

Distribution:      White - OSCIA Guelph: 2 - MNR;  
                          3 - Agriculture Canada: 4 - County/District  
                          5 - Landowner

**APPENDIX C**

**PERMANENT COVER STATISTICAL  
SUMMARY AND LIST OF DEMONSTRATION SITES**

**Demonstration Project.**

1. **Project Title:** Permanent Cover Program  
**Location:** Essex, ON  
**Coordinating Agency:** Essex Region C.A. 519-776-5209  
**Project Description:** Buffer Strip - Grass
  
2. **Project Title:** Permanent Cover Program  
**Location:** Essex, ON  
**Coordinating Agency:** Essex Region C.A. 519-776-5209  
**Project Description:** Flood Plain - Trees  
 Flood Plain - Trees & Shrubs  
 Highly Erodible Land - Shrubs
  
3. **Project Title:** Permanent Cover Program  
**Location:** Essex, ON  
**Coordinating Agency:** Essex Region C.A. 519-776-5209  
**Project Description:** Buffer Strip - Grass  
 Enhanced Buffer - Grass & Shrubs
  
4. **Project Title:** Permanent Cover Program  
**Location:** Essex, ON  
**Coordinating Agency:** Essex Region C.A. 519-776-5209  
**Project Description:** Enhanced Buffer - Grass
  
5. **Project Title:** Permanent Cover Program  
**Location:** Kent, ON  
**Coordinating Agency:** Ridgetown College 519-674-5456  
**Project Description:** Buffer Strip - Grass  
 Buffer Strip - Trees  
 Highly Erodible Land - Trees
  
6. **Project Title:** Permanent Cover Program  
**Location:** Elgin, ON  
**Coordinating Agency:** Elgin SCIA 519-631-4700  
**Project Description:** Highly Erodible Land  
 Buffer Strip - Grass
  
7. **Project Title:** Permanent Cover Program  
**Location:** Lambton, ON  
**Coordinating Agency:** St. Clair Region C.A. 519-245-3710  
**Project Description:** Flood Plain - Trees  
 Highly Erodible Land - Trees

- 
8. **Project Title:** Permanent Cover Program  
**Location:** Oxford, ON  
**Coordinating Agency:** Upper Thames R. C.A. 519-451-2800  
**Project Description:** Buffer Strip - Grass  
Buffer Strip - Trees
9. **Project Title:** Permanent Cover Program  
**Location:** Middlesex, ON  
**Coordinating Agency:** Upper Thames R. C.A. 519-451-2800  
**Project Description:** Highly Erodible Lands - Trees  
Flood Plain - Trees
10. **Project Title:** Permanent Cover Program  
**Location:** Bruce, ON  
**Coordinating Agency:** Bruce Community Pasture 519-881-3301  
**Project Description:** Highly Erodible Land  
Flood Plain - Trees
11. **Project Title:** Permanent Cover Program  
**Location:** Wellington, ON  
**Coordinating Agency:** Grand River C.A. 519-621-2761  
**Project Description:** Buffer Strip - Grass  
Buffer Strip - Trees
12. **Project Title:** Permanent Cover Program  
**Location:** Brant, ON  
**Coordinating Agency:** Grand River C.A. 519-621-2761  
**Project Description:** Buffer Strip - Trees
13. **Project Title:** Permanent Cover Program  
**Location:** Perth, ON  
**Coordinating Agency:** Grand River C.A. 519-621-2761  
**Project Description:** Buffer Strip - Trees
14. **Project Title:** Permanent Cover Program  
**Location:** Waterloo, ON  
**Coordinating Agency:** Grand River C.A. 519-621-2761  
**Project Description:** Buffer Strip - Grass  
Buffer Strip - Trees
15. **Project Title:** Permanent Cover Program  
**Location:** Haldimand-Norfolk, ON  
**Coordinating Agency:** MNR - Simcoe Area 519-426-7650  
Township of Norfolk 519-875-4485  
**Project Description:** Buffer Strip - Grass

16. **Project Title:** Permanent Cover Program  
**Location:** Niagara, ON  
**Coordinating Agency:** Niagara Peninsula C.A. 905-227-1013  
**Project Description:** Enhanced Buffer - Grass
17. **Project Title:** Permanent Cover Program  
**Location:** Niagara, ON  
**Coordinating Agency:** Niagara Peninsula C.A. 905-227-1013  
**Project Description:** Buffer Strip - Grass
18. **Project Title:** Permanent Cover Program  
**Location:** Northumberland, ON  
**Coordinating Agency:** Lower Trent Region C.A. 613-394-4829  
**Project Description:** Enhanced Buffers - Trees
19. **Project Title:** Permanent Cover Program  
**Location:** Renfrew, ON  
**Coordinating Agency:** Renfrew County OMAF  
**Project Description:** Enhanced Buffer - Trees
20. **Project Title:** Permanent Cover Program  
**Location:** Dundas, ON  
**Coordinating Agency:** Township of Matilda 613-652-4403  
**Project Description:** Buffer Strip - Grass
21. **Project Title:** Permanent Cover Program  
**Location:** Glengarry, ON  
**Coordinating Agency:** South Nation River C.A. 613-984-2949  
**Project Description:** Enhanced Buffer - Grass
22. **Project Title:** Permanent Cover Program  
**Location:** Perth, ON  
**Coordinating Agency:** Upper Thames River C.A. 519-451-2800  
**Project Description:** Highly Erodible Land
23. **Project Title:** Permanent Cover Program  
**Location:** Ottawa-Carleton, ON  
**Coordinating Agency:** Carleton County SCIA 613-828-9167  
**Project Description:** Flood Plains - Trees
24. **Project Title:** Permanent Cover Program  
**Location:** Perth, ON  
**Coordinating Agency:** Upper Thames River C.A. 519-451-2800  
**Project Description:** Flood Plains - Trees

25. **Project Title:** Permanent Cover Program  
**Location:** Middlesex, ON  
**Coordinating Agency:** Kettle Creek C.A. 519-631-1270  
**Project Description:** Highly Erodible Land  
 Buffer Strips - Trees
26. **Project Title:** Permanent Cover Program  
**Location:** Lambton, ON  
**Coordinating Agency:** MNR - Chatham Area 519-354-7340  
**Project Description:** Highly Erodible Land  
 Buffer Strip - Grass
27. **Project Title:** Permanent Cover Program  
**Location:** Lambton, ON  
**Coordinating Agency:** MNR - Chatham Area 519-354-7340  
**Project Description:** Highly Erodible Land & Windbreak
28. **Project Title:** Permanent Cover Program  
**Location:** Lambton, ON  
**Coordinating Agency:** MNR - Chatham Area 519-354-7340  
**Project Description:** Highly Erodible Land & Windbreak
29. **Project Title:** Permanent Cover Program  
**Location:** Kent, ON  
**Coordinating Agency:** MNR - Chatham Area 519-354-7340  
**Project Description:** Flood Plain, Highly Erodible  
 Land & Windbreak
30. **Project Title:** Permanent Cover Program  
**Location:** Essex, ON  
**Coordinating Agency:** Essex Region C.A. 519-776-5209  
**Project Description:** Grass Buffer Next to Marsh
31. **Project Title:** Permanent Cover Program  
**Location:** Essex, ON  
**Coordinating Agency:** Essex Region C.A. 519-776-5209  
**Project Description:** Buffer Strip - Grass

**APPENDIX D**  
**FINAL REPORT ON SOIL SURVEY**

## SOIL QUALITY EVALUATION PROJECT

### REPORT ON PROGRESS FOR YEAR 3 (1992-93) WITH A SUMMARY FOR THE NSCP PERIOD

A Report to the Agri-food Development Branch (Ontario),  
the Lead Agency for Ontario

#### EXECUTIVE OVERVIEW

This report on the Soil Quality Evaluation Program presents progress for the past year as well as summarizing achievements in the three years since the initiation of the program. An executive overview of the program for the three-year period will be followed by a summary of scientific achievements for this period. A more detailed review of scientific achievements for the 1992-93 fiscal year is followed by a financial report for this review period. The report will conclude with a current list of publications emanating from this program.

The Soil Quality Evaluation Program was initiated in 1989 in response to a requirement of the National Soil Conservation Program (NSCP) to monitor soil and associated environmental quality for the agricultural soils in Canada. Considerable funding for the first three years of this program provided through the NSCP has allowed the Research Branch and, in particular, the CLBRR the opportunity to more rapidly develop this program and to provide for its continuation beyond the NSCP period with A-base resources.

The first three years has seen the development of a conceptual framework for the evaluation of soil quality and a Geographic Information System (GIS) capability for regional and national assessments of soil and environmental quality. A primary focus of the program has been on assessing the susceptibility to change in soil quality through the development of improved capabilities to predict soil loss from wind and water erosion, change in the quality and quantity of soil organic matter, change to soil salinity and soil structure, and the impact of agricultural chemicals on soil and groundwater. A land use analysis capability has been established as a means for integrating farming practices and soil quality change and a network of soil quality benchmark sites provide a validation capability for the predictive systems. Finally, enhanced capabilities to evaluate the impact of soil quality change on soil productivity have been developed as a first step toward the evaluation of soil quality within the context of sustainable land management.

The scientific advances in the program have been reported in approximately 90 publications to date. An overview of the program was presented at an international soil conservation conference in Australia and the experience gained in this program was extremely useful in assisting the Bureau of Environmental Sustainability and OECD to develop indicators for assessing the impact of agricultural policy on the environment. Many of the individual achievements of the program were documented in a Summary Report on the Soil Quality Evaluation Program and presented at The International Workshop on Sustainable Land Management for the 21st Century, held recently in Lethbridge. Several international committees and working groups, as well as provincial agencies, have expressed an interest in applying SQEP methodology for soil quality assessment to their programs.

With the program emphasis, to date, being on systems development and data collection, evaluations of soil quality change are generally limited to test areas. Plans are currently underway to conduct more comprehensive assessments of the status of soil quality at provincial and regional levels. These assessments will be directed, initially, to provinces or regions where strong support for these assessments has been expressed through the Green Plan for Environmental Sustainability. Comprehensive assessment of the remaining agricultural lands will be forthcoming in cooperation with the provinces as other opportunities for funding arise.

Approximately three million dollars were provided from NSCP to this program. Nearly one-half of this amount was used to develop collaborators throughout the Research Branch, other federal and provincial agencies and the universities. There were approximately 30 scientists and 20 support staff involved in this program on a yearly basis, providing career development opportunities and training for many Research Branch scientists, postdoctoral fellows and students. The deployment of A-base resources from the CLBRR and collaborators was considerable. The estimated value of A-base resources directed to this program by the CLBRR, for example, was nearly triple the amount received from the NSCP.

## HIGHLIGHTS OF SCIENTIFIC PROGRESS FROM 1990 TO 1993

A conceptual framework for soil quality assessment has been completed and a draft document prepared that identifies appropriate methods for measuring soil quality attributes in the field and the laboratory.

Operational geographic information systems have been developed using two commercial GISs to integrate information for the assessment of soil quality at regional and national scales. These systems have been demonstrated for MB and ON. Cross-scale comparisons have been conducted to determine the degree of generalization involved in the national-level assessments. The appropriateness of various ground- and satellite-based sources of land use information was determined for each scale of assessment and the applicability of digital elevation data for upgrading topographic information provided on detailed soil maps was assessed. Procedures have been developed to assess the status of soil quality from data collected at some point in the past and to estimate the kind and direction of ensuing change by specific processes.

Files linking Census of Agriculture and Soil Landscapes of Canada (SLC) are complete for MB, SK and AB. Efforts to link Enumeration Areas to SLCs for ON and NS are continuing. Census Consolidated Subdivision data has been purchased for ON, NS, MB, SK and AB in order that dependant projects can proceed with some analyses. Farm type and characterization data has been extracted from the Census on the basis of Agricultural Resource Areas for MB, SK and AB. An image analysis capability has been established at the CLBRR to augment land use data from the Census with that from remote sensing. The development of a database management system, ELLY (Encyclopedia for Landscape and Land-Indexed Inquiry), custom designed for the SLC and associated Census data has been completed and demonstrated.

A network of 22 Soil Quality Benchmark sites has been established. Baseline characterization and documentation has been completed for two sites and is nearly complete for nine additional sites. One site has been re-sampled to determine change to parameters affecting soil quality in the four years since baseline levels were determined.

Progress in the development of protocols and data collection procedures for testing and validation of the Wind Erosion Research Model (WERM), being developed by USDA/ARS, has been impressive but development of the model has only reached the prototype stage, hence, original plans to have an operational capability to simulate wind erosion on an event basis by the end of the NSCP period will not be met. A model validation site was established at Lethbridge and erosion losses were monitored over 4-6 week periods in the spring and late fall-early winter of 1991 and 1992. Sixteen erosion events representing a total loss of 144 Mg ha<sup>-1</sup> or an average depth of 14.4 mm of topsoil were reported over the 3 ha site. The results will be instrumental in ensuring the WERM model will appropriately accommodate wind erosion conditions in western Canada and the Chinook Belt of Alberta, in particular. The impact of erosion on crop productivity also was measured at this site and the relationship was represented by a linear equation.

Studies at Lethbridge, aimed to validate the Tillage and Soil submodels focused on winter breakdown of aggregates under various tillage treatments and the impact of winter weather conditions on aggregate size distribution and surface roughness. Field investigations have been completed in MB to compare the impact of various tillage practices and crop rotations on crop residues and aggregate size and strength as well as to determine straw/grain relationships for several crops. A simplified method to determine surface roughness also was evaluated. Soil erodibility and residues were measured on chemical and conventional fallow treatments on several soils near Melfort, SK, and results compared to those from USDA that were used for developing the Soils and Decomposition submodels. Documentation of results for these various studies is in progress. Wind erosion monitoring sites were established in AB, SK, and MB to quantify erosion events under typical management practices. Erosion was not extensive in the wet spring of 1991 but single event losses as high as  $7 \text{ Mg ha}^{-1}$  and total losses of  $10 \text{ Mg ha}^{-1}$  for five events were recorded for one AB site in 1992. An image analysis technique for estimating crop residues was evaluated as a potential component of a residue management model.

A water erosion monitoring and prediction study entailed conducting baseline monitoring of soil erosion rates on agricultural landscapes across Canada. Cs-137 soil samples were analyzed from field-scale plots in BC, MB, ON, QU, and NB. Watershed-scale plots were sampled for Cs-137 analysis in SK and PE. Soil re-distribution at 2 QU sites averaged 24.3 and 12.9 t/ha/yr. The average soil movement per year of tillage was almost the same at each site. The most eroded landscapes positions at the 2 sites had lost 97 and 64 t/ha/yr. Soil movement from continuous potato production in NB averaged 53 t/ha/yr with a maximum value of 190 t/ha/yr over the last 30 years. Potato yield data showed a strong relationship with soil movement; about 0.15% loss of yield was associated with each 1 t/ha/yr soil loss.

Validation of the Revised Universal Soil Loss Equation (RUSLE) and WEPP model developed as part of the Water Erosion Prediction Project of USDA/ARS is ongoing since the models have just become available in their final forms. Preliminary versions of the WEPP model have been evaluated on microplot-scale data in ON, where sensitivity analysis of important input parameters has been conducted. The final version of the WEPP model will be tested with erosion plot data from across Canada. Then, it will be used in conjunction with the Cs-137 data to compare actual and predicted soil redistribution on a landscape. Winter erosion data from BC, ON, and MB will be used to evaluate the winter runoff and soil loss routines of the model. Recently-collected soil erosion data in BC and NB will be used to conduct a validation of RUSLE under Canadian climatic conditions. Climatic data on freeze-thaw cycles, rainfall on frozen ground, and snowmelt data was combined with winter soil loss data to better understand and predict winter soil erosion losses. Climatic data files are being compiled for 32 locations across Canada for use in erosion prediction equations.

The soil landscape maps for Canada were used as the basis for establishing water erosion risk maps. The risk of water erosion was estimated using the USLE for each polygon on the soil landscape map. A handbook for the estimation of water erosion in Canada is being compiled to provide soil conservation planners with current information for USLE or RUSLE soil loss

predictions. It is intended that the information in the handbook will improve the reliability of erosion predictions made with these existing methods.

The CENTURY organic matter simulation model was tested for Canadian climate, soils and crop rotations using data from long-term rotation studies in western Canada and erosion, tillage, and fertility plots in ON and QU. The model accurately simulated changes in soil organic carbon and nitrogen in the long- (more than 80 yr) and short- (less than 5 yr) term. Simulations under eroding conditions indicated that erosion was the primary process controlling organic matter levels in soil. In addition to the modelling, soils under different management regimes were sampled at 22 sites in eastern Canada to assess the effects of cultivation on the quantity and quality of soil organic matter. The mass of carbon in cultivated soils was about 35% less and the mass of nitrogen 20% less than in forested soils. Several cultivated soils had greater levels of nitrogen than corresponding forested soils. Work is continuing to develop a soil quality index for soil organic matter.

Seven sites have been instrumented and characterized for monitoring and modelling the long-term status of soil salinity for representative agricultural landscapes in the Canadian Prairies. Comprehensive data sets have been assembled for each of these sites. Preliminary evaluation suggests that the extent of salinity is not increasing at any of the sites, although there is some fluctuation in concentration of salts within the sites. Contaminant transport models (SEEP/W and CTRAN/W) have been used to simulate salinization processes at each site so as to determine the relative importance of the various factors controlling salinity. Preliminary output has identified the water flux at the soil surface as the major controlling factor in the dynamics of soil salinization. It also has shown that most of the salts in the saline fringe area of a glacial morainal slough are locally derived and are the result of shallow, local redistribution over short distances through geologic time.

Procedures involving field and laboratory measurements were developed and later modified for the measurement of the Non-limiting Water Range (NLWR) of soils. The field procedure included infiltration and redistribution of added water to allow measurement of the wet end of the soil-water desorption curve with a single measurement of water content and soil-water potential. In the laboratory, the penetrometer resistance of soil cores dried to different soil-water potentials was used to interpret both the aeration limits and the strength limitations for root growth. Soils at nine locations across Canada having a variety of cultivation histories were studied. The major findings include: an improved procedure for desorption of soil cores and a new soil probe design for the combined and simultaneous measurement of water content and water potential in the soil; the increasing soil strength which appears to be occurring under cultivation is limiting the availability of soil water more than has been previously recognized; about 20% of the soil horizons studied are showing inadequate aeration porosity, leading to possible restrictive root development; some of the intensively-cultivated soils showed a reluctance to wet, which gave non-uniform distribution of the infiltrated water and limited water retention; and the attempted application of the NLWR concept provided indications of some of the possible causes of soil physical degradation.

In another approach to evaluate change to soil structure, stress-strain functions were determined for 12 of the main soil associations found in the R.M. of Haldimand-Norfolk, ON. These data were used in conjunction with estimated soil moisture profiles from the soil water retention model (SWATRE) to derive probability distributions for total soil porosity changes during critical periods of the corn growing season. Comparison of stress-strain relationships (remoulded vs structured) resulted in a segregation of the Haldimand-Norfolk soils into 3 groups based on the relative positions of these stress-strain functions under saturated conditions (i.e. degree of over consolidation). Crop cover information was overlain with generalized soil mapping to identify the soil landscapes that are most susceptible to traffic-induced soil compaction from row cropping. A key finding is that earlier model forms for soil compression do not perform well on structurally intact subsoils. Secondly, the compressive behaviour of structured soils in this municipality can be predicted reasonably well from consolidation behaviour of the remoulded (slurried) soils and hence from their consistency limits. This enables the development of a soil survey interpretive procedure whereby a user can interpret the magnitude of below-ground limitations to crop productivity arising from high soil strength from fundamental and widely accessible data on soil physical properties.

A study of the modelling and monitoring of agrochemical migration in soil showed that approaches being used were highly variable and generally of local scale or specific intent. An assessment of modelling practices led to the choice of the Leaching Estimation And CHemistry Model (LEACHM) for predicting the fate and transport of chemicals in the root zone. The model was modified to allow its use in situations where the water table comes into the zone of analysis and the functions used to represent the soil water properties were changed to use those proposed by Van Genuchten. The expansion from point data, as resulting from the LEACHM model, to regions was achieved using geostatistical analysis, followed by kriging to estimate values of parameters for grid points. A GIS was used to identify factors controlling the root zone migration of chemicals in the Grand River, ON watershed. Linear correlation coefficients indicate that the loadings reaching the groundwater table results from a complex interaction of many soil and climate factors. The atrazine loadings were predicted to be very low where soils are fine-textured and high on alluvial sands. Thus, this approach is useful in identifying the regions of higher risk from agrochemical migration.

An analysis of FP&I well water data showed that nitrate levels in some of the sampled wells were high but the ancillary data were not useful in identifying any causal factors. The sparse geographic coverage of the location of the wells made it difficult to make additional use of these data and the analysis was terminated.

As an indication of the possibility of contamination of Canadian agricultural soils with industrial organic compounds, analyses were conducted on 30 soils from different provinces. Very low or not detectable levels of most industrial organic chemicals were found in the agricultural soils analyzed. The exceptions were residues of pesticides currently in use and the detected levels were consistent with their use in crop production and are not known to represent a significant hazard to the environment. Other ubiquitous compounds, such as phthalate esters and polychlorinated biphenols (PCBs) occurred frequently in small amounts. In addition, municipal sludge from Hamilton and Sarnia were incubated with soil to monitor the persistence of chemicals arising from this

source. Even though these sludges are thought to represent worst-case industrial organic contamination possibilities, it was concluded that land application of these sludges according to recommended ON practice does not represent a significant hazard from organic chemicals to agriculture and the environment.

In an attempt to determine the impact of soil quality change on crop yield and sustain-able production, an extensive literature review was conducted and an annotated bibliography of research efforts which focused on the effects of soil degradation on crop productivity was produced. A survey of innovative conservation farmers identified indicators that distinguish between the kinds and severity of soil degradation, determine losses of crop productivity due to soil degradation, and ascertain threshold levels at which ameliorative measures should be taken. These farm-level observations were also applied to a framework for evaluating sustain-able land management, and integrated with the scientific studies to provide a rule base for an expert system which would function as a conservation planning and research tool.

## STUDY PROGRESS

The portion of the report to follow identifies annual goals for each study and highlights progress toward these goals for 1992-93.

### Study 01 - Soil Quality Criteria and Standards

**Goal:** To continue the development of a framework for evaluating soil quality and initiate a study to compile data relating biological production and soil quality.

**Progress:** A framework for the assessment of change to the quality of the agricultural soils in Canada been documented in A Summary Report on the Soil Quality Evaluation Program and a poster was presented at the International Workshop on Sustainable Land Management. In collaboration with the Parkland Agricultural Research Initiative, the Soil Performance file of CanSIS has been utilized for the development of criteria and standards for soil quality assessments in the prairie provinces.

### Study 02 - Soil and Environmental Quality Analysis and Assessment

**Goals:** **i)** To complete an evaluation of available digital elevation data for use in characterizing landscape shape. **ii)** To complete an assessment of soil quality susceptibility to change at a national level, based on soil quality status and sensitivity as documented in discussion documents. **iii)** Assemble data on cropping, climate, landscape shape, and land resource properties for the study areas and analyze it to identify areas of expected soil quality change.

**Progress:** **i)** Digital elevation data from topographic sources showed close agreement with topographic information contained on detailed soil survey maps; enhancing the quality of information for some areas but failing to provide as much information in other areas. **ii)** Development of concepts and definitions for soil quality assessments, procedures for assessing inherent soil quality and the conduct of sensitivity analysis in terms of databases, logic and algorithms used for the assessments have been completed and documentation of some of these aspects initiated with presentations at GIS conferences in Vancouver and Ottawa, the Summary Report on the Soil Quality Evaluation Program, and the International Workshop on Sustainable Land Management. **iii)** Documents were prepared comparing soil quality assessment methods for a detailed soil map area and comparing national and detailed soil quality algorithms, using the MB SLC database.

### Study 03 - Land Use Analysis and Monitoring System

**Goals:** **i)** To complete the reprocessing of the 1991 Census of Agriculture into a land-based Census by merging the legal location of farm headquarters with the appropriate

polygon on the Soil Landscapes of Canada (SLC) maps for the prairies, edit the farm headquarters and the map polygon legal location files, and conduct a preliminary merge of the two files by province. For ON and NS, link the Enumeration Area (EA) boundary files of Statistics Canada with the Agroecological Resource Area (ARA) map files. **ii)** To develop and implement a remote sensing work station at the Central Experimental Farm, and **iii)** To transfer existing technologies and develop new procedures and methods in the field of agricultural land use analysis and monitoring.

**Progress:** **i)** Files linking Census of Agriculture and SLC are complete for MB, SK and AB. The number of farms reporting, sum, mean, median and variance for each of 110 census variables have been extracted for each SLC polygon. Delays in the availability of EA boundary files has hindered the acquisition of data for ON and NS, but the files are now available and work is ongoing to determine the feasibility of linking EA's with SLC's. In the meantime, CCS (Census Consolidated Subdivision) data has been purchased for ON, NS, MB, SK and AB, in order that dependant projects can proceed with some analyses. In a related project, 'farm type' and characterization data has been extracted from the Census on the basis of ARA's for MB, SK and AB. **ii)** All contracts for purchase, delivery and installation of a workstation and software for remote sensing work have been completed. Training in system management and image analysis is complete and the system is functioning above expectations. A variety of remote sensing/GIS projects in AB, ON, NB, NS and PE are in progress. **iii)** All contractual obligations of Axion Spatial Imaging to supply CLBRR with a database management system custom designed for the SLC and associated Census data have been met with the receipt of several copies of ELLY (Encyclopedia for Landscape and Land-Indexed Inquiry). Copies of the software have been distributed to various regional centres and Ottawa, and several staff have become familiar with its operation. Progress to date in the development of improved capabilities for land use analysis was documented in the Summary Report on the Soil Quality Evaluation Program and in a demonstration at the International Workshop on Sustainable Land Management. The system was successfully demonstrated at the International Workshop on Sustainable Land Management. An interim report has been received for the Ontario land use study (on contract with the University of Guelph).

#### **Study 04 - Soil Quality Benchmark Sites**

**Goals:** **i)** To complete all laboratory characterization (detailed baseline soil data) on 11 benchmark sites across Canada. **ii)** To complete the preparation of benchmark site documentation for 8 of the 11 sites. **iii)** To design and establish computer data formats for both laboratory and field information. **iv)** To collect field data and complete field baseline information on all 19 sampled sites. **v)** To establish three additional benchmark sites and resample 3 original sites.

**Progress:** **i)** Laboratory characterization (detailed baseline soil data) of 11 benchmark sites across Canada (01-BC, 03-AB, 06-AB, 08-SK, 10-SK, 12-MB, 13-ON, 14-ON, 22-NB, 23-PE and 24-CEF) has been completed except for available P and K, clay mineralogy and

soil moisture retention (see variance). All laboratory data are electronically filed. **ii)** Benchmark site documentation is continuing. Interim documents have been completed for 05-AB and 20-NB. These, and subsequent documents, include the following information: objectives, selection criteria, location (map), current and historic land management practices, site manager and co-operators, detailed soil and topographic map, tabular data for chemical, clay mineralogical, particle size, surface area, soil moisture retention and bulk density, total elemental composition, and saturated hydraulic conductivity. Some sites also have penetrometer and soil moisture readings, biopore and earthworm counts, crop yields, long-term regional climatic summaries and current site data, and a description of field and laboratory methods. **iii)** Completed design and formatting of laboratory and field information. **iv)** Completed the collection of in situ soil data (Ksat, penetrometer, soil moisture, root counts) and crop yield on all sites and earthworm data for central and eastern sites. Soil and contour maps completed for 03-AB, 06-AB, 08-SK, 10-SK, 12-MB, 13-ON and 14-ON. Maps were not completed for 01-BC, 23-PE and 24-CEF. **v)** Selected sites, described and collected samples for two major pedons, collected 100 loose samples for laboratory characterization and collected surface samples for Cs<sup>137</sup> analyses, including bulk density, at eroded sites for 04-AB; 07-SK; 25-NF. Prepared detailed soil (1:1500) and contour (0.5 m interval) maps for 25-NF. In addition, re-sampled 20-NB for laboratory characterization.

**Variance:** **i)** Available P and K has not been completed. **ii)** Soil moisture retention is scheduled for completion in Sept., 1993. **iii)** The Soil Quality Benchmark Site program was documented in the Summary Report on the Soil Quality Evaluation Program.

### **Study 05 - Wind Erosion Monitoring and Prediction**

**Goals:** **i)** Monitor actual wind erosion events as well as pertinent soil and climatic parameters in order to test WERM model predictions of erosion loss, and to characterize the eroded material in terms of its nutrient status and its content of pesticide residues. Assess the effect of erosion loss on crop productivity. **ii)** to collect pertinent data to facilitate the development, testing and validation of the tillage, soil and decomposition submodels of WERM for conditions in western Canada following protocols used by USDA/ARS scientists, **iii)** Establish a number of sites across western Canada to provide data on actual soil losses due to wind erosion, and to compare these losses with those predicted by WERM.

**Progress:** **i)** A total of 8 erosion events occurred in 1992. This brought the total number of events at the site over two years to 16. Total soil loss for the past year was 35.17 Mg ha<sup>-1</sup> and 144 Mg ha<sup>-1</sup> for the 16 events. This represents an average depth of 14.4 mm of topsoil over a 3.14 ha area. A significant decline in crop yield, represented by the equation  $y = 3106 - 3.6x$  ( $r^2 = 0.36^{**}$ ), where:  $y$  = grain yield in kg/ha and  $x$  = distance to protected surface in m occurred at the WERM site. For every 10 m increase in the fetch distance from the protected surface, grain yield decreased by 36 kg ha<sup>-1</sup>. Further analysis was conducted on the 16 erosion events and the results presented at an erosion conference in Regina.

Another paper that addresses the quantification of wind erosion on summerfallow in southern Alberta has been reviewed, internally. A poster on long- and short-term variability of aggregate size distribution in tillage and chemical fallow was presented at the SSSA annual meetings.

Temporal measurements were made of soil properties, crop residues and crop yields under wheat on both no-till and cultivated treatments at Brunkild, MB and under a wheat-bean rotation at Carman, MB. Data collected from actual wind erosion events at two sites in MB was prepared for presentation at the Manitoba Soil Science Meetings. Progress to date in the development of improved capabilities for wind erosion prediction was documented in the Summary Report on the Soil Quality Evaluation Program and in a poster at the International Workshop on Sustainable Land Management.

**ii)** Further validation of a TILLAGE submodel was undertaken at the Fairfield Farm at the Lethbridge Research Station. It was found that winter breakdown of aggregates was more prevalent on disc harrow and rototiller treatments than on a blade cultivator. Validation of this submodel was continued at the Brunlild and Carman sites in MB where measurements, in the spring and in the fall were made to determine aggregate size, amount of surface residue, bulk density and moisture content, and strength of 20 mm aggregates. Additional sampling also was done at the Soil Quality Benchmark site where straw/grain relationship for barley, canola, wheat and white beans was determined.

Validation of the SOIL submodel involved the measurement of soil erodibility in conventional tillage, fallow with herbicides and tillage, and fallow with herbicides only treatments of a chemical fallow study on a Black Chernozemic soil at the Melfort Research Station. Similar measurements were conducted on a Dark Gray Luvisol soil under fallow. Thirteen variables related to soil erodibility were measured; five times during the field season at the former and eight times at the latter site.

Soil wind erosion losses due to saltation and surface creep were measured at one sampling date in a wind tunnel for various treatments on the Chernozemic soil at the Melfort Research Station. Surface roughness was measured using a simplified chain technique on Winnipeg research sites; this method proved to be simple and reproducible although it has not been compared to Pin Meter results. An assessment of the stability of the various aggregate size fractions was done on selective 1992 fall samples. The clay content, organic carbon and carbohydrate content were determined. Based on the results, the 0.84 to 2.3 mm size aggregates have the higher clay and organic carbon content as well as carbohydrate content.

A freeze-thaw study which is part of the SOIL submodel validation, was carried out at the Fairfield Farm. A small plot was cultivated with a chisel cultivator in September 1992 and sampled for aggregate size distribution in conjunction with measurements of air and soil temperature, relative humidity, snow depth, depth of freezing and the number of freeze/thaw cycles, soil moisture, surface roughness and wet aggregate stability on 1-2 mm aggregates over the winter period.

Validation of the DECOMPOSITION submodel involved measuring decomposition of crop residues over the fallow season for conventional tillage, conventional tillage plus herbicides, and herbicides, only, treatments on plots at Melfort. Samples were analyzed at 6 times during the growing season for hemicellulose, cellulose, and lignin. Decomposition curves were compared to temporal changes described in research by the USDA/ARS.

**iii)** Monitoring and characterization sites were selected at Retlaw and Crossfield, AB, in conjunction with Alberta Agriculture. Four clusters (each with 4 dust samplers) were installed at each site to quantify erosion events under typical management practices. Samples for aggregate size distribution analysis were taken at each site after erosion events. Erosion losses ( $\text{Mg ha}^{-1}$ ) at Retlaw were calculated as follows: Apr. 3 - 0.3; Apr. 9 - 0.5; Apr. 18 - 7.1; Apr. 27 - 0.2; Apr. 30 - 1.9 and May 11 - 0.6. This site was of loam texture and had little residue. In cooperation with staff at PFRA-Morden and MDA-Carman and Morden, dust collectors were set up in the spring at four sites on fields that had special crops the previous year (potatoes on a Black, sandy loam soil; and canola on a Black, clayey soil); the fields had evidence of previous erosion problems. Dust was collected on two wind events. Soil from the various sieve heights was analyzed for organic carbon and clay content; the soil was also sieved to determine aggregate sizes (negligible material finer than 0.1 mm size was found; this finer fraction was probably lost through the screen (0.11 mm opening) at the top of the collectors. Also, a semi-quantitative assessment of soil loss from fields that had previous erosion was determined by taking topographic levels across several locations in the field boundary containing transported soil; soil volume, soil bulk density, and length were determined and the amount of soil calculated.

In cooperation with PFRA, approximately 180 photographs of stubble residue from fields in SK were analyzed with Adobe Photoshop and Graftek Ultimage software to determine the usefulness of the software for estimating the percentage of residue cover. These estimates may then be used in developing a management model. Crops included wheat, durum, barley, canary seed, lentils, peas and flax. Photographs of each crop were taken at regular intervals over the period that the field lay fallow. As a result of this analysis, improved methods were developed for acquiring the photographic images, thereby enhancing the quality of future computer results.

## **Study 06 - Water Erosion Monitoring and Prediction**

**Goals:** **i)** To complete the editing and preparation for publication of a handbook on soil erosion prediction in Canada. **ii)** Undertake analysis of soil erosion and Cs-137 data for benchmark sites, and use results to verify or calibrate USDA-WEPP soil erosion model under Canadian conditions. **iii)** Test the water erosion prediction procedures using the results of the erosion plot monitoring in Peace River region. **iv)** Test water erosion models using plot and field scale data from ON and initiate experiments to measure erosion rates. **v)** Quantify the risk of weather conditions that are associated with water erosion events.

**Progress:** **i)** Preliminary information on soil erodibility chapter was evaluated. Further editing of the handbook and preparation of graphic material for inclusion is still required. **ii)** All Cs-137 analyses from the benchmark sites have been completed. Data for the ON benchmark site has been compiled. The Ontario Land Resource Unit will be the central clearing house for Cs-137 data. **iii)** Preliminary testing of WEPP model with the Beaverlodge data and field measurement of saturated hydraulic conductivity for Dawson Creek and Beaverlodge plots have been completed. Data from the Peace River region has been compiled in format suitable for WEPP validation. Data compilation for model evaluation and testing using real climatic data are proceeding. **iv)** WEPP model has been calibrated for seasonal small plot data for the Guelph soil for 2 rainfall intensities. Testing is continuing for another soil texture. Results will be prepared for internal review. Field plots are being established to measure soil loss at a benchmark site; the Guelph rainfall simulator was evaluated relative to the USDA simulator for inter-rill erosion measurement. **v)** CLIGEN data have now been prepared for 23 stations across Canada. Currently 13 of these stations have been completed for use in models. The data compilation procedure has now been documented.

In addition, a study at the University of Alberta on the impact of water (and wind) erosion on soil productivity, using the Erosion/Productivity Index Calculator (EPIC) model, has been completed. A water erosion workshop was held to report progress and develop a future plan of action. Testing and validation of the tillage erosion model that was developed is ongoing. Progress in meeting goals has been slowed; awaiting release of the final version of the WEPP model by the USDA/ARS and by staff reductions and leaves. Progress to date in the development of improved capabilities for water erosion prediction was documented in the Summary Report on the Soil Quality Evaluation Program.

### **Study 07 - Evaluating Soil Organic Matter Changes**

**Goal:** **i)** To test the updated version of the CENTURY model and assess the model's performance in different soil/crop rotations. **ii)** Continue evaluation and characterization of organic matter fractions that may be used as indices of soil quality in agricultural soils. **iii)** Assess the effects of cultivation on the quantity and quality of soil organic matter in eastern Canadian soils.

**Progress:** **i)** The CENTURY model (version 4.0) was tested with data sets obtained from long-term crop rotation studies in SK and AB. The CENTURY model mimicked the dynamics of soil organic matter in the 30 cm depth within 20% of the observed values. The model was tested using results from a fertilizer experiment with corn on the Macdonald Campus of McGill University. Evaluation of corn yield, soil organic C and N were conducted and a variety of sensitivity analysis of the model investigated. The CENTURY model predicted changes in soil organic C and N within 10% of observed values over a relatively short time under continuous corn. The model did not predict yearly yield variations accurately, however average yield predictions were accurate. The model was also tested on erosion plots at the University of Guelph. Input data including erosion measurements

under continuous corn and rotations (hay, oats, corn) resulted in simulated values within about 10% of observed values over 30 years of cropping. In comparison to a previous version, version 4.0 has greater flexibility to handle input data, and provided better prediction for soil organic matter change. Progress to date in the development of improved capabilities for the prediction of organic matter change was documented in the Summary Report on the Soil Quality Evaluation Program and in a poster at the International Workshop on Sustainable Land Management. iii) Samples from paired cultivated and forested sites in ON, QU and the Maritimes were analyzed for total organic C and N, microbial biomass C and light fraction C and N to assess management impacts on soil organic matter. Soils under different management regimes were sampled at 22 sites in eastern Canada. Each site included a native forest and one or more crop production system or a pasture; four profiles were sampled under each management site. The mass of carbon in cultivated soils was about 35% less than in forested soils. At all sites the losses of carbon exceeded the losses of nitrogen. Consequently, the mass of nitrogen in cultivated soils was about 20% less than in forested soils. Several cultivated soils had greater levels of nitrogen than did the corresponding forested soils. The results of this study including the impact of management on active fractions of organic matter, such as the microbial biomass and light fraction, will be presented as a poster at the CSSS annual meetings in St. John's, NF. Study team members are collaborating to synthesize this information for a review of soil organic matter quality and its role in soil quality.

### **Study 08 - Soil Salinity Monitoring and Prediction**

**Goals:** i) *Continue* data collection and characterization of the 8 monitoring sites. ii) Initiate data analysis and modelling of individual sites. iii) Prepare draft reports.

**Progress:** i) Characterization was completed and *monitoring* for weather, soil salinity, and water levels was continued at seven sites: MB - Warren, SK - Cory, SK - St. Denis, SK - Prairie View, AB - Forestburg (Lunty), AB - Crossfield and AB - Blackspring Ridge. There appears to be more seasonal dynamics than annual change in salinity. Frequent and consistent *monitoring* over a period of time will be required to establish any trends in the status of salinity. An analysis of the salt balance in the landscape shows that most of the salts in the saline fringe area of a glacial morainal slough were locally derived and were the result of shallow, local redistribution over short distances of tens to hundreds of meters over geologic time. ii) Preliminary runs of the mathematical modelling of salinization processes was completed for five of the seven monitoring sites and for the test site at Hamiota. The major controlling factor in the dynamics of soil salinization according to the modelling done to date is the water flux at the soil surface. iii) Progress to date in the development of improved capabilities for the prediction of soil salinity was documented in the Summary Report on the Soil Quality Evaluation Program, in a poster at the International Workshop on Sustainable Land Management, and various other reports.

**Variance:** Satellite site at the Morden Research Station has will not be reported due to lack of information and characterization. Under-estimation of the time requirement for modelling has precluded modelling activities for the Forestburg and Blackspring Ridge sites.

## **Study 09 - Structure Assessment and Prediction**

**Goals:** **i)** Establish, adapt and carry out the procedures for determining a soil profile's "Non-Limiting Water Range" (NLWR) for five well-known benchmark sites. **ii)** Conduct an investigation into soil compaction risk from farm traffic associated with corn production systems in southwestern Ontario, using the soil landscapes of the Regional Municipality of Haldimand-Norfolk as a case study (contracted to the University of Guelph).

**Progress:** **i)** The laboratory measurements of desorption curves and soil strength (penetrometer resistance) at different water contents has been completed on the soil cores taken during the 1991 field season. The laboratory measurements on the cores taken from four field sites in the 1992 field season are 75% completed. The analysis of the 1991 field and laboratory data have been completed for 80% of the sites and conclusions have been drawn. In general, the more intensive or the more extensive in time has been the cultivation the lower is the NLWR. For example, the Ap horizon of the Lethbridge soil can only retain 10 mm (or 2/3 as much) of available water in the top 15 cm of soil in long-term continuous wheat or wheat-fallow rotation as opposed to 15 mm available from a native grass site. At Termuende, there is greater NLWR from soil cultivated for 14 years than from soil under native grass or cultivated for 80 years. Presumably the cultivation of virgin soil gives an initial improvement in the pore space for root growth which is later lost unless sustainable cultivation practices are used. The Clinton site showed that 14 years of no-till management following long-term conventional tillage led to an increasing level of available water and more favourable conditions for root penetration. The more critical aspect limiting the water availability of the soils studied is the limiting strength which would prevent root penetration. In essentially all horizons studied, the 2 MPa root penetration limit was reached before the soil was dried to the - 1500 kPa wilting point potential. About 20% of the horizons showed a low enough aeration porosity to restrict aeration. Thus, the NLWR concept has shown where to anticipate plant growth limitations from the particular soils in this study.

Some of the procedures used for desorption of the soil cores were included in the CSSS Methods Manual and a more detailed paper is currently being revised for possible publication in the CJSS. The procedures used in the field measurements were modified by developing improved tensiometers as a part of the wave guide probes used for the TDR water content measurements. Thus, it is now possible to measure both water content and water potential (tension) on the same soil. The improved system was used to complete field experiments at Clinton (ON), Elora (ON), Indian Head (SK) and Charlottetown (PE). The 1992 field data have been assembled and edited in readiness for combined analysis with the laboratory measurements from the cores collected in 1992 field work.

ii) Work has concentrated on the measurement of stress-strain functions for 12 of the main soil associations found in the R.M. of Haldimand-Norfolk. This testing has been carried out under variable initial conditions of moisture content, structural integrity and pre-stress history. Two consolidation testing techniques have been used to examine the correspondence between the normal consolidation line (slurry consolidation) and the virgin compression line of structurally intact soils ("fast" uniaxial compression) for these soil associations. Data were collected from static, uniaxial compression of 285 soil cores sampled from the profiles of 12 major soil associations in the municipality. The analyses include determining regression-based relationships that allow prediction of "compression index" (slope of the virgin compression line) and the "preconsolidation stress" of the soils in this region with data on clay and organic matter contents, degree of saturation and initial void ratio. A key finding is that the Larson (1980) model form, derived from compression in prepared aggregate beds, does not perform well on structurally intact subsoils due to the overriding influence that the initial void ratio has on the configuration of the compression line, even on "treatment replicate" soil cores.

Normal consolidation lines were measured by consolidating soil slurries made up of the same group of soils represented above. The experimental approach included refinements to the stresses at the upper and lower plastic limits, allowing for an alternate test protocol for soil consistency (Atterberg) limit testing. Test results show that there is a high degree of correspondence between these compression data under saturated conditions. These data are being used in conjunction with estimated soil moisture profiles from the SWATRE soil water retention model to derive probability distributions for total soil porosity changes during critical periods of the corn growing season. Comparison of stress-strain relationships (remoulded vs structured) resulted in a segregation of the Haldimand-Norfolk soils into 3 groups based on the relative positions of these stress-strain functions under saturated conditions (i.e. degree of overconsolidation). The hypothesis has also been tested that the compressive behaviour of structured soils in this part of Ontario can be predicted reasonably well from the consolidation behaviour of those same soils when in a remoulded (slurried) condition, and hence from their Atterberg consistency limits. This hypothesis has been corroborated for a sufficiently wide range of soils that a soil survey interpretive procedure ("pedotransfer function") has been developed and tested that will aid in characterizing the degree of overconsolidation of agricultural soils without the need for an extensive and costly compression testing program. This goal has been achieved by assembling the necessary physical characterization data for all soil series characterized by the Ontario Centre for Soil Resource Evaluation (formerly the Ontario Institute of Pedology) during the last five country-level soil inventory upgrades in southwestern Ontario and that meet the minimum data requirements. This amounted to 229 individual soil horizons from 104 major soil series. In this pedotransfer function, a "first approximation preconsolidation stress" variable is estimated from dry bulk densities (void ratios) measured in situ and from other soil properties needed to estimate the normal consolidation line. A statistical analysis of variance has shown the extent to which this variable, depicting the degree of soil overconsolidation, is influenced by mode of deposition, soil horizon depth (effective overburden pressure), soil texture and past soil/cropping management (traffic, tillage).

In order to assess the spatial distribution of soil compaction risk levels, LANDS 5 Thematic Mapper imagery was obtained for 1990 and 1991 (July). Crop cover information was also obtained from ground inspection for several sections of the regional municipality for these years to act as "training areas" for digital image analysis with EASI-PACE and to allow statistical confidence levels to be determined. Preliminary results suggest that the total area of the major crop groups within the six local municipalities as classified from the satellite imagery correspond well to total areas obtained from the 1991 Census of Agriculture. Field level verification from 1991 further shows that the major row crop groups were correctly identified at between 82% (soybeans) and 100% (tobacco) of the time.

Overlay analysis of crop cover and soil associations has been carried out with the SPANS geographical information system. This analysis, in combination with the results of laboratory soil compression testing, identified soils that are highly susceptible to traffic-induced soil compaction given their present use for row crop monoculturing.

Progress to date in the development of improved capabilities for the prediction of soil structure change was documented in the Summary Report on the Soil Quality Evaluation Program.

### **10/11 - Predicting the Fate of Organic and Inorganic Additions to Soil**

**Goals:** **i)** To define the scope and extent of modelling and monitoring of agrochemical migration in soil. **ii)** To evaluate FP&I well water data for usefulness in identifying possible causal factors for the contaminated samples. **iii)** To determine which, if any, organic chemicals persist in soil where sewage sludge has been applied.

**Progress:** **i)** Dr. Sidney Vieira was contracted to develop and test a methodology to predict agrochemical migration in soils on a landscape basis. This study, conducted in conjunction with Great Lakes Water Quality activities, involved studying the Grand River Watershed, ON, where soil and landscape data was available at a broad, 1:1,000,000 scale and the portion of this watershed which falls within the Haldimand/Norfolk Regional Municipality where more detailed data at a 1:45,000 scale was available. The primary objective was to use the available soil attributes from the two data sources as input for a solute transport model (LEACHM), to predict the risk of groundwater pollution within a region which contributes to the Great Lakes. For the Grand River Watershed, the polygon information for soil layers was obtained from the National Soil Data Base (NSDB). Missing values were obtained from alternate databases or were estimated using pedotransfer functions available from the literature. The pedotransfer functions were tested against field measured data and their performance was evaluated using linear correlation coefficients. Values for soil texture, organic carbon, bulk density and Ksat for the Haldimand/Norfolk region also were extracted from the NSDB. Pedotransfer functions were used to provide several missing values and for the soil desorption curve points. Groundwater contamination with atrazine was assessed by calculating the annual mass loading and the time necessary for it to reach 3 ppb at 90 cm depth with the LEACHM model.

Climatological data corresponding to the station closest to each soil profile was extracted and used for that soil unit. Geostatistical analysis, involving spatial autocorrelation, was used to extrapolate from point data to regions. Kriging was then used to estimate values on a fine regular grid of 2 km by 2 km for the watershed and 200 m by 200 m for the Haldimand/Norfolk region. The contour maps generated with the values estimated by kriging were input into a GIS and the rasterized maps were reclassified and color printed with respective legends. For the Grand River watershed region, the loadings of atrazine to the groundwater were limited by the soil attributes where the soils are fine textured, and by climate for soils with higher hydraulic conductivities. Except for an alluvial soil with high sand content and close proximity to the river, the soils of the Haldimand/Norfolk region have hydraulic conductivities that are sufficiently low so as to prevent high loadings even in varied climate regimes. The use of agrochemicals on the alluvial soil should be restricted because virtually all of the unused chemical passes through in less than one year.

Progress to date in the development of capabilities for the prediction of soil water contamination by agrochemicals was documented in the Summary Report on the Soil Quality Evaluation Program.

**iii)** The Wastewater Technology Centre of Environment Canada determined the concentrations of selected industrial organic contaminants in Canadian agricultural soils and the potential for organic contamination of soils from municipal sludge application to agricultural lands. Twenty four soil samples selected from eight SQEP Benchmark sites from across Canada, to represent typical Canadian agricultural soils, and six samples from two intensively cropped southern Ontario farms, where there had been repeated heavy use of pesticides for many years, were analyzed for a series of industrial organic compounds. Results for the 24, mainly surface soils from the Benchmark sites and the six intensively cropped soils indicated no significant contamination with base-neutral and acid extractable organic compounds (BN&As). There was no detection, or only trace amounts of polynuclear aromatic hydrocarbons (PAHs) - except naphthalene, chlorinated benzenes, heterocyclic nitrogenous compounds (HNCs), nitrosamines, haloethers, a variety of "other compounds" and acids - except phenol and pentachlorophenol. It is unlikely that the BN&As observed in the soils represent significant agricultural or environmental hazards. The compounds which exceeded method detection limits (MDL), occurred at small concentrations and degrade in soils. Although the production and use of polychlorinated biphenyls (PCBs) has been banned in Canada since the mid-1970's, they are ubiquitous in the environment and small amounts occurred in all soils. They are not taken up by plants and it was concluded that they do not represent a significant hazard to agricultural crops. Production and use of organochlorine pesticides (OCs), except endosulfan, has been banned in Canada since the mid-1970s. Thus, a higher incidence of alpha chlordane, dieldrin and aldrin in the intensively cropped than in other soils was assumed to reflect greater past use of these compounds in intensive rather than in general crop production. However, in most cases only trace amounts of OCs were observed in the soils from either group. Endosulfan (Thiodan) is a stomach insecticide used on field crops and the small concentrations observed in several soils were thought to reflect its use during the growing season in which the soil samples were taken. Total DDT concentrations in several soils approached levels

that could represent an environmental hazard. Only one soil, in an apple orchard, had residue levels that may represent a significant environmental hazard. The results of organophosphorous pesticide (OPs) analysis were similar for both groups of soils. Fonofos, which is moderately persistent in soil, was the only compound detected and it was observed at concentrations that probably do not represent a significant hazard to the environment. Neutral, phenoxy acid and carbamate herbicides were measured in surface soils from seven of the Benchmark sites and the intensively cropped farms. Results were similar for the two groups of soils and indicated no detection of most of these compounds in most of the soils. It was concluded that residues of these compounds probably do not represent a significant hazard to the environment.

Hamilton and Sarnia municipal sludges were monitored for industrial organic contaminants from September 1992 to January 1993. These sludges were thought to represent worst-case organic chemical contamination in Ontario. Both sludges were applied to sandy loam and silt loam soils at rates of 0, 8, 32 and 200 t ha<sup>-1</sup> dw. The sludge-treated soils were incubated aerobically for eleven weeks prior to analysis. Composite surface soil samples were taken during November, 1992 from eight sludge-treated fields. One field had received a single application and six had received multiple applications of sludge according to recommended practise. The eighth field was a future landfill area owned by a regional municipality and it had received repeated surface applications of sludge each year during 1982 to 1989 inclusive. The sludges and all other soils included in the studies were analyzed for PAHs, total PCBs and OC pesticides. In general PAHs, OCs and PCBs were not detected or concentrations approximated the respective MDLs in two southern Ontario surface soils not treated with sludge. Treating these soils with Hamilton and Sarnia sludges at rates which approximated the maximum acceptable loading for ON soils did not measurably change their PAH, OC and PCB concentrations. Treating them with sludge at a rate greatly exceeding acceptable ON practise caused only minor increases in the concentrations. Moreover, there was evidence for degradation of some compounds, particularly the low molecular weight PAHs, during the eleven-week experimental period. It was concluded that land application of southern ON sludges according to recommended practise probably does not represent a significant PAH, OC and PCB hazard to agriculture and the environment.

A more complete report on contamination of agricultural soils with industrial organic compounds was documented in the Summary Report on the Soil Quality Evaluation Program.

## **Study 12 - Land Evaluation for Agricultural Sustainability**

**Goals:** i) to set the groundwork for the development of an expert system on soil degradation-crop productivity for prairie agricultural production; and ii) to begin preparation for a case study on the sustainability of conventional and conservation-based agriculture on an AB farm using the framework for the evaluation of sustainable land management (FESLM).

**Progress: i)** The objectives of the expert system are to estimate the impacts of soil degradation on crop yields using farmer defined indicators and to suggest practices that could be used to maintain or restore soil quality and thus soil productivity. In the past year an Annotated Bibliography has been published, summaries and analyses of the questionnaires have been completed for both the prairies and PE, the prairie summary results have been compared to the most relevant scientific results identified in the Annotated Bibliography, regional agronomists and scientists have participated in the validation of the farmers opinions and these results have been incorporated into the knowledge database, the rule base for the expert system has been developed using the questionnaire results and scientific evidence, the first version of the expert system was produced and it is currently being restructured and refined, and a poster on the impacts of soil degradation on crop yields as estimated by innovative Canadian farmers was presented at the International Workshop on Sustainable Land Management. ii) A preliminary outline for the FESLM case study has been prepared and a draft list of possible sites for investigation has been compiled.

### **Project Development and Coordination**

**Goal: i)** To direct the development of a soil quality evaluation program for Canada. ii) To coordinate the implementation of this program. iii) To communicate program developments to all participating agencies and others.

**Progress: i)** A comprehensive, national program to monitor the quality of the agricultural soils in Canada has now completed the third year of operation. Program delivery relies heavily on resources identified in the Monitoring component of federal-provincial NSCP agreements. Collaborative agreements have been developed between the CLBRR and seven Research Stations of Agriculture Canada, totalling \$294,500 and 12 agreements with four Universities and one Research Council totalling \$887,900. An additional \$166,760 has been committed in nine professional service contracts to individual researchers at Universities or in the private sector. An outline of agreements for 1992-93 is presented in Tables 1 and 2.

There have been approximately 30 scientists and 20 technicians, students and other support staff actively involved in the project over the past year. In addition, there have been approximately 11 scientists, accompanied by support staff, from Research Stations, PFRA and other Federal agencies and 18 scientists, accompanied by support staff, from Universities and other agencies. The essence of these agreements and staff involvements are as was presented in the 1990-91 annual report.

ii) Work progress has been appraised and reported, work plans revised and financial control maintained for each of the 12 studies established within this program. Extensive collaboration with Research Stations, Universities and other agencies has continued. A statement of SQEP expenditures for 1992-93 against the MOU with the Agri-food Development Branch in Ontario is presented in Table 3 and a comprehensive statement for all Lead Agencies as Table 4. As noted in the aforementioned tables, expenditures for

1992-93 included deferral of \$10,000 in each of Operating and Capital budgets. The deferral of \$10,000 in Contributions from 1991-92 to 1992-93 was not realized. Collaborated with Saskatchewan Institute of Pedology in developing a conceptual framework for soil quality evaluation. Assisted with planning future monitoring programs in SK and AB as part of the Green Plan initiative. Conducted a workshop on soil quality monitoring in Ottawa. Consulted to OECD on the development of a framework for the evaluation of the impact of the agricultural sector on the environment and with the Policy and Evaluation Branch on the assessment of the NSCP program. Conducted a workshop and developed a plan for reporting on soil quality. **iii)** Reviewed progress in the SQEP program at the Expert Committee on Soil Survey. Reported progress on a quarterly basis to all lead agencies and collaborators. Participated in the 7th ISCO conference in Australia and presented a paper on the SQEP program. Presented a poster and assisted in the organization of the International Workshop for Sustainable Land Management for the 21<sup>st</sup> Century.

**Table 1. Status of agreements with Research Stations for 1992-93.**

| RESEARCH STATION | PROJECT                   | AMOUNT |
|------------------|---------------------------|--------|
| Beaverlodge      | Water erosion monitoring  | 6,500  |
| Lethbridge       | Wind erosion monitoring   | 43,500 |
| Swift Current    | Water erosion monitoring  | 10,500 |
| Melfort          | Wind erosion monitoring   | 13,000 |
| Ste. Foy         | Organic matter evaluation | 10,000 |
| Charlottetown    | Organic matter evaluation | 12,000 |
| <b>TOTAL</b>     |                           | 95,500 |

**Table 2. Status of contribution agreements for 1992-93.**

| INSTITUTION                | TITLE AND COOPERATOR                        | AMOUNT  |
|----------------------------|---|---------|
| University of Alberta      | Evaluating organic matter (Robertson)       | 5,000   |
|                            | Erosion-productivity (Izzauralde)           | 27,463  |
| University of Guelph       | Soil compaction risk assessment (McBride)   | 65,000  |
|                            | Evaluation of soil loss rates (Kachanoski)  | 10,000  |
| University of Saskatchewan | National Soil Quality Evaluation (Anderson) | 70,247  |
| University of Manitoba     | Groundwater monitoring of nitrate (Cho)     | 6,000   |
|                            | Soil salinity monitoring (Racz)             | 12,000  |
|                            | Wind erosion (Racz)                         | 14,000  |
|                            | Soil quality assessment (Racz)              | 48,000  |
|                            | Water erosion monitoring (Shaykewich)       | 4,000   |
| Alberta Research Council   | Salinity monitoring                         | 36,000  |
|                            | Soil quality benchmark sites                | 30,000  |
| <b>TOTAL</b>               |   | 327,710 |

**APPENDIX E**  
**FINAL REPORT ON MONITORING**

**REPORT**

**on**

**NATIONAL SOIL CONSERVATION PROGRAM**

**SOIL SURVEY UPGRADE COMPONENT**

**1990-1993**

Prepared by: K. Bruce MacDonald  
Ontario Land Resource Unit  
Agriculture Canada  
70 Fountain St.  
Guelph, Ontario  
N1H 3N6

## **EXECUTIVE SUMMARY**

The purpose of the National Soil Conservation Program (NSCP) Soil Survey component was to promote a standard compilation of information on the quality, extent and location of agricultural lands in Ontario to provide standard reference data for policy, planning and extension initiatives. The soil survey upgrade sub-program was given a budget of \$ 200,000 over the three year duration of the program.

Activities in this sub-program were started by Dr. C. J. Acton who established the general guidelines and managed the activities from 1990 until the fall of 1991 when he left to participate in a CIDA project. Subsequently, the activities were coordinated and managed by K. B. MacDonald. Throughout this time there was ongoing consultation with associated personnel in the university, provincial and private sector clients.

There were three areas of activity under this sub-program. The first was the development of an overall approach to soil survey information in the province. This included critical assessment of the requirements for the information and guidelines for upgrading surveys which were inadequate. This activity was carried out in-house with a great deal of consultation with associated agencies. The second activity consisted of a several small projects conducted in-house to speed up the development of a generalized provincial level soil survey map for broad scale planning at regional, provincial and national levels. This activity also included a completion of data compilation for a detailed soil re-survey map and report. The third activity dealt with the need to upgrade substantial areas of the province for which the current soil survey information is inadequate. The requirements for additional information to bring the survey up to modern requirements were defined and developed into "statements of Work" which formed part of requests for proposals. Three proposals were funded for a total cost of \$125,000. The remainder of the funds were used to support in-house projects to prepare generalized detailed maps and reports.

The following pages present a short summary of the activities carried out under this sub-program. The first section outlines the work done to develop a clear coordinated program and subsequent sections provide a precis of the statements of work along with an executive summary of the project activities and conclusions. The detailed reports are maintained separately.

Respectfully

K. Bruce MacDonald  
Ontario Land Resource Unit

## Table of Contents

|  |    |
|--|----|
| EXECUTIVE SUMMARY .....  | 2  |
| <u>BACKGROUND</u> .....  | 4  |
| Development of Soil Survey Upgrade Requirements<br>and Procedures (developed in-house with consultation) .....   | 4  |
| Application of Geographic Information Systems (GIS) for Soil Survey<br>Upgrading in Ontario .....  | 7  |
| Development, Evaluation and Demonstration of Soil Survey Upgrade .....   | 10 |
| Phase 1: Evaluate GIS and digital elevation technology compared to conventional air<br>photo interpretation to assign slope classes and proportions to existing soil polygons<br>in the Oxford County pilot study area ..... | 12 |
| Phase 2 - Preparation of a multi-county digital soil map for Oxford and adjacent<br>counties .....   | 14 |
| Unsolicited Proposal: Research and Development of a Methodology for<br>Soil Survey Upgrade and an Information System .....   | 18 |

## **SOIL SURVEY SUB-PROGRAM OF THE NATIONAL SOIL CONSERVATION PROGRAM**

### **BACKGROUND**

The Canada-Ontario Agreement on Soil Conservation provided for \$ 11.1 million from both Canada and Ontario in matching funds over a three year period ending March 31, 1993. The soil survey upgrade sub-component had a budget of \$ 200,000 and was administered by the head of the federal soil survey unit in Guelph.

The soil survey upgrade component dealt principally with the development and implementation of a process to provide standard reference data for policy, planning and extension initiatives to provincial, federal and private sector personnel. The development activity involved extensive consultation with partners and clients to develop a statement of requirements and the implementation is achieved through a standard compilation of information on the quality, extent and location of land resources in Ontario. At the outset of this activity it was clear that the traditional procedures for collection of land resource information by comprehensive re-survey were too costly and time consuming. A major component of this activity consisted of evaluating feasibility of upgrading existing surveys using new technology and procedures.

Projects were carried out by Agriculture Canada, University of Guelph, Upper Thames River Conservation Authority, and Gregory Geoscience.

### **Development of Soil Survey Upgrade Requirements and Procedures**

(developed in-house with consultation)

The soil resource data base for Southern Ontario has mainly been compiled on a county, regional or municipality basis over many years. This represents the archive of soil resource information from which most agricultural based resource decisions are now and will continue to be made. Due to changes and improvements over time in survey methods, sampling procedures, classification standards, etc. the soil information for Southern Ontario (published and/or available in digital form) varies significantly on a county or regional municipality basis. In many cases, the information is deficient in either topographic (slope) information, analytical site specific data or both. In addition, on a provincial basis the available information is inconsistent in its accuracy, reliability, and conformity to established standards. It also contains major discrepancies in available interpretive information, in particular the soil capability (CLI) interpretations. The development and proliferation of GIS technology in both the private and public sector has led to increasing demands for soil data in digital format. With computerized procedures for manipulating the data the inconsistencies in data quality and content across administrative boundaries is causing increasing problem and concern.

In the course of land use and land management planning across the province, it is frequently necessary to revise and update the information in existing surveys or to prepare updated

interpretations in response to specific requirements. These requests usually involve expert soil surveyor and often require additional field work and site checking. In many cases, the results of these specific projects meet the immediate planning needs but do not contribute to the overall body of soil inventory information. The intent of the soil survey upgrade activity is, that whenever it is necessary to collect additional soil inventory information the upgrade procedures would be used to collect a consistent minimum amount of data. In this way, the overall provincial data would be upgraded gradually as individual specific projects are carried out and the additional cost to each project would be marginal. The soil inventory data for the province would eventually build up to a single clearly defined minimal standard. (There may be circumstances where the information needs are so specific or the study area is so small that collection of the upgrade information will not be warranted). In addition, there may be requirements for upgrade projects in specific areas of high priority.

The objective of this project is to identify the kinds and level of information required for planning at the County, township or watershed level, or for broad targeting of soil-related agricultural programs. It will allow resource managers to extrapolate research findings, transfer management practices to similar soil types, target soil conservation efforts and help address other soil related issues.

Specifically, this involves the development of consistent soil inventory information for the province of Ontario at a nominal scale of 1:50,000 for regional and county use. The minimum requirement for this level of soil survey information will be to carry out interpretations for CLI agricultural capability and for requirements for the provincial level official plan.

#### Proposed information content of a Streamlined 1:50,000 scale upgraded soil survey.

The streamlined upgrade would include a standardized legend and, in particular, standardization of the criteria by which polygons are delineated.

Features of the database:

- The basic spatial unit is the map polygon and each Polygon a is defined in terms of
  - soil (code + modifier), % of the polygon occupied and associated slope and stoniness class
  - up to three soils can be defined within a polygon
  - inclusions may comprise up to 20 % of each delineation.

A soil name record defining the general properties of the soil is linked to each soil (code + modifier)

At least one soil layer record and up to 9 is linked to the soil (code + modifier) for a land use which is either agricultural or non-agricultural.

Linked to each soil (code + modifier) is a typical example (specific site location) of the soil in question.

Note: this link is suggested because it is clearly not feasible to store all possible kinds of information about each individual soil in the soil survey (map) database. When additional information is required, it may be associated with the site description or at least the typical site provides a location where the user can go and sample to obtain further analytical information. The specific sites potentially offer good locations for additional studies.

Generic Legend development: Work with the soil map legends in South Western Ontario and also in Lanark and RMOC, the important and common elements (diagnostic?) of the legend should include:

- Surface texture
- Parent materials
- Topographic Classes
- Drainage class
- Soil Phases
- Polygon (mapunit) proportions
- Soil Series/type/name

It may well be appropriate to add information on:

- Quality/reliability
- Representative site identified/described (Y/N)
- Additional data available (Y/N)
- Pointers/linkages.

Scale, Survey Intensity Level (SIL) and standards: The upgrade scale for Ontario is basically fixed at 1:50,000 (a recommendation of "A study of the use of soil survey information in Ontario" OIP publication 86-1). It is clearly relevant to review the information associated with a streamlined 1:50,000 soil survey upgrade critically and identify the kinds of uses and interpretations which would be appropriate and also, just as importantly, to clearly identify uses and interpretations which would not be appropriate with the 1:50,000 data without additional information or field checking. The streamlined 1:50,000 upgraded soil survey must have sufficient data for CLI interpretations and provincial level official plan requirements.

Any streamlined 1:50,000 upgraded soil survey should adhere to established provincial and federal standards. To be acceptable as a provincial data set the soil inventory map must meet the requirements of the Canadian System of Soil Classification, the CanSIS or OIP field manual for describing soils and the survey intensity level specifications outlined in the "Soil Mapping System for Canada". It may be that the minimum map resolution represents a map of topography, materials, texture and mode of deposition. The SIL may be closer to 4-5 than to 2-3 so that it may not be possible to identify individual soil components within the polygons

but it may still provide acceptable accuracy for the proposed uses of provincial level official plan and CLI agricultural capability.

The delineation of wetland areas are an important component of an upgraded soil survey. The definition of wetland areas should, of course, correspond to the accepted (OMNR?) or CSSC definition.

One aspect that the upgraded survey must deal with is the expectations of the user of digital data in working with a legend versus the expectations of a user of conventional maps.

Data linkages - A streamlined 1:50,000 upgraded soil survey will serve only a limited subset of the applications of land resource data. Data from other sources, collected at different scales, will be required for the myriad of other needs. The ways of identifying when other data are available, the kinds of linkages and pointers and the possible structures for nested data bases will be very important components of the data associated with an upgraded soil survey.

## **Application of Geographic Information Systems (GIS) for Soil Survey Upgrading in Ontario**

(Contract No. 01950-1-0190/01-XSE)

Contractor - University of Guelph

### **Statement of Work:**

The traditional approach to upgrading soil data base information would most likely focus on field data collection and remapping of areas, which is extremely time consuming. However, digital data bases and Geographic Information Systems Technology offer the possibility of upgrading the soil resource information in a more timely and efficient fashion by integrating existing soil data with existing topographic and geologic information. In addition, the science of remote sensing and image analysis offers another rapidly available source of data to assist with upgrading the existing soil data base.

### **Objectives:**

- To develop a methodology for integrating digital land resource data using GIS technology and remote sensing to upgrade older soil surveys in Ontario at a scale of 1:50,000.
- To test the methodology in a small pilot study area in Southwestern Ontario and evaluate its applicability in other soil landscapes in Southwestern Ontario.

## **Introduction**

The currently existing soil data base for Ontario varies significantly in its accuracy, reliability and conformity to established standards. Existing maps are either on a county or regional basis and are at varying scales. This variation exists because of changes that have been made to soil survey methods, sampling and data collection and classification procedures. The existing soil information in many cases is extremely general with only very general soil classes being identified with little or no topographic information and only very general definitions of texture and drainage classes. Specific data indicating slope, texture and drainage information is extremely important for determination of soil capabilities for agricultural production and land use planning and for calculation of potential soil erosion which is vital for use in soil conservation programs. The soil data base for Ontario needs to be upgraded to include this vital information and to bring the data base to a consistent level of accuracy and reliability.

The traditional approach to upgrading soil data base information would most likely focus on field data collection and remapping of areas. This is extremely time consuming. However digital data bases and Geographic Information Systems Technology offer the possibility of upgrading the soil resource information in a more timely and efficient fashion by integrating existing soil data with existing topographic and geologic information.

## **Specific Objectives**

To examine the potential of using the Terrasoft Geographic Information System as an aid in the soil survey upgrade process.

To test this potential using a small pilot study area in Southwestern Ontario.

To use the Terrasoft DTM to calculate slopes for the study area and test the accuracy of the resultant calculations through field verification.

## **Conclusions**

This investigation has shown that the Terrasoft GIS is capable of producing a reasonable estimate of slopes. The maps produced could be of use as a basic input for soil survey upgrades. The surveyor could estimate slope categories for existing soil polygons from these maps. Also it is possible that areal estimates of slope categories within a polygon could be determined using the software. Although this was not attempted for this particular project.

If this methodology is to be pursued further for application in soil survey upgrading, the Terrasoft version 10 DTM needs to be applied to the study area to see if it offers improved accuracy of slope modelling. Also the methodology should be tested on a much larger study area to identify technical issues which may be associated with larger file sizes, processing time and computer memory as a result of working with a much larger study area. Also, the issue of areal estimates of slope categories should be investigated for its use and practicality.

In addition, a good test of the model would be to use the predicted slopes in conjunction with existing soil polygons to produce an interpretive map of soil capability for agriculture. If a sufficiently accurate interpretive map can be produced, then it can be concluded that the GIS system is an excellent tool to assist in soil survey upgrades.

In summary, it can be said that this methodology appears to hold promise for use in soil survey upgrading but further testing, particularly in the areas suggested above is necessary before any final conclusions are reached.

## **Development, Evaluation and Demonstration of Soil Survey Upgrade**

**Phase 1: Evaluate GIS and digital elevation technology compared to conventional air photo interpretation to assign slope classes and proportions to existing soil polygons in the Oxford County pilot study area.**

**Phase 2 - Preparation of a multi-county digital soil map for Oxford and adjacent counties.**

Contract No. 01950-2-0592/01-XSE

with Upper Thames River Conservation Authority

### **Statement of Work**

**Phase 1:** The contractor shall provide technical support services in analyzing and assessing available digital elevation and soil inventory data to improve and standardize old soil survey maps. The contractor shall also provide professional soil survey services and consultation to develop and test procedures. The work shall include:

1. Use the existing Digital Elevation Data for the Study area to:
  - Calculate slope aspect and define slope extents based on breaks in aspect.
  - Calculate average slope lengths.
  - Prepare a digital physiographic map for the study area and intersect with the digital elevation data to create a map of slope class/landform units.
  - Compare the units created by combinations of slope class and landform with the existing soil polygons (recognizing that, in many cases, soil polygons will consist of major and minor soil components each with a different slope class and landform).
2. Based on Aerial Photography of the study area:
  - Carry out a conventional stereographic analysis of the area to upgrade the existing soil survey with slope information. This will result in an assessment of the validity of the existing soil polygon boundaries; and for each polygon the designation of one or more slope classes contained along with an assessment of the proportion of the polygon occupied by each slope class.
  - Carry out a conventional stereographic analysis to estimate the slope in percent on a regular grid spacing of 300 x 300 m.
  - Meet with the Ontario Centre for Soil Resource Evaluation to review the requirements of soil upgrade procedures for Ontario and to establish appropriate techniques to meet the objectives.
3. Combine digital data and data compiled from air photo interpretation to:

- Compare slopes estimated by air photo interpretation to slopes estimated by DEM based on the sample grid established for photo interpretation (all samples and also stratified by slope classes)
- Compare the slope classes, proportions and polygon boundaries established by digital techniques to those derived from conventional photo interpretation and assess the usefulness of these digital techniques for slope upgrade for soil survey data at scales of 1:63,360 and 1:50,000.

**Phase 2:** to provide technical support services to combine and integrate available digital soil inventory data for counties adjacent to Oxford (Middlesex and Elgin), to define the diagnostic criteria to be used to delineate soil areas and develop a basic legend structure for the regional digital soil layer, to analyze and document the differences in map legend content between the old (Oxford) soil inventory information and the recent (Middlesex and Elgin) and, where possible, to upgrade the Oxford data to modern standards and complete the edge match between Oxford, Middlesex and Elgin counties. The work will include:

1. Digital soil inventory map and attribute data for Middlesex and Elgin Counties will be edge-matched and combined to produce a single contiguous digital coverage for the two county area. Any problems or inconsistencies along the map boundaries will be resolved with the authors. A copy of the combined data (lines and attribute data) will be provided in Terra Soft format to the Guelph Unit office.
2. Create a digital data layer containing the location of the sample site data for the counties of Middlesex and Elgin and integrate these data with the digital soil map layer to identify where representative sites are located for all soils on the maps.
3. Carry out legend analysis and development for Oxford and surrounding counties to define the diagnostic criteria to be used to delineate soil areas for a regional digital soil layer and to develop a basic legend structure.
4. Edge-match the digital soil inventory map for Oxford County with the adjacent boundaries in Middlesex and Elgin Counties. Conduct a detailed analysis of the shared boundary to summarize (i) the adjacent attribute information and (ii) the adjacent map legend information.
5. Review the edge-match between Oxford, Middlesex and Elgin counties to upgrade the Oxford data to modern standards where possible and identify the nature of the inconsistencies which must be resolved through field work.

**Phase 1:**

In Ontario, soils information varies greatly across the province in terms accuracy and the extent of information available. This is due to the fact that soil survey in Ontario was carried out county by county over a relatively long period of time ranging from the early 1930's to the late 1960's. Inconsistencies in the soil database exist due to the changes both in survey methods and the types and amount information available to surveyors over this period of time.

Soil survey information can play an important role in activities such as soil conservation, regional planning and environmental assessment and therefore should be as up to date and reliable as possible. In recognition of this fact efforts to upgrade the soils database for Ontario have been and are being made. Recently upgraded surveys include Waterloo, Peterborough, Niagara, Haldimand-Norfolk, Brant, Ottawa-Carleton, Elgin and Middlesex counties with Kent county currently under way.

Upgrades have been accomplished through remapping of areas at a larger scale (increased to 1:50000), more intensive collection of field data, stereographic interpretation and revision of map legends.

Such upgrade methods can be very time consuming. Geographic Information Systems technology offers a means by which information important in conducting soil survey can be quickly and efficiently made available to surveyors. New survey methods that make use of currently available digital databases and GIS need to be investigated. Efforts are currently under way to incorporate LANDSAT data in soil survey upgrade. This study, however, focused on integrating GIS technology and Digital Terrain Models (DTM's) into the process of soil survey upgrade.

**Study Objectives**

The objectives of this study were: 1) To generate a DEM, slope and aspect maps for the study area using Terrasoft GIS software. 2) to evaluate the usefulness of these and other available digital products for survey upgrade and determination of slope length. 3) to test the accuracy of the digital products developed.

**Conclusions**

The Ontario soils database varies considerably with respect to detail and accuracy of the data. To satisfy the needs of today's resource managers many of the existing surveys require upgrading. Conventional methods of soil survey upgrade can be time consuming; GIS technology offers some possible means of expediting the process which require investigation. This study evaluated the use of GIS and Digital Terrain Modelling in the soil survey upgrade process.

This study found that the reliability of the slope and aspect generated by Terrasoft is questionable; some problems can be attributed to the software itself, but some problems arise because the detail and nature of the base topographic data utilized. It should be noted that the

software might perform better if the base topographic data could be enhanced i.e. additional contour info could be added (if any exists). The software also offers the option of using a coverage of spot elevations instead of digitized contours to generate a DEM. Using this approach may provide a better digital product from which to work.

Although the accuracy of the techniques employed were questionable, the nature of the products created show promise as basis for beginning a soil survey upgrade. Using a combination of slope, aspect and elevation maps surveyors may establish areas of differing drainage. In combination with the existing survey information, it should be possible to quickly establish a generalized soil map with polygons representing areas of homogeneous slopes, drainage and surface texture. This map could be refined with more conventional methods such as field sampling, but would hopefully reduce the amount of such activity required.

## **Phase 2: Objectives**

The specific objectives for this study were as follows:

- 1) To combine digital soil maps for Middlesex, Elgin and Oxford counties in a single digital coverage using Terrasoft GIS software.
- 2) To assess the capabilities of the software when dealing with very large volumes of this type of data.
- 3) To investigate the possibility of using this data in upgrading soils data in Oxford county along the along the Oxford- Elgin/Middlesex border.
- 4) To investigate the requirements for producing a map legend suitable for the entire area.

## **Study Data**

The data utilized in this study consisted of digital soil coverages for Oxford, Elgin and Middlesex counties. Both Elgin and Middlesex coverages are products of recent resurveys while the Oxford is based on the original survey of the county conducted in the early 1950's. The location of these counties in Southwestern Ontario and their relation to one another are illustrated in figures 1 and 2.

The Middlesex county resurvey was completed in 1992, the resurvey improved the map scale from 1:126,720 to 1:50000, significantly improving the detail and precision of the soils data. There was also a much more in depth physical and chemical characterization of soils. The county was divided into 3 different map sheets along township boundaries. Soil polygon symbols consist of a soil association code, drainage and phase modifier for a dominant and subdominant that exists in the polygon. Under this is a letter code for slope classification

The Elgin county survey is very similar to Middlesex, again it is the product of a recent resurvey conducted at a 1:50000 scale. For the published maps the county was also divided into 3 maps sheets. Map symbology differs somewhat for the Middlesex map however, instead of code for soil association and drainage modifier, these elements were combined to form various soil series within each association.

The Oxford county soils coverage is based on the original survey which was completed in the early 1950's. The scale of the survey is 1:63360 (1 inch to 1 mile). The level of precision in differentiating criteria is much coarser then that of the previous surveys described, and the accuracy is not comparable to the resurveys.

CANSIS digital database files containing in depth characterization of soils described in each survey should be available for each county. While this is true for Oxford, the files have not yet been completed for Elgin and Middlesex since these surveys have only been completed recently.

## **Overview of Technical Procedures**

The technical procedures involved several main steps as follows: 1) Merging digital linework from the various coverages (seven in all, 3 for both Middlesex and Elgin counties and

1 for Oxford) into a single map universe 2) Editing and edgematching linework along mapsheet and county boundaries 3) Processing new topology and linking of the separate databases.

After each individual coverage had been imported into Terrasoft format, they had to be merged into a single coverage.

During merging it is possible to offset the coordinates of the coverage being merged in, this makes it possible to optimize the positioning of each mapsheet relative to one another for edgematching. Within Middlesex county no alterations were made between mapsheets and they were merged into a single Middlesex county coverage as is. In Elgin county, however, there was a considerable gap between the second and third mapsheets which was minimized with the use of the offset function plus the rubbersheeting function. After the individual mapsheets were merged for each Middlesex and Elgin counties the resulting coverages were then merged. In order to get the best fit it was also necessary to use the offset and rubbersheeting function on the Middlesex coverage when it was merged in with the Elgin coverage.

Since each individual coverage was more or less digitized as a separate entity, the linework along joining edges never match perfectly. Terrasoft does not have a specialized edgematching feature, so reconciling these differences required quite a bit of manual editing of linework. This involved both deleting redundant linework, and manipulating points of the remaining coverage so that matching polygon boundaries were fitted together cleanly. Following

this, the Oxford coverage was merged in with the Middlesex/Elgin coverage, no offsets were made. When the three mapsheets were merged, the necessary editing of linework took place. There were some significant edgematching problems in Middlesex/Elgin that were resolved with the aid of the survey authors. It should be pointed out that editing of polygon boundaries will alter the extents of many soil types.

The next step was processing the polygon topology for the entire coverage. The main concern at this point was if the software could handle this much data efficiently, which it did fairly well; processing time was fairly lengthy (approx. 2 hr), but not unreasonable.

Once polygon topology had been developed linking the new coverage to attribute database tables of the original coverage was necessary. To achieve this it was necessary to develop polygon labels in the original coverage that would be unique in the combined coverage. These labels were merged into the combined coverage and allowed a new attribute table to be created that incorporated all the data from the original coverages.

The steps described here may seem simple, but required the bulk of the contract period to complete because of the amount of experimentation that was involved.

The software seems deal with this amount of data satisfactorily. Performing simple queries on the coverages worked quite well. Using the dynamic labelling function however, was extremely slow. Since the software is running on a lower end machine (25 MHz 386) it is conceivable that performance could be significantly improved through hardware upgrade.

To complete the coverage an operation to dissolve the boundaries between polygons that cross map sheet or county boundaries should be undertaken. This operation requires that

there be an identical attribute between the two polygons so that the dissolve may occur. The most logical attribute to use is the map symbol, which will work well within counties. It should be possible to carry out a dissolve between Elgin and Middlesex counties since the soils types have been correlated, but the map symbol conventions are different which for the time being make this operation impossible. Involving the Oxford portion of the coverage in this operation would also prove extremely difficult. The difference in scale and level of precision between Oxford and Elgin/Middlesex means that edgematching possibilities for soil polygon boundaries are almost non-existent.

### **Oxford Upgrade Possibilities**

Bringing together these three surveys raises the question of whether or not it may be possible to somehow extend boundary lines from Elgin/Middlesex into the adjacent area of Oxford county, thus upgrading the information in these areas of Oxford. Using only the soil polygon boundary lines this would not be possible, but with the additional layers of information such as surficial geology data or topographic data generated from digital terrain modelling, such an operation may be feasible.

Time constraints prevented a full investigation of this portion of the study and should possibly be pursued further in the future.

### **Legend Development**

With the creation of the new coverage it was necessary to determine whether or not a legend suitable for the entire coverage could be developed. The existing legends for Elgin and Middlesex are fairly closely related in format and the soils described have been correlated between counties. The Oxford legend on the other hand, differs substantially from the previous two in form and content.

The best approach seemed to be to use a selected group of soil physical and chemical properties which exist for each soil within the CANSIS files, however, since the Elgin and Middlesex surveys have only been recently completed, the CANSIS files have not been completed for either county. Oxford county does possess completed CANSIS files but since many of the attributes are really only estimates, especially those in the layer file, the reliability may come into question.

The suggested list of soil properties is as follows:

- SOIL\_CODE
- MODIFIER
- Map
- Mode of deposition 1
- Depth
- Mode of deposition 2
- Surface texture
- Parent material texture
- Drainage class

Depth of control section  
Surface organic matter content  
Surface ph class

## **Conclusions**

In this study, three adjacent digital soil survey coverages, Oxford, Elgin and Middlesex counties, were combined using Terrasoft GIS software in order to investigate the feasibility and usefulness of such a digital product.

This investigation showed that the hardware and software used seems to have the capacity to handle this volume of data reasonably well. From a practical stand point, this type of product may only be useful in digital form since it would require 9 E-sized sheets to plot the coverage at 1:50000 scale and still 4 E-sized sheets at the 1:100000 scale.

In addition, this study was very useful for discovering and correcting previously undetected discrepancies between mapsheets and between counties.

Two aspects of this study, map legend development and survey upgrade opportunities, were not fully investigated due to time constraints and availability of data, and should be more thoroughly investigated in the future.

## **Unsolicited Proposal: Research and Development of a Methodology for Soil Survey Upgrade and an Information System**

Contract No. 01950-2-1711/01-XSE

Gregory Geoscience Limited

### **Objectives**

The overall objective of this research project is to develop and test a new methodology for a soil survey upgrade that will lead to a consistent and continuous soils database for Eastern Ontario and possibly all of Ontario. To this end, the following specific objectives are defined for the project.

1. From all the soil surveys of Eastern Ontario, develop a common legend that defines the soils in Eastern Ontario relative to one another. The legend for Ottawa-Carleton may be used as a foundation on which to build the new legend.
2. To develop and test a survey upgrade methodology using air photo analysis and field sample techniques. The methodology must be quick, cost-effective and produce data that will fit into the common legend to be developed in this study. The methodology will edge match county boundaries to produce a seamless database.
3. To investigate other possible sources of soils information and evaluate their potential for incorporation into the soil survey database.
4. To define a database structure that will provide a uniform level of soil information for Eastern Ontario, and yet be open to expansion and provide linkages to other more detailed soil information.
5. To define the type of application for which the general level soils survey data is suited and those applications for which more detailed information must be added.
6. To define an operational soil survey upgrade program for Eastern Ontario.

### **Recommended Operational Soil Survey Upgrade**

The research carried out in this project in itself cannot be used as a model for operational soil survey due to the unacceptable schedule of tasks and the lack of a final product evaluation. However, the work does suggest a sequence of tasks that, if carried out, would lead to an upgrade of the soil surveys in Eastern Ontario and possibly the rest of the province. The goal of such an upgrading process is to provide a consistent seamless soils database that is built on one common legend.

It is recommended that before this method is accepted for operational work it should be tested proto-operationally for the remainder of Lanark County or part thereof. This should be done for several reasons.

1. The tasks should be carried out in the proper prescribed sequence.
2. Both time and financial requirements for operational programs can be more accurately determined.
3. To test database structure and integration.
4. To suggest minor modifications to the methodology that may be required for an operational program.

### Method

The proposed methodology for an operational soil survey upgrade is presented in the following tasks.

#### Pre-Mapping Phase:

- Task 1. Assemble and review existing soil survey maps, physiographic, surficial geology and other information, become familiar with soil types, their morphology, association and parent material groupings.
- Task 2. Enlarge the existing soils maps to 1:50,000 or 1:20,000 scale. Most of the existing county soil surveys are available in digital form.
- Task 3. Select the appropriate base and prepare copies on a stable base for a township or county. The recent Ontario Base Maps (OBM) at 1:10,000 reduced to 1:20,000 are appropriate. Alternatively, the 1:50,000 scale NTS can be utilized. Research needs to be done on the cost effectiveness of utilizing orthophoto mosaics or enlarged satellite imagery as a plotting base.
- Task 4. Acquire existing aerial photography suitable for the upgrade if available or have new photography flown for the upgrade area. It is desirable to have a consistent scale and imagery that is taken in the spring season after the snow has gone but before the leaves on the deciduous trees have emerged. The spring photography is more suitable for the assessment of micro-topographic features and for soil drainage and wetness conditions. Also, areas that are subject to inundations are more readily identified when the natural ground vegetation or crops are low or suppressed.

At the end of this pre-mapping phase all reference, base maps, air photos and digital data will have been gathered. These materials will form the foundation of the soil survey upgrading process.

### Mapping Phase

- Task 5. Carry out a reconnaissance investigation of the soil survey area to gain familiarity with the landscape features and physiographic components to develop a photo-interpretative legend.
- Task 6. Undertake a systematic stereoscopic examination of the aerial photographs identifying, delineating and classifying the main landform-soils-terrain features. This establishes the polygons or basic map unit that reflects a sameness or homogeneity, or exhibits a consistent heterogeneity. This exercise should be done without referral to the existing soils map. The basic elements of landform-soils-terrain mapping is the landform itself. Within the landform framework the soil materials are interpreted or estimated. Also interpreted is the soil drainage condition. The slope or topographic conditions within the polygon is interpreted in terms of degree of slope or topographic feature.
- Task 7. Based on the photo-interpretative landform-soil-terrain analysis, plan a field survey to confirm the landform-soil-terrain interpretation and to collect in-depth data on the soil morphology and drainage characteristics. At each site selected, a comprehensive data sheet should be completed and the location of the site marked on the aerial photograph. As a guideline, a minimum of 1 sample site per 250 hectares is considered sufficient. However, if the landform-soils of the upgrade area are complex, more sample sites may be required. The actual location of field sample sites is determined during the airphoto interpretation. The data from these sites will be used to validate and make adjustments to polygons as they are mapped from the air photos. The data will also be used to extend the attribute database information recorded for each soil type.
- Task 8. Based on the field work, some adjustments to the interpretation may be required and the polygons and the classification adjusted. The interpretation is then finalized.

### Post-Mapping Phase

- Task 9. Transfer the interpreted information and the sample point locations on the aerial photographs to the cronaflex copy of the base map or ortho-photo. The OBM mapping has numerous reference features which can assist in the plotting. It

is important to plot the data as accurately as possible to avoid distortion or exaggeration of the polygon.

- Task 10. To ensure that all polygons close and have been classified, carry out a colour check of the polygons to assure all areas have been completed. Some further field checking may be required.
- Task 11. The finalized field map is digitized for GIS entry. Each polygon is given a unique number to permit linkage with the attribute table. The digital files are processed in a GIS to produce the raw soil polygon map which will be used as a base on which to build the upgraded soil survey map. The map will be developed using a UTM base that is now the accepted Federal and Provincial base.
- Task 12. The digital soil attribute file will be produced for the study area. The unique soil polygon number will be listed in the attribute file as a link to the map. It is possible that this attribute file could be developed during the field sample program and modified after map finalization. This could save some project time.
- The attribute files will be added to the GIS database. They will be used to reclassify the soil polygon map and prepare new soil attribute maps.
- Task 13. Based on the results of Tasks 7, 10, and 12, a set of soil representative sites will be defined. These sites will be visited in the field where a soil pit will be dug and comprehensive soil attributes recorded. Sample soil profiles will be extracted and removed for preservation and laboratory analysis. As part of the collection of the representative site record, the exact position of the site location will be recorded so that it may be revisited in the future to add information on the soil or monitor changes in the soil. This may be done by large scale plotting of the geographic position (air photo) or with a GPS system.
- Task 14. The soil attribute maps will be combined in the GIS to produce a landform class soil map that is defined using the common legend developed in the research phase of methodology development.
- The attribute maps will also be used to develop a CLI map using land capability matrices that are based on the landform CLI assignment table.
- Task 15. Final products will be produced for the study area. (Report, paper map, digital files for soil polygons, soil attributes, field sample sites and soil representative sites.)

**APPENDIX F**  
**FINAL REPORT ON RESEARCH**

# **NATIONAL SOIL CONSERVATION PROGRAM**

## **RESEARCH COMPONENT**

### **SUMMARY REPORT**

Prepared by: A. S. Hamill, Ph. D., P. Ag.  
Agriculture Canada  
Research Station  
Harrow, Ontario  
N0R 1G0

Disclaimer: The views contained herein do not necessarily reflect the views of the Government of Canada or the NSCP Implementation Committee.

## EXECUTIVE SUMMARY

The purpose of the National Soil Conservation Program (NSCP) Research Component was to encourage research related to soil management practices toward the long term productivity of soil. The research sub-program was given a budget of \$1.1 million for the two year duration of the program.

The initiation of the process to handle this component began in the fall of 1990. Dr. W. I. Findlay was appointed Scientific Authority for the solicitation of proposals for Soil Conservation Research. Through numerous committee meetings and with the assistance of individuals from the private sector, university, OMAF and Agriculture Canada, areas of concern were consolidated to issues which were subsequently developed into a "Statement of Work: which would be part of the Request for Proposals (RFP). Proposals totalling \$4.45 million were submitted for consideration against the \$1.1 million available. A rigorous review system, often involving out of province referees, was used with a preplanned evaluation criteria form. Twenty-nine referees were involved in the initial cut prior to committee prioritization. Six proposals were selected for contract, three for in-house support and two for contribution agreements. In addition, a literature search on buffer strips was supported.

All of this effort was completed before Dr. Findlay announced his pending retirement in the late spring of 1991. His dedication and thoroughness as Scientific Authority set the stage and paved the way for the smooth running administration of these research projects. A sincere expression of gratitude is extended to him on behalf of myself and all those involved in the initial organization (many of whom have now also retired).

The following pages present a short summary of the proposal selection process (in addition to the above), the statement of work, and the successful recipient. In each case where research was carried out, an Executive Summary (prepared by the awardee) and/or an edited version of the conclusions is provided. This document provides a "snapshot" of the findings related to the projects for which detailed reports are maintained separately.

Respectfully

A. S. Hamill, Ph.D., P. Ag.  
Scientific Authority  
Harrow Research Station

# TABLE OF CONTENTS

|  | Page |
|--|------|
| EXECUTIVE SUMMARY .....  | i    |
| BACKGROUND .....   | 1    |
| RESEARCH AREAS .....   | 1    |
| UNIVERSITIES, COLLEGE, AND PRIVATE AGENCY COMPETITION .....  | 2    |
| IN-HOUSE COMPETITION .....   | 3    |
| DELIVERABLES AND PROPOSAL FORMAT .....   | 4    |
| PROPOSAL REVIEW .....  | 4    |
| RESPONSE TO THE CALL FOR PROPOSALS .....   | 4    |
| PART I - RESEARCH CONTRACTS THROUGH SSC .....  | 6    |
| Project A  |      |
| Soil Macropore Structures and Their Effect on solute Transport to Tile Drains ..   | 6    |
| Effect of Macropores on Contaminant Transport to Tile Drains .....   | 7    |
| Project B  |      |
| Manure Management to Sustain Water Quality .....   | 10   |
| The Evaluation of Three Manure Composting Methods for Nitrogen<br>Conservation Environmental Impact, Crop Growth Response and<br>Operating and Maintenance Costs ..... | 11   |
| Manure Management to Sustain Water Quality .....   | 14   |
| Project C  |      |
| Prediction of Crop Responses to Changes in Soil Quality .....  | 18   |
| Project D  |      |
| Influence of Soil Management Systems on Soil Quality .....   | 19   |
| Influence of Soil Management Systems on Soil Quality: Potentially Mineralizable<br>Nitrogen .....  | 20   |
| Project E  |      |
| Methodologies for Assessing Soil Structure (Degradation) in a Meaningful Way .   | 25   |
| Project F  |      |
| Open Category RFP under the NSCP Research Program .....  | 26   |
| The Effect of Soil Quality on Field Scale Runoff under Conventional and<br>Conservation Tillage Systems .....  | 27   |
| Literature Review Pertaining to Buffer Strips .....  | 31   |
| PART II - IN-HOUSE RESEARCH .....  | 35   |
| Project G  |      |
| Soil Macropore Development as a Mechanism for Root Distribution and Solute<br>Transport .....  | 35   |
| Rainfall simulator - Grid Lysimeter System for Preferential Solute Transport<br>Studies Using Large, Intact Soil Blocks .....  | 36   |

|  | Page |
|--|------|
| Project H  |      |
| Composting Manure as a Means of Sustaining Air and Water Quality . . . . .   | 39   |
| Project I  |      |
| Prediction of Crop Seedling Responses to Changes in Soil Quality . . . . .   | 41   |
| Project J  |      |
| Soil Biota as Indicators of Soil Quality . . . . .   | 42   |
| Response of earthworms, soil biota, and soil structure to agricultural practices<br>in corn soybean and cereal rotations . . . . . | 44   |
| Project K  |      |
| Methodologies for Assessing Soil Organic Matter Sustainability . . . . .   | 46   |
| Crop Residue Decomposition and Organic Matter Dynamics in Alternative<br>Management Systems on Coarse Textured Soils . . . . .     | 47   |
| Project L  |      |
| Open Category RFP under the NSCP Research Program . . . . .  | 50   |
| PART III - CONTRIBUTION . . . . .  | 51   |
| The Relationship between Landscape Position, Tillage Practices, and Soil Loss:<br>Model Development . . . . .                      | 52   |
| Methodologies for Assessing Soil Structure and for Predicting<br>Crop Response to Changes in Soil Quality . . . . .                | 55   |
| APPENDIX A . . . . .   | 59   |

## **RESEARCH SUB-PROGRAM OF THE NATIONAL SOIL CONSERVATION PROGRAM**

### **BACKGROUND**

The overall purpose of the National Soil Conservation Program was to encourage the implementation of appropriate soil resource management practices to maximize societal benefits and sustain the long-term productivity of soil with the framework of environmentally sustainable agriculture.

The Canada-Ontario Agreement on Soil Conservation provided for \$11.1 million from both Canada and Ontario in matching funds over a three year period ending March 31, 1993. The Monitoring, Research, and Soil Survey activities under the Canada portion of the agreement had a budget of \$1.1 million each.

The Research component of the program was administered for Agriculture Canada by the Harrow Research Station. The key processes of land use, tillage practices and cropping systems that result in changes in soil quality were studied in terms of the sensitivity of soil to degradation, the conditions under which degradation occurs and its impact on productivity. A major task was research into changes in soil organic matter, nutrients, erosion, and pesticide levels related to land use, tillage practices and cropping systems for intensively cultivated land.

Projects were carried out by Agriculture Canada, universities, colleges or other agencies.

### **RESEARCH AREAS**

1. The following areas of research were considered for support:
  - (a) the development of soil management systems that protect fragile land and improve the environment, and are economically viable.;
  - (b) the development of indicators of degradation or conservation that can be used in monitoring the resource base;

- (c) development of methods to improve the transfer of conservation technology, e.g. "expert systems".
- 2. Preference was given to projects which were complementary to ongoing Federal and Provincial related research activities in soil and water conservation e.g. Soil and Water Environmental Enhancement Program (SWEEP), Great Lakes Water Quality Agreement and the Land Stewardship Program.
- 3. Preference was given to extend existing research projects, as compared to starting new research projects.
- 4. Preference was given to projects where there was good potential for commercial application of specific research results that had high potential for improvement of soil and environmental quality.

### **UNIVERSITIES, COLLEGE, AND PRIVATE AGENCY COMPETITION**

Within the general guidelines offered above, specific issues were defined by the Implementation Committee in Ontario for Canada's portion of the agreement. Competitions were based on five issues plus one open category subject to the guidelines above. These issues are:

- A) Soil macropore structures resulting from tillage and their effects on solute transport;
- B) Manure management to sustain water quality;
- C) Response of crops to soil quality;
- D) Influence of soil management systems on soil quality (e.g. soil biota);
- E) Methodologies for assessing soil structure (degradation) in a meaningful way;
- F) An open category to accommodate unique ideas about soil quality within the terms of the NSCP program not included in the identified issues above.

One competition was open to Universities, colleges and other agencies in Ontario. It excluded federal research stations and laboratories except where collaborative

participation at no additional cost was indicated. This call for research proposals was distributed through Supply and Services Canada (SSC) with statements of work under the following titles:

Statement of Work Title:

- Project A: Soil Macropore Structures and Their Effect on solute Transport to Tile Drains
- Project B: Manure Management to Sustain Water Quality
- Project C: Prediction of Crop Responses to Changes in Soil Quality
- Project D: Influence of Soil Management Systems on Soil Quality
- Project E: Methodologies for Assessing Soil Structure (Degradation) in a Meaningful Way
- Project F: Open Category RFP under the NSCP Research Program

Level of Effort

The suggested level of effort was \$50,000.00 annually for two years (\$100,000) ending March 31, 1993.

**IN-HOUSE COMPETITION**

The issues to be addressed by Federal Research Stations under Canada's portion of the agreement follow. This competition is based on five issues plus one open category subject to the guidelines above. These issues are:

- A) Soil macropore development as a mechanism for root distribution and solute transport
- B) Composting of manure as a means of sustaining water quality;
- C) Prediction of crop seedling responses to changes in soil quality;
- D) Soil biota as indicators of soil quality;
- E) Methodologies for assessing soil organic matter sustainability;
- F) An open category to accommodate unique ideas about soil quality within the terms of the NSCP program not included in the identified issues above. The In-house component was more clearly, but not exclusively related to the

effects of cover crops compared to the University and private sector. It was considered that the two lists, those in-house and those to the private sector and University, would be complimentary. Further coordination occurred during proposal review. Redundancies, where noted were resolved among qualified proposals in favour of the private sector.

The separate call for proposals for in-house research was held for federal research institutions on issues complimentary to those described above.

For these proposals statements of work were established with the following titles:

Title:

- Project G: Soil Macropore Development as a Mechanism for Root Distribution and Solute Transport
- Project H: Composting Manure as a means of Sustaining Air and Water Quality
- Project I: Prediction of Crop Seedling Responses to Changes in Soil Quality
- Project J: Soil Biota as Indicators of Soil Quality
- Project K: Methodologies for Assessing Soil Organic Matter Sustainability
- Project L: Open Category RFP under the NSCP Research Program

Level of Effort

The suggested level of effort was \$40,000.00 annually for two years (\$80,000.00) ending March 31, 1993.

## **DELIVERABLES AND PROPOSAL FORMAT**

A detailed list of deliverables was provided to the respondents as well as a format for presenting the proposals.

## **PROPOSAL REVIEW**

Included with the call for proposals was a copy of the "evaluation criteria" (Appendix A) which was to be used by the Proposal Review Committee when the proposals were reviewed. This Committee consisted of a representative from the following groups: Agriculture Canada, Ontario Ministry of Agriculture and Food, University of Guelph, Ontario Soil and Crop Improvement Association and the Scientific Authority (Harrow Research Station representative, as chairman).

## **RESPONSE TO THE CALL FOR PROPOSALS**

An overwhelming response was obtained both from the SSC competition and the in-house call, with 24 and 27 proposals being received in each respectively. The value of 48 proposals deemed appropriate for NSCP funding totalled \$4.45 million, a measure of the level of participation by the scientific community.

The proposals were circulated in groups of 4-5 to 29 outside referees who were asked to provide technical evaluations and peer review. The cooperation from soil scientists and other specialists was outstanding. The evaluations by the referees were used by the Proposal Review Committee to generate a short list of the best proposals prior to a meeting for final prioritization.

The following pages present the project titles and a brief summary of the results as presented by the successful bidder.

## **PART I - RESEARCH CONTRACTS THROUGH SSC**

### **Project A**

**Title: Soil Macropore Structures and Their Effect on solute Transport to Tile Drains**

#### **Purpose:**

Recent evidence suggests that contaminants such as phosphorus, pesticides and bacteria are rapidly transported to tile drains by rainfall events shortly after surface application. Such transport most likely occurs through macropores.

#### **Objectives**

1. To characterize macropore transport of contaminants to tile drains.
2. To suggest or develop soil management systems which will curtail excessive amounts of such transport.

#### **Scope**

This statement of work is quite specific in its requirements. The technical approach to the problem should be well defined, and supported with the laboratory and scientific equipment necessary to perform the soil physical measurements required. Alternatives to natural precipitation events should be considered if field studies are involved. The data collected should be valid for use in extrapolating the results to a number of soils and soil management situations.

#### **Successful Bidder**

Environmental Soil Services (Dr. R. G. Kachanoski) - \$96,924.00

## **Effect of Macropores on Contaminant Transport to Tile Drains**

Environmental Soil Services;

Dr. R. G. Kachanoski and Dr. I. J. van Wesenbeeck

A series of solute transport experiments were conducted to determine the effect of surface soil boundary conditions, initial soil water content and water application rate on the movement of reactive and non-reactive tracers. Experiments were conducted at four sites in southern Ontario over a range of soil textures, where migration of agricultural chemicals to the water table or tile lines may pose a serious threat to water quality. The selected sites were near Alliston, Brantford, Crediton, and Woodslee where intensive characterization of soil hydraulic and solute transport properties was being conducted under a separate GLWQ study.

Specific objectives of this study were to characterize the macropore transport of reactive and non-reactive chemicals through the root zone in representative Ontario soils and to determine the effect of surface and initial soil boundary conditions on the movement of contaminants through soil macropores. Plot scale tracer experiments were conducted to compare treatments that included simulated tillage incorporation of chemicals into the soil surface, surface spreading (non-incorporation) of chemicals, and varying water application rate and timing. The information collected also provides input into a data base with soil hydraulic, physical and chemical modelling parameters for use in the Great Lakes Water Quality modelling project, the National Soil Conservation Program, and the Soil Quality evaluation modelling projects.

Results indicate that the tillage incorporation of the chemical into the top 10 cm of soil significantly reduced the loss of both reactive and non-reactive tracers from the root zone, and hence would minimize tracer migration to the water table or tile lines. The effect of tillage incorporation was especially significant in the heavier textured soils, but some effect was also measured in the lighter texture soils. Tillage incorporation results in a 500% increase in surface (0-10 cm) absorption of a reactive tracer compared to non-incorporation. The effect of the tillage is to disrupt the macropore continuity and mix the tracer into the finer pores of the soil matrix where it is bypassed by the infiltrating water. Higher soil water content at the time of tracer application also resulted in more loss of

tracer from the root zone. This was related to the increase in water filled pores, especially macropores, at the higher water contents.

Deep transport of both the reactive and non-reactive tracers occurred for all treatments and water application rates indicating that significant preferential flow of contaminants can occur even under unsaturated conditions.

Measurements of hydraulic properties using the Guelph Pressure permeameter and undisturbed core were completed. The measurements indicated significant variability as would be expected at sites with significant macropore flow. However, average values of the hydraulic properties would not have predicted the preferential flow and transport that was observed at the sites. Thus, it is likely that the occurrence of fast transport of surface applied chemicals will have to be predicted by including additional information from a site.

## Conclusions

1. Reactive and non-reactive tracer (Sr and Cl) were found at depths well below the mean depth predicted by the amount of applied water, and the soil water content, for all treatments at all the study sites.
2. Incorporation of the tracer into the soil surface by tillage significantly reduced the loss of the tracers (reactive and non-reactive) to the approximate depth of the water table or tile lines. The effect was most noticeable in the clay sites where there were significant cracks, soil structure, and macropores. In these soils, tillage incorporation increased the retention of a reactive tracer in the top 10 cm of soil by over 500%. The effects of tillage were two-fold:
  - i) tillage appears to have destroyed pore continuity resulting in less flow of contaminant through the macropores, and
  - ii) tillage caused mixing of the tracer into the finer pores of the soil matrix where it was bypassed by macropore flow.
3. Solutes leached under transient conditions generally exhibited greater recovery at the high and low rates compared to the prewetted soils. However, significant amounts of deep transport did occur in the transient treatments for a portion of the

solute mass, especially at the high rate. The bulk of the reactive tracer in the shallow layers is related to the initial sorption of water into the initially dry soil matrix, until steady state  $\theta_v$  is attained. Solutes are then bypassed as the matrix water content increases, and the flow bypasses the matrix. This effect was noticed most in the clay sites, and least of all in the sandy sites.

4. The above result also indicates that solutes applied to the soil are more likely to reach tile lines or to the water table if the initial soil water content is high at the time of chemical application. Results of the biotracer experiments by the Ausable-Bayfield Conservation Authority showed that transport of bacteria to the tile lines occurred much more rapidly if the soil was near saturation.
5. Retardation of Sr was greatest at the low rates of water application for all of the soils. This shows the importance of retention time for the adsorption and degradation of chemicals in the soil. Tillage incorporation also has the effect increasing retention time of a solute in the soil matrix, thereby allowing it to reach equilibrium adsorption and reducing downward movement of the tracer.

## **Project B**

Title: **Manure Management to Sustain Water Quality**

### **Purpose**

A major contributor of nitrate-N to groundwater is application of livestock manure, even when applications are consistent with the agricultural code of practice. Application of manure in late summer or fall, frequently on sod prior to fall plowing results in excess concentrations of nitrates in the soil during the fall and spring leaching periods. However, it is usually difficult for farmers to apply manure at a time when crop demand for nitrogen is high. Approaches such as manure composting and use of cover crops have potential to convert the N to an organic form and release it for crop use in the subsequent season.

### **Objectives**

1. To evaluate methods of manure management designed to retain the nitrogen in a non-leachable form during the fall and winter following application.
2. To measure the effectiveness of these approaches as a means for supplying nitrogen to a crop during the subsequent growing season.

### **Scope**

This statement of work is quite specific in its requirements. The technical approach to the problem should be well defined. In light of the short period of funding and the need to produce definitive results within the time frame of this program, the proposal should clearly indicate how the management of manure and the production of a subsequent crop is to be handled. The description of existing or ongoing work which may contribute to a proposal should be given in sufficient detail to permit assessment of the opportunity for success.

### **Successful Bidders**

Ecologistics Limited; Dr. D. R. Cressman - \$98,008.00

University of Guelph; Dr. M. J. Goss - \$97,953.00

## **The Evaluation of Three Manure Composting Methods for Nitrogen Conservation Environmental Impact, Crop Growth Response and Operating and Maintenance Costs**

Ecologistics Limited;  
R. St. Jean - Project Leader

### Conclusion

The data collected for the passive aeration, turned pile and forced aeration composts and a control pile of stored manure did not indicate a significant difference in nitrogen volatilization losses between treatments. The losses ranged from 30.1 percent for the passive aeration compost process to 44.4 percent for the control pile of manure. The data did indicate that the three composts and control pile of manure underwent different degrees of stabilization, as indicated by the significant differences in carbon loss. Carbon losses ranged from 18% for the forced aeration compost to 36 percent for the turned pile compost. The data showed a general trend of higher nitrogen losses from the manures which underwent the highest levels of stabilization. The control pile of manure actually showed the highest level of nitrogen volatilization losses, although not statistically significant.

The peat moss cover skin on the passive aeration windrow demonstrated an excellent capacity for nitrogen retention. Nitrogen increased by a factor of 1.87 during the composting process. However, approximately one third of it was in the ammoniacal form and would be very susceptible to loss during handling and spreading of the solid material. It would also require thorough mixing with the compost in order to make effective use of the additional nitrogen. The data indicated that a 50.8 percent reduction in carbon occurred in the cover skin resulting in a concentration of nitrogen to 4.3 percent on a dry matter basis.

It was observed that composting of livestock manures can not be completed under covered conditions without the addition of moisture, to maintain levels above the 45 percent range at which moisture becomes limiting to the biological process. Moisture levels in the finished composts ranged between 21.8 percent for the passive aeration compost to 33.3 percent for the turned pile compost. The three composts and control pile of manure were retained under cover for an 8 to 12 month curing period, irrigated to a 50-60 percent

moisture level and mixed to assess their potential for reheating. All materials reheated to active composting temperatures in the 45 to 60EC range, indicating that the rapid biological stabilization activity associated with composting was not complete. The high evaporative capacity of composting manure indicates it has potential as a treatment process for barnyard runoffs and dairy farm milkhouse washwater.

Leachate analysis indicated that the potential for nitrogen loss by leaching was not significantly altered by the composting processes examined. But, the compost with the greatest degree of biological stabilization had the lowest mean nitrogen levels in the leachates, indicating a possible trend. Distilled water leachates contained total Kjeldahl nitrogen (TKN) ranging from a mean of 240 mg/l for the turned pile compost to 399 mg/l for the raw manure used in the composting processes. Differences were not statistically significant, however, composting did result in higher levels of phosphorus in the acetic acid leachates from compost, compared to raw manures. There was no significant difference in phosphorus leaching between treatments in the distilled water leachate.

The crop growth response trials showed a definite trend of more consistent yields from the plots receiving commercial fertilizers compared to all other treatments. However, at least one treatment plot from each of the compost treatments achieved yields equivalent to the fertilizer yields.

There was no significant difference in corn yields between treatments, even at a 75 percent level of confidence. The cold, wet growing season experienced during the plot trial experiment is thought to have confounded the results to some degree, due to the slow rate of nutrient mineralization from organic amendments and potential for denitrification in cold, waterlogged soils.

Corn plants harvested in July for comparison of total plant dry weight and tissue nutrient analysis had higher plant weights for plots receiving compost pre-plant incorporated compared to winter application. Fall harvested grain corn and whole corn plants did not show any significant difference in yields between pre-plant and winter compost applications. Mean grain corn moisture levels were all in the 53 to 55 percent range, indicating that no difference in corn maturity resulted from the various treatments.

The economic comparison indicated that the mechanically mixed forced aeration composting system has the lowest energy requirements at \$0.185/tonne of manure composted followed by \$0.190/tonne for the passive aeration compost and \$0.72/tonne for the turned pile compost. The mechanically mixed forced aeration composting method has no direct labour requirements associated with the process itself. The passive aeration method requires 0.039 hours/tonne followed by the turned pile method with 0.147 hours/tonne. The capital cost estimates indicate that the turned pile and passive aeration composts have similar capital costs of \$19,300, for concrete pads and leachate collection and re-distribution systems. The mechanically mixed forced aeration system had the highest capital cost of \$80,000, assuming equivalent tonnage capacity.

## **Manure Management to Sustain Water Quality**

University of Guelph;

M. J. Goss, W. E. Curnoe, E. M. Beauchamp, P. S. Smith, B. D. C. Nunn

### **EXECUTIVE SUMMARY**

A field experiment was established at the Winchester Research Station of Kemptville College of Agricultural Technology to investigate the fate of nitrogen from cattle manure applied to land previously under alfalfa residues, and the consequences for the quality of water resources. The objective of the programme was to evaluate the risk of nitrate leaching from fall-applied manure, and evaluate whether this could be alleviated by timely agronomic practices. Specific practices considered were the use of cover crops, incorporation of straw residues and sowing a winter cereal crop.

The following treatments were imposed and test crops planted.

1. Alfalfa ploughed in; grass (Timothy); no manure; corn (check).
2. Alfalfa ploughed in; grass (Timothy);  $172 \times 10^3$  L ha<sup>-1</sup> liquid cattle manure; corn (manure check).
3. Alfalfa ploughed in; 54 t ha<sup>-1</sup> composted cattle manure; corn.
4. Alfalfa ploughed in; liquid manure; barley; wheat.
5. Alfalfa ploughed in; liquid manure; oilseed radish cover crop; corn.
6. Alfalfa ploughed in; liquid manure; 3.8 t ha<sup>-1</sup> straw (dry weight) incorporated; corn.
7. Alfalfa ploughed in; liquid manure; straw; oilseed radish cover crop; corn.
8. Alfalfa ploughed in; liquid manure; winter wheat, corn.
9. Alfalfa ploughed in; winter wheat; corn.
10. Alfalfa ploughed in; barley; wheat.

The liquid cattle manure was injected, and the solid manure applied with a conventional spreader. The soil at this time contained 80 kg ha<sup>-1</sup> mineral nitrogen. Only 5 kg ha<sup>-1</sup> of mineral nitrogen was present in the 98 kg N ha<sup>-1</sup> from the composted cattle manure, but the liquid manure contained 203 kg N ha<sup>-1</sup> as mineral nitrogen.

The experimental programme involved the sampling of soil, soil water, and plant material to assess the fate of the nitrogen from the manure, the availability of the nitrogen to crops, and the presence of mineral nitrogen, including the mobile nitrate ion, in the soil.

The cropping history of the chosen site was known, along with information on crop response to N fertilization. This knowledge was considered essential so that information gained at this site would then be more readily transferable to similar farm systems in other areas of Ontario.

Three periods were identified as crucial for evaluating the agronomic practices. These were the fall, the period of spring runoff, and the main growth stages of the spring sown crop. The results from the field experiment were evaluated for these three periods.

The volumetric water content of the top 100 mm of soil was approximately 0.15 at the time the manure was applied at the end of August. This was ideal for injection, but severely impaired the establishment of the grass. Growth of the winter wheat, oilseed radish, volunteer oats from the incorporated straw, and wild mustard weeds was good in the fall of 1991.

The uptake of mineral nitrogen ( $y$ , kg N ha<sup>-1</sup>) by all crops in the fall was directly related to the dry matter produced ( $x$ , t ha<sup>-1</sup>) according to the equation:  $y = 0.43x - 10.2$  ( $p < 0.001$ ). By the end of November almost all the mineral nitrogen applied in the manure could be accounted for in the soil and plants. In unmanured plots there was 55 kg NO<sub>3</sub>-N ha<sup>-1</sup>, 78 kg NO<sub>3</sub>-N ha<sup>-1</sup> in plots that received composted manure, and 134 kg NO<sub>3</sub>-N ha<sup>-1</sup> in plots given liquid manure. All this nitrogen was at risk of leaching.

The winter was cold and the snow cover was ended by heavy rain on January 14, after which the temperature dropped sharply and killed the winter wheat crop.

There was little through drainage in the early spring and all plots contained more mineral nitrogen at planting in May than in November. Two periods of leaching were identified in late spring and early summer. The maximum concentration of nitrate-N recorded in the water draining from the rooting zone for all treatments exceeded the Ontario Drinking Water Objective of 10 mg L<sup>-1</sup> during one or both periods.

The Ontario soil nitrogen test suggested that the unmanured plots would require some fertilizer nitrogen to obtain the maximum economic yield, but all manured plots contained sufficient nitrogen. When the test was repeated at the time for side-dressing corn, nitrate-N had increased by an average 26% for the treatments where nitrogen was immobilized during the fall.

The growth and yield of the corn, and the grain yield of spring barley were largely unaffected by treatment. The yield of barley was influenced by the lodging that took place preferentially on the manured plots. Although earlier in the season nitrogen uptake by barley was greater on manured plots than on plots that received no manure, there was no significant difference at harvest, probably because of the lodging which made sampling difficult.

Nitrogen released by the ploughing of the alfalfa hay soil provided sufficient nitrogen for the corn crop. The total nitrogen in the control treatment at harvest was  $150 \text{ kg N ha}^{-1}$ . The crop on land injected with liquid manure contained  $225 \text{ kg N ha}^{-1}$ , but this was not converted into significantly more harvestable yield. About half of the additional nitrogen was present in the grain, but the remainder was in the harvest residues that will contribute to the organic matter pool of the soil and be remineralized in the future. There was more nitrogen in corn crops grown on land where cover crops were grown in the previous fall compared to that in unmanured controls. However, the increase only occurred after August 20. This indicated that the main period for release of nitrogen from the cover crop residues only took place late in the season. If cereals rather than corn had been the test crop it strongly suggests that most of this nitrogen would have remained in the soil where it would have been at risk of leaching.

Since yields of corn were unaffected by the treatments imposed despite the indications of the soil nitrogen test, it is clear that adjustments are needed when making fertilizer recommendations based on the test to ensure that the nitrogen from crop residues (straw or cover crop) is included. The soil N test, which only takes account of nitrate-N, clearly underestimated the amount of mineral nitrogen available in the soil on all treatments. This was even true for controls where nitrogen from below-ground residues of the alfalfa hay was not adequately assessed. The results indicated that  $115 \text{ kg N ha}^{-1}$  was an appropriate credit for the underground residues of the alfalfa hay.

The study strongly indicated that applying liquid manure in the fall was potentially hazardous to water resources. The risk from leaching was high in the fall immediately after application, in the following spring, and in the next fall period, especially if cereals were grown in the spring. None of the fall treatments to immobilize nitrogen were adequate to reduce the risk significantly.

Composted cattle manure did not pose a significant hazard in the fall after application, but did so in the fall of the following year.

## **Project C**

**Title: Prediction of Crop Responses to Changes in Soil Quality**

### **Purpose**

Several components in the Soil Quality Evaluation Project (SQEP) under NSCP involve monitoring or predicting changes in soil characteristics that are known or assumed to affect crop yield. Benchmark sites are to be established to monitor changes in these characteristics. What is missing is a system to integrate these changes in terms of the response of crops.

### **Objectives**

1. To evaluate existing crop productivity models in terms of their suitability for predicting crop response to changes in soil quality.
2. To modify and adapt the most suitable model as required.
3. To prepare and document the model in a form that will permit its use with the soil quality monitoring data.

### **Scope**

This statement of work is quite specific in its requirements. The technical approach to the problem should be well defined with identification and demonstration of knowledge of existing candidate models. With a view to linking this model with the development of a data base, there should be good coordination and liaison with scientists establishing the benchmark sites and conducting the monitoring of soil quality characteristics in the SQEP.

### **Successful Bidder**

University of Guelph; Dr. B. Kay - See Part III.

## Project D

Title: **Influence of Soil Management Systems on Soil Quality**

### Purpose:

Several components in the Soil Quality Evaluation Project (SQEP) under NSCP as well as field staff such as the Soil Conservation Advisors are involved in predicting changes in soil characteristics. These characteristics may be described as those which are useful for identifying soil quality degradation or the reversal of soil degradation (soil quality improvement) attributable to tillage/cropping/land use systems.

### Objectives

1. To identify soil quality parameters which may be identified with soil management systems and which can be shown to be useful indicators of soil quality for crop production.
2. To describe field/laboratory methodologies which will characterize the chosen parameters.
3. To relate temporal changes in the selected soil quality parameters to tillage, cropping or land use systems.

### Scope

This statement of work is general in its requirements. It might be described as the provision of tools for the Soil Conservation Advisor. It should address specific areas of interest such as microflora, vertebrate/invertebrate populations in soil, level and quality of organic matter, stability of soil structure, soil erosivity or soil pH as examples. It should clearly identify the responsiveness of the parameter to the land use change and the importance of the parameter in soil management sustainability. Two constraints need to be observed. The time frame of the study does not permit establishment of tillage and cropping systems in the field, and the "motherhood" approach to soil quality factors would not expect to yield definitive results. Therefore, it is considered that the proposal will offer an extension to or enrichment of existing and ongoing work.

### Successful Bidder

Environmental Soil Services; Dr. R. G. Kachanoski - \$47,998.00

## **Influence of Soil Management Systems on Soil Quality: Potentially Mineralizable Nitrogen**

Dr. R. G. Kachanoski and Dr. P. von Bertoldi

### **EXECUTIVE SUMMARY**

The objective of this study was to assess the effects of soil loss and tillage system on the long term nitrogen (N) mineralization potential of a number of Ontario soils. Estimates of potentially mineralizable nitrogen  $N_0$  ( $\text{mg N kg}^{-1}$ ), mineralization rate constant  $k$  ( $\text{wk}^{-1}$ ), and total nitrogen supplying potential  $N_F$  ( $\text{kg N ha}^{-1}$ ) were obtained from 22 week incubations of soil samples. The soils selected were the Ap horizons of selected soil landscape positions from the provincial Tillage 2000 project. A total of 104 soil landscape positions, each split into two tillage systems (conservation, conventional), for a total of 208 benchmark locations were analyzed. The landscape positions were selected to cover a range of soil types, textures, past erosion, and tillage treatment. Benchmarks were classified as severely eroded, moderately eroded, or depositional based on their level of  $^{137}\text{Cs}$ , a naturally occurring soil tracer.

The value of  $N_0$  and  $N_F$  were significantly lower by up to  $200 \text{ kg N ha}^{-1}$  in soil landscapes that were classified as eroded than in the depositional sites. Conservation tillage systems significantly increased the value of  $N_0$  and  $N_F$  in eroded landscapes compared to conventional tillage systems. Moldboard systems had lower values in eroded landscapes than either minimum or no-till systems. Increased values of  $N_F$  were found in depressional areas of conventional tillage systems, which was related to a significant increase in the amount of soil present and not to an increase in  $N_0$ .

The data clearly suggest that conservation tillage systems have had a significant remediating effect on the most severely degraded and eroded soil landscapes. Regression analysis of  $N_0$  and Ap horizon soil organic matter indicated that the differences between tillage systems increased as the soil organic matter decreased. At a soil organic matter of 7 to 8%, there was no difference in tillage systems. For soils low in organic matter, no-till  $N_0$  values were 5x and 3x higher than moldboard and minimum tillage systems respectively.

The large differences in N mineralization potential in different erosion classes, and the significant effects of conservation tillage in remediating the effects of erosion, suggest these types of measurements may be valuable in long term soil quality monitoring programs. In addition, the relationship between the N mineralization potential and the actual field N mineralization rates needs to be examined. The work would have implications for the release of nitrate in the late fall and early spring (periods of high leaching risk), and also on the interpretation of spring soil N tests.

## Discussion

### Conservation versus Conventional Tillage

At each pair of benchmarks there was a conservation and a conventional tillage system. The average value of  $N_b$  was 103.1 and 99.2 (mg N kg<sup>-1</sup>) for the conservation and conventional tillage systems respectively. This difference is statistically significant at the 0.05 probability level. The magnitude of the difference (i.e. 4%), however, is not particularly large. A small (6%), but statistically significant increase in the mineralization rate constant  $K$  in the conservation tillage system, was also found. However, the total N supplying potential  $N_F$  was similar in both the conventional and conservation tillage system. The slightly smaller value of  $N_o$  in the conventional system was offset by a slightly larger value of the specific mass of the Ap horizon, which combined gave equal values of  $N_F$  for the two tillage systems. The average value of soil organic matter was 3.3% in both tillage systems.

The average values for the benchmarks classified as severely eroded (E), moderately eroded (M), and depositional (D) for both the conservation and conventional tillage benchmarks, are also given. Across both tillage systems, separation by erosion class was statistically significant ( $> 0.01$  probability) for both  $N_o$  and  $N_F$ , with  $E < M < D$ . In addition there was a significant interaction of erosion class and tillage system. The values of  $N_o$  and  $N_F$  were 15% and 18% higher in the severely eroded conservation benchmarks compared to the severely eroded conventional tillage benchmarks. There were no statistical differences in  $N_o$  values between tillage systems in the moderately eroded or depositional classes. The value of  $N_F$  was 10% higher (significant at 0.05 probability level) in the conventional tillage system in the depositional areas. The value of the mineralization rate constant  $k$  was always higher in the conservation system in each of the erosion classes, but the difference was not statistically significant in the moderate erosion class (M).

The data suggest that the effect of conservation tillage was to increase both the potential rate of N mineralization and the potential amount of organic N available for mineralization in severely eroded benchmarks. The increase in  $N_F$  in the depressional benchmarks of the conventional systems is attributable to a statistically significant increase (0.05 probability) in the amount of soil in the Ap horizon, probably from increased erosion and tillage translocation of soil. Thus, it appears that the conservation tillage systems had a remediating effect on the most degraded areas within the fields.

The value of soil organic matter was also significantly affected by erosion class with  $E < M < D$ . However, no significant differences between tillage systems were not found. This suggests that the 4 to 5 yrs of conservation tillage has changed a smaller, active portion of the organic matter in the soil, but the larger, more resistant portion of the organic fraction has not changed measurably.

#### Paired Tillage Comparisons

A summary of the measured mineralization parameters for the different paired tillage comparisons and erosion classes was presented. For every tillage comparison the values of  $N_o$  and  $N_F$  were significantly different in the erosion classes, with  $E < M < D$ . The values of the mineralization constant  $k$  had an opposite trend with  $E > M > D$ . The erosion classes also had significantly different soil properties consistent with the occurrence of soil redistribution. For example, the  $\%CaCO_3$  was considerably higher in the severely eroded sites suggesting the incorporation of parent material ( $C_k$  horizon) into the surface Ap horizon. Soil organic matter, solum depth, and relative yield also follow expected relationships with the erosion classes. A detailed summary of the relationships of the soil properties and erosion class has been given by Kachanoski et al. (1992).

For the severely eroded (E) benchmarks, the values of  $N_o$  and  $N_F$  were significantly ( $> 0.05$  probability) greater in the MIN and NT systems compared to the MB system. There was no significant difference in these variables in the paired NT and MIN eroded benchmarks. Moderate erosion (M) benchmarks generally had values between the E and D erosion classes, with no measurable differences between tillage systems. The values of the mineralization constant  $k$  were generally higher in the conservation tillage system for each paired comparison, but the differences were not as large and statistically significant as the other mineralization parameters.

The paired tillage comparisons indicate that the effect of conservation tillage is to reduce the variability in N mineralization parameters between eroded and non-eroded sites within a field. The N mineralization potential in the eroded sites increases in conservation tillage relative to conventional tillage, and the opposite effect occurs in the depositional areas. The results are consistent with the process of redistribution of carbon rich topsoil from eroded to depositional areas.

The remediating influence of conservation tillage on the N mineralization potential is encouraging, as is the decrease in variability between locations in the field. In the provincial Partners In Nitrogen project (OMAF, Univ. of Guelph, Fertilizer Inst. of Ont.), which was field testing the new Ontario soil N test for corn, a major problem was the variability of the soil test and the variable response of corn within a field to applied N fertilizer (Kachanoski and Beauchamp, Final PINS report, Dept. Land Resource Science, Univ. of Guelph, 1993). Other studies have suggested that the variability in N fertility within a field is a major obstacle to meeting groundwater quality objectives (Van Noordwijk and Wadman, 1992). Adding N fertilizer to meet the average N requirements for the field, when there is high variability within the field, resulted in areas with high excessive N for leaching as nitrate.

The differences in total N supplying potential  $N_F$  in the erosion classes are very large, in some cases exceeding  $200 \text{ kg N ha}^{-1}$ . This difference is larger than the amount of fertilizer N normally applied to corn in Ontario. The differences in  $N_F$  values could easily account for the observed variations in the spring soil N test. If a correlation exists between the spatial pattern of  $N_F$  and the pattern of the N test or of crop response to applied N fertilizer, then the potential for mapping this variability exists. Of particular interest is the rate of change of the soil N test in the early spring period, and the relationship between the test taken at time of planting versus the test taken at time of sidedress. Since the soil N test measures only the amount of nitrate-N in the soil, the rate of change of the test is directly related to the rate of N mineralization occurring in the field.

The values for N mineralization parameters must be interpreted as potential values, and not the values for mineralization which would be occurring in the field. For example, the increase in  $N_0$  in the eroded locations under conservation tillage could be related to an actual decrease in the field N mineralization, resulting in a larger reserve of material left over. The decrease could be related to a number of factors such as physical stabilization

of labile substrate in soil aggregates, which are not destroyed by tillage. In any case, the measurements carried out in this study indicate that some qualitative and quantitative change in the soil organic fraction has occurred under conservation tillage, and this change was more prevalent in eroded areas. The implications of the measured changes need to be investigated.

As mentioned earlier, the values of total soil organic carbon did not show any significant differences between tillage treatments. However, the value of organic matter did change significantly from field to field, and these changes were correlated to changes in N mineralization. Regression of  $N_o$  versus % organic matter OM, for each of the tillage treatments (MB, MIN, NT) resulted in:

$$\text{MB; } N_o = 24.7 + 21.4 \text{ OM; } r = 0.60$$

$$\text{MIN; } N_o = 84.56 + 11.5 \text{ OM; } r = 0.66$$

$$\text{NT; } N_o = 138.2 + 7.1 \text{ OM; } r = 0.50$$

As indicated, the correlations with organic matter were all significant (0.01 probability). The regression intercepts and slopes changed significantly with tillage system. The regressions indicate that the effect of tillage system increases as the soil organic matter decreases. The intercept is the value of  $N_o$  that would be expected if the soil organic matter was close to zero, and the value for NT is 5x higher than MB. At a soil organic matter of 7 to 8% the values of  $N_o$  for MB, MIN and NT are essentially equal. This again indicates that the major influence of conservation tillage is in the soils which are more degraded (i.e. high erosion, low organic matter).

## Project E

Title: **Methodologies for Assessing Soil Structure (Degradation) in a Meaningful Way**

### Purpose

A component in the Soil Quality Evaluation Project (SQEP) under NSCP will seek to develop methods to measure soil structure in order to estimate the status of soil structure and changes in soil structure which may be identified with soil conservation practices.

### Objectives

1. To identify a method(s) for measuring soil structural changes which may be related to soil management systems and which can be shown to be useful for characterizing changes in soil quality.
2. To relate these measurements of structural changes to soil chemical and physical properties.

### Scope

This statement of work is quite specific in its requirements. The technical approach to the problem may be based on the concept of "non-limiting water range" (NLWR) which is being examined in the soil quality monitoring program to assess soil structural changes. Very limited information is available on the influence of inherent soil properties on the sensitivity of this parameter to soil management. The proposal must clearly indicate how the work will augment the Soil Structure Assessment and Prediction Study (STAPS) without overlapping other proposed work responsibilities or funding allocations under the current Canada/Ontario Agreement.

### Successful Bidder

University of Guelph; Dr. B. Kay - See Part III

## Project F

Title: **Open Category RFP under the NSCP Research Program**

### Purpose

The research program under NSCP is inviting unique proposals for research on soil quality issues which have not been identified in the foregoing five. They should be confined to the areas of work set out on page 1 of this guideline and subject to the preferences identified there. It is fully expected that any submission will be a serious contribution to our understanding of the conservation of soil quality, its measurement or extension to the agricultural community.

### Objectives

1. Please state the objectives of the proposed study clearly.

### Scope

Although the expected scope of the work is undefined here, the scope of the work in the proposal should be clearly stated. The proposal should fall within the guidelines given above, observing the two year time frame, and the suggested level of effort. On farm demonstrations are discouraged in favour of more technically sophisticated studies which relate to our understanding of sustainable and/or restorable soil quality.

NOTE: Any proposed work on Buffer Strips, for which a literature review is being commissioned as an initial step, should be deferred until the literature review has been completed.

### Successful Bidders

Beak Consultants Limited; Dr. R. Walker and Dr. R. Tossel - \$97,575.00

Buffer Strip Review - Sole Sourced Contribution

Soil and Water Conservation Information Bureau; D. Robinson - \$14,830.00

## **The Effect of Soil Quality on Field Scale Runoff under Conventional and Conservation Tillage Systems**

Beak Consultants Limited;  
Dr. R. Walker and Dr. R. Tossel

### **SUMMARY AND CONCLUSION**

A summary of the main results of monitoring and analyses conducted for the NSCP study are presented below. Conclusions are based on interpretation of significant trends and differences in the aforementioned data sets.

#### **Agronomy**

No significant differences were noted for crop type or yield when comparing test microbasins to control. There were also no significant differences observed with respect to applications of fertilizers and pesticides, including metolachlor. The only difference between test and control microbasins involved surface crop residue. As expected, pre-plant and post-harvest residue counts in the test (no-till) microbasins were significantly higher than in the control (conventional tillage). The higher surface residues are incorporated into the soil surface resulting in an overall improvement of soil quality (higher organic matter content, moisture retention capacity, etc.). In theory, this affects soil microbial populations and subsequently affects microbial degradation of agrochemicals such as metolachlor.

#### **Soil Monitoring**

The physical and chemical properties of the soils of the test and control microbasins differed in a number of respects. The soils of the test microbasins (KTB1 and KTB2) exhibited the expected characteristics of soil under conservation management (no-till) when examined in comparison to the soils from the control microbasins (KCB1 and KCB2). These characteristics include:

- higher organic matter, both at the surface (0-5 cm) and at depth (25-30 cm)
- higher soil moisture retention, indicating smaller pore size distribution,

- greater soil moisture content throughout all seasons
- lower bulk density at surface and at depth, and
- generally lower soil pH (surface and sub-surface).

There were further differences evident in the chemistries of test and control soils, including lower levels of calcium in the test soils, which is also expected for no-till soils.

These general soil conditions for the test areas, especially elevated organic matter, provide an environment with a higher capacity for supporting soil micro-organisms than do the soil conditions found in the control areas. The test soils are therefore likely to have higher populations and activity levels of microbes. These micro-organisms, acting as decomposers, can in turn enhance the rate of degradation of agrochemicals such as metolachlor. Analyses of the soils from the Kettle Creek study area support the contention that metolachlor is degraded more readily in the test soils. Levels of metolachlor in soil samples from the test microbasins were much lower than those for control soil samples for almost every period of sampling. The difference in soil metolachlor concentration is most prominent during the periods closely following the application of the herbicide.

## Groundwater

The main results from groundwater monitoring are as follows:

- average linear velocity of groundwater samples from all microbasins, as expected for an agricultural area.
- nitrate and phosphorous were detected in groundwater samples from all microbasins, as expected for an agricultural area.
- levels of nitrate, soluble reactive phosphorous (SRP), and metolachlor are much lower in groundwater than in surface water.
- the chemical parameters addressed herein show no significant temporal or spatial trends within individual microbasins, and
- no significant differences in groundwater chemistry, including metolachlor concentration, exist between test and control microbasins.

## Surface Water

Surface water flow in the four study microbasins was quite variable over the NSCP study period. General findings concerning flow include the following:

- KTB1 consistently produced the lowest flow of all four microbasins
- KTB2 usually produced the highest flow of all four microbasins, and
- KCB1 and KCB2 produced similar flows throughout the period of study.

Overall, further examination of flow data during periods of adequate precipitation is required to accurately assess any differences between test and control microbasins with respect to flow. Flow during the NSCP study was too infrequent for a thorough assessment.

Analyses of surface runoff samples collected from the four Kettle Creek microbasins during the study period reveal several differences in water quality between the test and control microbasins. The two main conclusions with respect to concentrations of water quality parameters are:

- surface runoff nitrate concentrations were lower in the test microbasins, and
- surface runoff metolachlor concentrations were also lower in the test microbasins.

Microbasin water quality loads were also computed for six primary water quality parameters. The main findings are as follows:

- soil sorbed water quality indicators total suspended solids (TSS), total phosphorous (TP) and total Kjeldahl nitrogen (TKN) showed no consistent differences between test and control microbasins
- SRP and nitrate (dissolved water quality indicators) showed no clear differences between test and control (although indications are that nitrate may tend to be lower in the test microbasins), and
- in all cases, unit area metolachlor loads were lower in the test microbasin.

Overall, both soil and water quality analysis appears to indicate that the conservation tillage implemented in the test microbasins is having a positive effect on environmental quality with respect to residues of the herbicide metolachlor. The main reason for the improvement is

theorized to be the enrichment of soil organic matter and subsequent increase in populations of microorganisms (relying on organic matter to thrive) that act to degrade metolachlor and other compounds in the soil. Lower levels of soil metolachlor translate to lower water borne metolachlor delivered by runoff.

Recommendations for further study include:

- continuation of current studies to provide a larger and more conclusive data base with respect to surface water flow, and
- monitoring of degradation products of metolachlor in soil and water to better understand the fate of the herbicide in agricultural systems.

## **Literature Review Pertaining to Buffer Strips**

Soil and Water Conservation Information Bureau;  
D. Robinson

### **EXECUTIVE SUMMARY**

Buffer strips historically have been used for the improvement of surface water runoff from logging and surface mine operations. Most recently they have been promoted in the U.S. and now Ontario for feedlot and cropland runoff.

Buffer strips are bands of planted or indigenous vegetation situated downslope from cropland or animal production facilities to provide localized erosion protection and filter nutrients, sediment and other pollutants from agricultural runoff before they reach receiving waters. Buffer strips are also known as vegetative filter strips, grass filters, grass strips, riparian plantings and combinations thereof.

The two major removal mechanisms at work in vegetative filter strips are deposition and infiltration. As runoff enters the filter strip, its flow is retarded by the increased surface roughness and resistance of the vegetation. The decrease in velocity results in a decrease in the sediment transport capacity of the flow. If the resultant transport capacity is less than the inflow sediment load, sediment is deposited at the interface between the filter and the upslope area. The deposition wedge is typically 30-50 cm wide and occurs immediately upslope of the filter. Once this deposition zone fills up, the deposition front moves downslope in 50 cm intervals until the buffer strip is completely full. Sediment-bound pollutants are also deposited.

Soluble nutrients and some fine particles enter the soil profile with runoff infiltrating into the buffer strip. After entering the soil profile they can be removed by a combination of chemical, physical and biological processes. Mobile water soluble nutrients such as nitrate may leach through the soil profile.

Other mechanisms presumed to be at work are filtration of suspended solids, adsorption to plant and soil surfaces and absorption of soluble pollutants by plants. However, these mechanisms are not well understood at this time.

Research in the U.S. has shown that both tree and grass buffer strips can effectively remove coarse sediments if the runoff flow is shallow and uniform. Buffer strips are less efficient at removal of the small particle sizes. Buffer strips do remove sediment-bound nutrients but with a slightly less efficiency than sediment.

Removal of soluble nutrients by buffer strips is highly variable. The concentration can actually increase due to the re-release of previously trapped nutrients as flow passes through the buffer strip.

There is very little information currently available with respect to the abilities of buffer strips to remove pesticides or pathogens from runoff water. Sediment-bound pesticides and pathogens are likely deposited to some extent but could be re-released at a later time. Some pathogens and pesticide would be removed with infiltrating water. More research is needed in this area.

Buffer strips have been credited with stabilizing streambanks and reducing in-channel erosion. Tillage implements are kept away from the watercourse edge, heavy equipment off the banks and vegetation roots stabilize the soil.

The buffer strip width required depends on many site, vegetation and climatic factors. In general terms, the width required increases as:

- slope of the land above the filter strip increases
- cross-slope of the buffer strip increases
- drainage area increases
- particle size of the soil upslope decreases
- infiltration of the soil upslope decreases
- velocity/volume of runoff increases

There are currently no simple design models available. According to James Krider, the National Environmental Engineer with the United States Department of Agriculture in Washington, D.C. a national handbook with design recommendations for site-specific conditions is in draft form and should be available later this year. The design criteria only consider sediment and surface flow. This may offer some guidance to extension personnel in Ontario.

There has not been any research to date on recommended species for buffer strips for Ontario conditions. Species recommended for grassed waterways could serve as a guide for grass buffer strips. There has not been any research yet on the most appropriate species selection for riparian tree plantings.

Since runoff must cross the buffer strip as sheet flow in order to be most effective, in-field buffer strips or grassed waterways may be more appropriate in hilly areas where water tends to concentrate in natural drainageways prior to crossing the buffer strip.

No research to date has examined the effectiveness of buffer strips during the winter and early spring when vegetation is dormant. Runoff from snowmelt and winter/spring rains is very significant in Ontario.

Maintenance of a dense vegetation is essential to the long-term performance of the buffer strip. Mowing, fertilization and possibly herbicide application are necessary. Using the buffer strips as turn lanes or traffic lanes or for grazing livestock destroys the vegetation. Leaving a plough furrow parallel to the edge of the buffer strip results in water concentrating and flowing along the buffer strip edge and then crossing as concentrated flow at a low point. Furrows can be removed following ploughing with a light disking. There is also a tendency for the strips to get narrower each year due to ploughing of the edge of the strip. This should be avoided.

More research is needed in several key areas in order to utilize buffer strips effectively in Ontario.

1. How can they be used effectively in the upland areas of the province where flow tends to concentrate in natural drainageways prior to entering watercourses?
2. How effective are buffer strips during the winter and early spring when vegetation is dormant?
3. What is the ability of limited-width buffer strips in removing fine particles? This is of particular importance in the lowland areas of the province with heavy clay soils such as Essex, Lambton and Haldimand Counties.
4. Most experiments have been short-term. What is the long-term effectiveness of buffer strips? What is the fate of organic material trapped in the filter? Are nutrients

re-released into runoff flows? What impact do buffer strips have on subsurface water quality due to increased infiltration of runoff water and associated pollutants?

5. Simple design criteria which consider particle size, nitrogen, phosphorus, pathogens and pesticides under various site-specific conditions such as topography and soil texture are needed in order to utilize buffer strips effectively.
6. What is the effectiveness of buffer strips with respect to the removal of pathogens (if they are a problem) and pesticides?
7. What tree and herbaceous species are most suitable for vegetative filter strips here in Ontario?

## **PART II - IN-HOUSE RESEARCH**

### **Project G**

**Title: Soil Macropore Development as a Mechanism for Root Distribution and Solute Transport**

#### **Purpose**

Conventional wisdom has held that an advantage of using deep rooted crops, either as a main crop or soil improving crop, has been the development of deep root channels which improve drainage and offer new root channels for the growth of following crops. Soil drying creates extensive cracking in soils such as Brookston clay. It is not well understood how these factors may be related.

#### **Objectives**

1. To characterize macropore development under the influence of crops with different root development capabilities.
2. To relate macropore development to development of the subsequent crop and to solute transport.
3. To suggest or develop soil management systems which will curtail excessive amounts of adverse transport while retaining advantages of enhanced root development.

#### **Scope**

This statement of work offers large scope for innovative approaches to the problem. The requirements may be met by practical field observation, by innovative technical evaluation where suitable existing facilities are available, by more theoretical modelling approaches, or by any combination of these. The technical approach to the problem should be well defined with clear definition of the chosen approach. The foreseeable difficulties which put a successful conclusion at risk should be recognized and potential solutions suggested.

#### **Successful Bidder**

London Research Centre; Dr. B. T. Bowman - \$80,000.00

## **Rainfall simulator - Grid Lysimeter System for Preferential Solute Transport Studies Using Large, Intact Soil Blocks**

London Research Centre;  
Dr. B. T. Bowman

### **EXECUTIVE SUMMARY**

During recent years, there has been increasing interest in preferential water flow through soils and the resulting potential for rapid transport of pesticides, nutrients and other solutes to tile drains and groundwater. A technique has been developed to study in detail and under controlled conditions, the preferential flow of water and solutes in large, intact soil blocks, isolated at field sites and transported to the laboratory. The soil blocks, 46-cm (18") on each side (145 kg, 320 lb) were carefully cut with a flat shovel, then encased on the vertical sides with a polyurethane foam shell (inside a plywood box) to stabilize it during transport and later experimentation. The blocks were cut at least 46 cm deep to ensure that the A/B horizon interlayer was included. Unstable, preferential water flow (and solute movement) often occurs across dissimilar interlayer boundaries in soil profiles. A boiler plate was jacked under the block to isolate it, then the entire assembly was carefully lifted onto a truck and transported back to the laboratory.

In the laboratory, the block assembly was turned on its side, the base plate was removed, the base of the soil block was cleaned and an aluminum plate (60 x 60 x 2 cm) grid solution collector (containing a 10 x 10 grid of shallow, 2.38-cm square collector funnels) was sealed to the base of the polyurethane foam shell. The assembly was turned upright onto a portable dolly, then wheeled under a precision rainfall simulator, capable of uniformly delivering water to the soil surface over a 5 to 80 mm hr<sup>-1</sup> range. A grid of collector tubes below the collector plate was used to determine flow patterns of water and applied tracers. Much of the experimental data collected in this study were used to test the various components of the apparatus, as well as to characterize tracer movement through the soil blocks. Volumetric moisture content was continuously monitored at four depths in the soil block (2.5, 25, 33 40 cm) using horizontally-inserted side-by-side pairs of Time Domain Reflectometry (TDR) probes. The probes at 25 and 33 cm were on opposite sides of the A/B horizon boundary. A tensiometer was horizontally inserted beside each TDR probe-set to monitor, in real-time, the matric potential (soil water tension).

Initial tracer tests were conducted using the bromide ion (Br) as a conservative, non-reactive tracer, applied to the surface of an Embro slit loam soil block that has been in alfalfa for several years. Alfalfa roots, as well as numerous earthworm channels, had penetrated the full depth of the soil block. Under steady-state rainfall inputs and independent of the input rate (from 5.6 to 19.2 mm hr<sup>-1</sup>), initial traces of Br ion were quickly detected in the outflow from the block within 0.5 hr after the pulse had been applied to the soil surface. At saturation input rates (19.2 mm hr<sup>-1</sup>), the peak concentration of the Br pulse in the effluent occurred 1.25 hr after initial Br introduction after collecting 5 L (< 1/7 pore vol.). At 5.6 mm hr<sup>-1</sup> input, the Br peak was delayed until 16 hr, after collecting 11.3 (< 1/3 pore vol.). Approximately 85% of the water in the soil block was "bypassed" by the Br tracer. The distribution of water flow in the solution collector confirmed that extensive preferential flow of water and solute occurred in these tracer experiments.

This grid lysimeter apparatus will be used to characterize preferential water and solute movement in soil and is part of a larger collaborative effort which is investigating the same phenomena at larger scales at the same field sites where the soil blocks were obtained.

#### Concluding Remarks

Elucidation of the mechanisms controlling the preferential movement of water and solutes through soil require extensive and careful experimentation on intact soil samples that are large enough to be representative of true field conditions. Detailed and accurate measurements through space and time of the water and solute storage and transmission properties of the soil must be both known and controllable. The grid lysimeter system and the sample collection, containment and storage techniques described in this report are an attempt to satisfy these requirements.

#### Future Directions

This study has focused on the careful validation of the various components of the grid lysimeter system to accurately characterize preferential water and solute transport in intact soil blocks. We are quite confident that the current setup could be scaled up to accommodate considerably deeper intact soil profiles (perhaps up to 1 m) with modest strengthening of the support structures. This would permit realistic groundtruthing of various solute transport models to tile drain depths, and to further investigate the behaviour of

solute transport across heterogeneous soil interlayer boundaries. The grid lysimeter system is also well suited to examine stop-and-go (intermittent) flow phenomena in soils, which may well prove to be more relevant than much of the steady-state flow experiments which have been traditionally used to characterize solute behaviour in soil profiles.

## Project H

Title: **Composting Manure as a Means of Sustaining Air and Water Quality**

### Purpose

A major contributor of nitrate-N to groundwater is application of livestock manure, even when applications are consistent with the agricultural code of practice. Application of manure in late summer or fall, frequently on sod prior to fall plowing results in excess concentrations of nitrates in the soil during the fall and spring leaching periods. However, it is usually difficult for farmers to apply manure at a time when crop demand for nitrogen is high. Approaches such as manure composting and use of cover crops have potential to convert the N to an organic form and release it for crop use in the subsequent season. Aeration of liquid manure and conventional turning of manure piles offer questionable advantages as both a means of conserving N and reducing odours. Dr. S. Mathur's work at LRRC, Ottawa, is suggested as a basis for examining manure handling technology at the farm level.

### Objectives

1. To evaluate composting as a way to manage manure on the farm which will tend to convert or retain nitrogen in a non-leachable form while reducing losses of gaseous components associated with N losses or odour control during processing.
2. To demonstrate the ability of the system to deliver nitrogen to the soil in a form resistant to leaching during the fall and winter months following application; which will act as an effective source of N during the ensuing growing season.
3. To estimate the potential for losses of nitrogen in the field following application. These may involve estimates of biological fixation, rates of nitrification or mineralization, leaching losses and the rate of crop growth in systems which may include different kinds of soil incorporation.

### Scope

The technical approach to the problem should be well defined. In light of the short period of funding and the need to produce definitive results within the time frame of

this program, the proposal should clearly indicate how the management of manure and the production of a subsequent crop is to be handled. The description of existing or ongoing work which may contribute to a proposal should be given in sufficient detail to permit assessment of the opportunity for success.

Insufficient funds to support submitted proposals.

## **Project I**

Title: **Prediction of Crop Seedling Responses to Changes in Soil Quality**

### **Purpose**

Several components in the Soil Quality Evaluation Project (SQEP) under NSCP involve monitoring or predicting changes in soil characteristics that are known or assumed to affect crop yield. Benchmark sites are to be established to monitor changes in these characteristics. Recent work has been conducted which indicates the potential of cover crops to affect the wet aggregate stability and biomass of clayey soils. What is missing is an attempt to rank these changes in terms of the response of crops, either in terms of seedling performance or crop yield.

### **Objectives**

1. To evaluate changes in soil quality caused by use of cover crops and to relate these changes in soil quality to crop performance.
2. To attempt to characterize differences in soil quality in terms of stress on either crops or micro-organisms (aeration, carbon supply, N cycling).

### **Scope**

The requirement is to attempt to establish threshold values of soil quality related to crop performance. Soil degradation, as opposed to soil quality improvement, can be envisaged as a treatment, but there may be more information to be obtained from attempts to improve soil quality. The use of cover crops, especially the practice of intercropping e.g. annual rye grass in corn, may be an important practice if it can be shown that the perceived improvement in soil quality resulting from this practice can be demonstrated to have a favourable effect on the following crop. Caution is advised in the choice of variety or hybrid as a test crop because the response to the experimental conditions could be confounded with the mechanics of crop adaptability (susceptibility or tolerance) to stress.

Insufficient funds to support submitted proposals.

## Project J

Title: **Soil Biota as Indicators of Soil Quality**

### Purpose

Several components in the Soil Quality Evaluation Project (SQEP) under NSCP as well as field staff such as the Soil Conservation Advisors are involved in predicting changes in soil characteristics. These characteristics may be described as those which are useful for identifying soil quality degradation or the reversal of soil degradation (soil quality improvement) attributable to tillage/cropping/land use systems. The community structure of soil microflora and fauna may well be a suitable indicator of soil quality.

### Objectives

1. To identify biological indices which may be identified with soil management systems and which can be shown to be useful indicators of soil quality for crop production.
2. To describe field/laboratory methodologies which will characterize the chosen indices which might serve as field measurement tools for Soil Conservation Advisors.
3. To relate temporal changes in the selected soil quality indices to tillage, cropping or land use systems.

### Scope

This statement of work is general in its requirements. It might be described as the provision of tools for the Soil Conservation Advisor. It should address specific areas of interest such as microflora, vertebrate/invertebrate populations in soil related to the level and quality of organic matter, stability of soil structure, soil compaction or soil pH as examples. It should clearly identify the responsiveness of the parameter to the land use change and the importance of the parameter in soil management sustainability. Two constraints need to be observed. The time frame of the study does not permit establishment of tillage and cropping systems in the field, and the "motherhood" approach to describing soil quality factors would not be expected to yield definitive results. Therefore it is considered that the proposal will offer an extension to or enrichment of existing, ongoing work.

Successful Bidder

London Research Centre; Dr. A. D. Tomlin - \$76,600.00

## **Response of earthworms, soil biota, and soil structure to agricultural practices in corn, soybean, and cereal rotations**

London Research Centre;

Dr. A. D. Tomlin, Dr. C. M. Tu, J. J. Miller and J. DaFonseca

### Summary

The comparative effects of herbicide treatments, crop rotations and weed control practice on soil fauna, microflora, and soil microfabric features (e.g. soil particle size and shape) were measured in a multifactorial experimental design. Because of the extensive availability of nutrients in earthworm casts both at the surface and within the burrows, agronomic techniques enhancing or reducing earthworm populations have significant consequences for processes involving soil microflora and soil microfauna colonizing the burrows and for infiltration rates for air and water into soil.

Herbicide treatments reduced earthworm and some mite populations as much as machine cultivation for weed control. Continuous soybean rotations reduced abundance of earthworms, mites and springtails compared to rotations containing cereals and continuous corn rotations. Most of the faunal and microfloral increases can be ascribed to increases in available soil organic matter.

Image analysis is a powerful tool which allows the physical associations of minerals, aggregates, organic matter and biotic components of soil to be measured in situ. Statistical analysis of image analyzed microfabric scenes taken from the resin impregnated soil blocks revealed differences in particle size (area) for both the herbicide and hand-hoed plots but not for the non-weeded control in all three crops. The particle shape parameter showed a similar result, except that there was no significant difference for herbicide treatment. This could be due to the 'homogenizing' effect of the weeds (or at least their roots) on soil physical structure. Using impregnated blocks, image analysis and spatial mapping of elements in earthworm faecal pellets in earthworm burrows it is possible to trace micro-scale interactions occurring in earthworm burrows, and compare cropping and tillage treatments on these interactions.

As a consequence of this research predictions can be made on the effect of tillage practices and weed control methods on populations of earthworms and mites with some confidence. Image analysis techniques of soil microfabric and fine soil structure were developed and measurements were made on the microfabric response to cropping, tillage and weed control methods and segregation of these differences with high statistical confidence was accomplished.

#### Future research

It now necessary to separate (tease apart) the contribution of agronomic practices from faunal/biotic contributions to soil microfabric. As a result of this research a method of accomplishing this goal by tracking identifiable microfabric-scale pedofeatures in the various treatments, and subjecting those features to fluorescence imaging and statistical analysis to establish their spatial distributions is now available. The imaging method is now feasible using fluorescence microscopy that incorporates an ultra-sensitive colour video camera and image analysis software. Further work could emphasize the relationship between fauna, soil structure, and plant roots in response to tillage treatments and weed control methods, for example.

## **Project K**

Title: **Methodologies for Assessing Soil Organic Matter Sustainability**

### **Purpose**

A component in the Soil Quality Evaluation Project (SQEP) under NSCP will seek to develop methods to measure the status of soil degradation. A factor thought to relate to soil structure and soil quality, frequently attributed to soil conservation practices, is soil organic matter (OM). The addition of crop residues from either main crop, cover crop or manures is commonly recommended as a practice for sustaining or improving the OM status of soil. In the cycling of carbon involving photosynthesis, respiration and microbial fixation of carbon there may be a pattern which would define the probable status of soil organic matter in conjunction with the level of microbial activity associated with carbon enrichment or depletion of the soil.

### **Objectives**

1. To identify a method(s) for measuring or estimating soil OM levels which may be related to soil management systems and which can be shown to be useful for characterizing changes in soil quality.
2. To relate these estimates of OM change to changes in soil chemical and physical properties.

### **Scope**

This statement of work is very general in its requirements. The technical approach to the problem may involve a modelling exercise based on a close review of the literature as input for prediction of the OM status of the soil. Alternatively, data from current research which involves production of cover crops, use of livestock manures, green manures or crop residues may suggest a balance sheet approach. The direct measure of soil carbon levels alone is not considered here to be a useful predictor of sustainability. Current techniques for estimating microbial biomass may be useful. It is assumed that factors such as aeration of C/N ratios will be considered. The ultimate focus of the task should be prediction of sustainability of OM levels in soil.

### **Successful Bidder**

Delhi Research Station; R. Beyaert - \$99,600.00

## **Crop Residue Decomposition and Organic Matter Dynamics in Alternative Management Systems on Coarse Textured Soils**

Delhi Research Station;  
R. Beyaert

Crop residues provide the primary organic source of energy and nutrients affecting soil biological, chemical and physical processes, including organic matter formation. Gains in soil organic matter through plant deposition are offset by losses through decomposition by the soil microflora and leaching of soluble compounds. Changes in crop management affect the soil organic matter in two ways: by altering the annual input of organic matter into the soil and by altering the rate at which organic matter decomposes or is lost. This study examined the effects of management, namely cropping sequence and tillage, on above-ground plant biomass production, on certain agronomic indices such as crop yield and on the rate of decomposition of crop residues and the proportion stabilized in soil organic matter during the first two years of decomposition.

A field study was established to examine the effects of soil management on the organic inputs and losses in a coarse-textured soil cropped to tobacco-fall rye, continuous corn and soybean-winter wheat cropping systems managed under both conventional and conservation tillage practices. In general, harvestable yields of soybeans, tobacco and corn were higher in 1991 than in 1992 with the reverse being observed for the two cereal crops. With the exception of tobacco in both 1991 and 1992 and corn grain in 1992, harvested yields of crops grown under conservation tillage were not significantly different than the yields of crops managed under conventional tillage practices.

The total weight of above-ground non-harvested crop residues differed among crops, cropping systems and tillage practices. In general, total residue weights for the various crops paralleled differences in crop yield for the same crops. Yields of non-harvested biomass were greatest for the continuous corn system and least for the tobacco-fall rye rotation with the soybean-winter wheat rotation being lower than the corn system but higher than the tobacco-fall rye rotation. Crop residue weights of the cereal crops were lower in 1991 than 1992 whereas residue weights of the other crops were higher in 1992 than in 1991. Residue inputs of fall rye were no significantly different when managed under the two different tillage practices in either of the two years of the study, however, wheat residues

were significantly lower under conservation tillage practices than under conventional tillage practices in 1991. Tillage practices did not affect the weight of corn residues in 1991 but conventional tillage resulted in higher residue weights in 1992. Similarly, residue weights were higher when soybean was managed under conventional tillage than when managed under conservation tillage in 1992 but resulted in similar residue weights in 1991. The weight of tobacco residues returned to the soil were significantly higher when the crop was managed under conventional tillage in 1991 but tobacco residue weights were similar for both tillage systems in 1992.

The field study also examined the effects of management on the rate of mineralization of crop residues.  $^{14}\text{C}$ ,  $^{15}\text{N}$ -labelled residues from each of the crops were either incorporated to simulate conventional tillage or surface applied to simulate conservation tillage within square steel microplots in the field. Root decomposition was followed within separate microplots from above ground crop residues. All crop residues followed the characteristic rapid decomposition within the first year with a subsequent slowdown of the rate of decomposition in the second year of the study. For all crops, surface applied residues were mineralized to a lesser extent in the short term than incorporated residues but approached similar decomposition rates by the end of the second year of the study. Tobacco residues decomposed at a slower rate than wheat, rye or corn residues which all mineralized more slowly than soybean residues. Roots decomposed more slowly than crop residues incorporated into the soil, however, had a similar decomposition rate to surface applied residues. Less residue nitrogen was available to the subsequent crop when residues were surface applied rather than incorporated into the soil probably due to greater amount of immobilization of nitrogen during the decomposition of the residues.

Similar amounts of residual carbon and nitrogen remained within the soil following a two year decomposition period, however differences in the amounts and position of residual carbon and nitrogen were detected between the tillage practices. No-tillage practices resulted in a stratification of the decomposition products near the soil surface whereas conventional tillage practices uniformly mixed these decomposition products within the plow layer. While no difference in the total amount of carbon and nitrogen within the soil could be detected during the two year period of the study, this stratification of residual decomposition products detected with the use of tracers suggests that the organic matter levels of soils managed under no-tillage practices will increase at the soil surface where they can be of greater use to prevent soil erosion and improve soil quality. However, as a

result of the decomposition of organic materials at the soil surface organic matter levels will be reduced deeper in the soil profile under no-tillage practices. In contrast, mixing of crop residues within the plow layer causes a faster decomposition rate in the short term and results in a more uniform organic matter content within the soil profile in the depth of tillage.

## Project L

Title: **Open Category RFP under the NSCP Research Program**

### Purpose

The research program under NSCP is inviting unique proposals for research on soil quality issues which have not been identified in the foregoing five. They should be confined to the areas of work set out in the background of this guideline and subject to the preferences identified there. It is fully expected that any submission will be a serious contribution to our understanding of the conservation of soil quality, its measurement or extension to the agricultural community.

### Objectives

1. Please state the objectives of the proposed study clearly.

### Scope

Although the expected scope of the work is undefined here, the scope of the work in the proposal should be clearly stated. The proposal should fall within the guidelines given above, observing the two year time frame, and the suggested level of effort. On farm demonstrations are discouraged in favour of more technically sophisticated studies which relate to our understanding of sustainable and/or restorable soil quality.

Insufficient funds to support submitted proposals.

### **PART III - CONTRIBUTION**

Contribution agreements were supported to continue two ongoing research projects which were deemed extremely important to understanding soil structure and erosion modelling.

University of Guelph;

Dr. R. G. Kachanoski - \$76,528.00

University of Guelph;

Dr. B. D. Kay - \$83,472.00

## **The Relationship between Landscape Position, Tillage Practices, and Soil Loss: Model Development**

University of Guelph;

D. A. Lobb and Dr. R. G. Kachanoski

### **EXECUTIVE SUMMARY**

In 1987, the University of Guelph initiated a soil erosion study, Management of Farm Field Variability I. Soil Erosion Processes on Shoulder Slope Landscape Positions (SWEEP/TED), at two field sites in southwestern Ontario, one in Brant County and the second in Middlesex County. The study measured tillage translocation and tillage erosion on convex upper slope landscape positions. The estimated rate of soil loss resulting from net downslope translocation was in excess of  $6.5 \text{ kg m}^{-2} \text{ yr}^{-1}$  at the Brant County field site and in excess of  $4.5 \text{ kg m}^{-2} \text{ yr}^{-1}$  at the Middlesex County field site. Subsequent examination of that data recognized that tillage erosion was responsible for at least 70% of the total soil lost on the upper slope landscape positions based on estimates of total soil loss using resident  $^{137}\text{Cs}$ .

A second study, Soil Loss by Tillage Erosion: The Effects of Tillage Implement, Slope Gradient, and Tillage Direction on Soil Translocation by Tillage (SWEEP/TED), by the University of Guelph from 1990 to 1991 at two field sites in Huron County was conducted to determine the effect of tillage implement type on the magnitude of tillage translocation and tillage erosion under a range of slope gradients in topographically complex landscapes. All four tillage implements, the chisel plough, mouldboard plough, tandem disc and field cultivator, were found to be erosive, causing soil loss on upper slope landscape positions and soil accumulation in lower slope landscape positions.

The objective of this, the third study conducted by the University of Guelph, study was to define the relationship between tillage erosion and landscape position in the form of a model based on the data collected in the Huron County study.

In the proposed model, tillage erosion was calculated as the net translocation at specified points in the landscape, the difference between the soil translocated into a point and the soil translocated out from that point during a single tillage operation. Tillage translocation

was related to slope gradient and slope curvature by a simple linear function. The translocation in to and out from a point was calculated from forward and backward differences in topographic conditions. Therefore, the model predicted soil redistribution from forward tillage translocation along two-dimensional landscape profiles.

The proposed tillage erosion model was calibrated using experimental data from the Huron County study Soil Loss by Tillage Erosion: The Effects of Tillage Implement, Slope Gradient, and Tillage Direction on Soil Translocation by Tillage (SWEEP/TED).

The proposed tillage erosion model was validated using data collected during two preceding studies, Management of Farm Field Variability I. Quantification of Soil Loss in Complex Topography (SWEEP/TED) conducted in Brant County and Soil Loss by Tillage Erosion: The Effects of Tillage Implement, Slope Gradient, and Tillage Direction on Soil Translocation by Tillage (SWEEP/TED) conducted in Huron County. Resident  $^{137}\text{Cs}$  radioactivity was used to estimate soil redistribution within the landscapes of the field sites. These estimates of soil loss and accumulation were compared to those predicted by the tillage erosion model based on the topography of the field sites.

The proposed tillage erosion model provided a reasonably accurate prediction of soil redistribution at the Brant County field site when compared to the estimated using resident  $^{137}\text{Cs}$  radioactivity. The tillage erosion model provided a relatively poor prediction of soil redistribution at the Huron County field site when compared to that estimated using resident  $^{137}\text{Cs}$  radioactivity. There is some indication that the poor prediction for the Huron County site was due in part to the model's simplicity (not able to predict the effect of curvature asymmetry on tillage erosion - a problem which would be greater at this site than the Brant County site because of smaller scale of the ridge). Soil losses, based on the  $^{137}\text{Cs}$  data, were situated on the convex upper slope landscape positions, but they were greater in severity on the should slope position of the steeper of the ridge's two slope faces. Although the model correctly predicted the general pattern of soil losses and accumulations, the model underpredicted the magnitude, or severity, of soil losses at both field sites. Too few data of soil accumulation estimates were available to make a similar inference about soil accumulation. Several possible reasons for this underprediction of soil loss were identified: 1) the tillage implements and the tillage sequence used to predict the soil redistribution may have been less intensive than those responsible; 2) inaccuracies associated with the use of resident  $^{137}\text{Cs}$  may have caused overestimation of soil redistribution (the problem

associated with point measurements resulting in apparent losses on backslope positions, as well, the current level resident  $^{137}\text{Cs}$  for a non-eroded site may be much less than the assumed  $2500 \text{ Bq m}^{-2}$  in Huron County); 3) wind and water erosion may have caused soil redistribution in addition to that caused by tillage erosion (the redistribution pattern is inconsistent with that of soil erosion by overland water flow).

For a first attempt at modelling tillage erosion in complex landscapes, the performance of the proposed model was considered very good. Clearly, there are limitations to the complexity and consequently predictive capabilities of the model due to the lack of experimental data for calibration procedures, particularly tillage depths. AT the time the study was initiated, the number of parameters involved and the complexity of the relationships was not fully appreciated. This was exploratory research, and therefore presuming that a model could be developed on such a data set was very ambitious.

The fact that the proposed tillage erosion model predicts greater rates of soil loss on convex upper slope landscape positions where severe soil loss occurs, and soil accumulation in concave lower slope landscape positions where soil accumulation is observed, indicates that this model is more appropriate than water erosion models for predicting soil erosion in topographically complex landscapes. Consequently, it can be presumed that the proposed tillage erosion model is more appropriate than water erosion models for basing soil conservation decisions relating to soil degradation and soil productivity. Comprehensive soil erosion models including submodels for erosion by wind, water and tillage may provide the best prediction of soil redistribution in topographically complex landscapes.

## **Methodologies for Assessing Soil Structure and for Predicting Crop Response to Changes in Soil Quality**

University of Guelph

B. D. Kay, A. da Silva, K. Denholm, N. Eshraghi, E. Perfect and V. Rasiah

### **EXECUTIVE SUMMARY**

The objectives of this study were:

- (a) to identify a method(s) for measuring soil structural changes which may be related to soil management systems and which can be shown to be useful for characterizing changes in soil quality across a range of soil conditions and
- (b) to evaluate existing crop productivity in terms of their suitability for predicting crop response to changes in soil quality.

The budget associated with the contract was directed to field and laboratory studies related to objective (a) and the collection of field data to be used in the evaluation of crop productivity models [obj. (b)]. The research related to objective (b) has been part of the work plan of an Agriculture Canada Research Branch staff person and the salary expenditures associated with this part of the project have not been charged to the contract.

The field studies for the project were located on the farm of Mr. Don Lobb, Huron County. This site was one of the T-2000 sites investigated during the Ontario Land Stewardship program and is one of the longest running field scale side-by-side comparisons of zero and conventional tillage in Ontario. The comparison is maintained as a strip about 0.5 km in length which traverses soils with clay contents ranging from 7 to 35%. The site was maintained in corn production in 1991 and 1992. (The study has been extended to 1993 and supported by funds from alternative sources). Thirty-six locations (soils) were identified on each transect (tillage treatment) for detailed studies on soil structure.

Soil structure can be defined in terms of structural form and structural stability. Structural form relates to the arrangement or "architecture" of solid and void spaces whereas structural stability refers to the resistance of structural form to deformation (including

fragmentation) when stress is applied. Structural form can progressively change subsequent to a change in soil or crop management practices through changes in the level of stress applied to a soil or by changing the population of soil organisms (e.g. earthworms). Structural form will also change if the stress remains constant but stability changes. Management practices can cause changes in stability by causing changes in the level of stabilizing materials (primarily organic in origin) in soils. Methodologies to assess both structural stability and structural form were assessed in this study. Pedotransfer functions were developed, where possible, in order to describe the contribution of inherent soil properties to the magnitude of the different parameters that were measured.

Parameters which were used to describe structural stability related to the resistance of soil to deformation by two types of stress: moving water and mechanical stress causing fragmentation. Stability parameters related to moving water were assessed at two different scales: that of aggregates  $> 0.25$  mm, and that of clay-sized particles ( $< 0.002$  mm). The resistance to mechanical stress was assessed using tensile strength and the distribution of aggregate sizes created by tillage.

Preliminary studies using rainfall simulation techniques indicated that the amount of runoff and the amount of sediment in the runoff arising from a rainfall event were related to dispersible clay and time to ponding; and that these parameters became more important as the extent of surface cover by crop residues decreased. Time to ponding is related to infiltration characteristics and was found to be strongly dependent on wet aggregate stability. Stability parameters at the scale of aggregates and at the scale of dispersible clay both appeared, therefore, to be important in describing runoff and sediment load in the runoff. Studies were therefore initiated to assess both characteristics in more detail.

A turbidimetric technique was developed to expedite characterization of dispersible clay across the range of soils on the study site. The technique involved developing a standard curve (turbidity as a function of concentration of dispersible clay) which can be described as a function of inherent soil characteristics (clay and organic matter content), and then characterizing the dispersibility of clay. Variation in the characteristics of the standard curve with soil properties appeared to be due to the concentration range in which the standard curve was determined and the mean weight diameter of the dispersed clay fraction. A single curvilinear standard curve was found to be applicable to all of the soils on the study site since the curvilinear representation incorporated the influence of both

concentration and mean weight diameter. The dispersible clay content was found to increase with increasing clay content, increasing water content and decreasing organic matter content; the variation in dispersible clay content with tillage appeared to be due primarily to the influence of tillage in reducing the organic matter content.

Wet aggregate stability was found to increase with clay, water and organic matter content. The reduction in stability with tillage appeared to be related to the reduction in organic matter content with tillage.

The response of soil to mechanical stress was assessed by considering tensile strength measurements and the dry aggregate size distribution created in seedbed by tillage. Tensile strength increased with increasing clay content, wet aggregate stability and decreasing organic matter content. Aggregate size distributions were assessed using different approaches. A description of the distribution by fractal theory was found to be most accurate. The analyses indicated that the number of aggregates in the largest size fraction increased with increasing clay content, wet aggregate stability and decreasing organic matter content. A comparison of tensile strength and aggregate size distribution characteristics showed a highly significant correlation indicating increasing fragmentation with decreasing tensile strength. The analyses suggest that one parameter could be predicted from the other and that, for a given application of stress through tillage, either parameter could be predicted from inherent soil characteristics.

Parameters that were used to describe structural form included both static and dynamic parameters. Bulk densities and relative bulk densities were measured. The concept of least limiting water range (LLWR) was used to describe the combined effects of structural form on aeration, resistance to penetration and available water and represented measurements under "static" conditions. Structural form was characterized under dynamic conditions using infiltration measurements. Once again the sensitivity of these parameters to inherent soil properties and to management was determined.

Bulk density was found to vary with clay and organic matter contents and was higher on the no till than the conventional till treatment. The relative bulk densities were determined by dividing the observed bulk density of each soil by the bulk density determined after compacting each soil with a compressive stress of 200 kPa. The bulk density after compaction was also found to vary with clay and organic matter content. The relative bulk

density was however constant across all soils for a given tillage treatment and was 11% higher on the no till treatment. This type of analysis has not been done before and obviously has important implications for all laboratory studies in which bulk density and inherent soil properties are variables.

Values of LLWR were determined by establishing the functional dependence of the water release curve (potential versus water content) and the soil resistance curve (resistance to penetration versus water content) on bulk density, clay and organic matter content. Limiting values were then assigned, using generally accepted criteria in the literature, for aeration (10% air filled porosity), field capacity (0.01 MPa), permanent wilting point (1.5 MPa) and resistance to penetration (2.0 MPa) to these functions in order to define the LLWR for each soil. Analyses showed a wide variation in LLWR with clay and organic matter content for a given tillage treatment. Correlation of LLWR with plant growth parameters indicated a strong correlation between LLWR and plant population. Analyses are still underway relating soil water content and LLWR to leaf extension during the growing seasons.

Infiltration was measured in the non-trafficked inter-rows on all 36 locations under both tillage treatments. The field saturated hydraulic conductivity,  $K_{fs}$ , was found to be higher under the no-till treatment than under conventional till and may reflect greater continuity in macropores in the no-till treatment. A statistically significant, but poor, correlation existed between  $K_{fs}$  and inherent soil properties.

Data were collected that could be utilized in evaluating plant growth models. Climatic records were obtained from a weather station maintained on the site. Additional information on plant response parameters (yields, root distributions) were also recorded.

Adaptation of current crop productivity models is being undertaken by Mr. Ken Denholm, Agriculture Canada Research Branch, Guelph as part of this project. This activity has not progressed as rapidly as originally anticipated. However, once the models are developed a complete data set is available to assess the models in terms of their ability to predict yield response on soils of different structure and under the dramatically different climatic conditions that existed in 1991 and 1992.

## APPENDIX A

### Evaluation Criteria

Proposals were evaluated in accordance with the following criteria. Bidders were advised to address these criteria in sufficient depth in their proposals.

|                     |   | Maximum<br>Points (%) |
|---------------------|---|-----------------------|
| A)                  | <b>TECHNICAL PROPOSAL</b>   | 40                    |
| 1)                  | Scope and Objectives (10 points) <ul style="list-style-type: none"> <li>- understanding of the problem</li> <li>- conformance to NSCP program criteria</li> </ul>   |                       |
| 2)                  | Design (15 points) <ul style="list-style-type: none"> <li>- scientific merit</li> <li>- conceptual framework, sampling and analyses, data management</li> </ul>   |                       |
| 3)                  | Impacts (10 points) <ul style="list-style-type: none"> <li>- consideration of scientific, environmental, social and economic impacts, recognition of technology transfer</li> </ul>   |                       |
| 4)                  | Understanding of Related Problems (context; 5 points) <ul style="list-style-type: none"> <li>- knowledge of related problems, links with scientific, professional and farming communities</li> </ul>  |                       |
| B)                  | <b>TECHNICAL QUALIFICATIONS</b>   | 30                    |
| 1)                  | Management Team (10 points) <ul style="list-style-type: none"> <li>- relevant experience and involvement of senior personnel</li> </ul>   |                       |
| 2)                  | Key Personnel (15 points) <ul style="list-style-type: none"> <li>- Scientific, and agronomic qualifications with demonstrated research capabilities of both the researcher and research establishment applicable to soil conservation</li> </ul>        |                       |
| 3)                  | Team Organization (5 points) <ul style="list-style-type: none"> <li>- line of control, role of associates and proposed sub-contractors</li> </ul>   |                       |
| C)                  | <b>RESOURCES</b>  | 15                    |
| 1)                  | Human resource needs planned and flexible   |                       |
| D)                  | <b>CONTRACT MANAGEMENT</b>  | 15                    |
| 1)                  | Financial Capability, Terms and Conditions (10 points) <ul style="list-style-type: none"> <li>- sufficient to ensure support facilities for life of contract</li> <li>- levels of conformance, sub-contract confirmation, general conditions</li> </ul> |                       |
| 2)                  | Control Procedures (5 points) <ul style="list-style-type: none"> <li>- work plan and schedule</li> <li>- control of progress, costs and subcontracts, as applicable</li> </ul>  |                       |
| <b>TOTAL POINTS</b> |   | <b>100</b>            |

The results of the proposal evaluation according to the above criteria was the prime tool in the overall evaluation; any proposal that received less than 70% of the total points was excluded from further consideration. However, price, level of effort and the method of payment was also considered in the overall evaluation to determine the best value to the Crown. The Crown reserved the right to enter into negotiations concerning price and level of effort.

In accordance with Treasury Board Policy on contracting-out science and technology, proposals received from suitable industrial sources was given precedence over proposals from Universities and other non-profit organizations. This in no way precluded the use of Universities and other non-profit organizations as subcontractors on any project.

**APPENDIX G**

**LAND STEWARDSHIP RESEARCH PROGRAM PROJECTS**

**TITLE:** AGROFORESTRY RESEARCH AND DEVELOPMENT

**STATUS:** Proposal

**PROJECT**

**ORGANIZATION:** Prof. Andrew M. Gordon, OAC, Principal Researcher, N. Kaushik, P.A. Williams, Dept. of Env. Biology, R. McBride, Dept. of Land Resource, W. Nickling, Dept. of Geography, M. Tollenaar, Dept. of Crop Science, P. Stonehouse, Dept. of Ag. Economics. Cooperating with Research Station Services, UofG, Petawawa National Forestry Institute, Ontario Tree Improvement and Forest Biomass Institute.

**DURATION:** 3 years

**REQUESTED**

**FUNDING:** Year 1 - \$274,588; Year 2 - \$288,317.40; Year 3 - \$302,733.27

**OBJECTIVES:**

1. To promote the use of agroforestry practices by establishing a research-demonstration area on a tract ' of land located in Guelph on Victoria Road.
2. Research Area 3.1 - Intercropping of Agricultural and Tree Crops To develop appropriate row or spot-intercropping system that will:
  - a) allow the compatible and simultaneous farming of land for multiple crops, some of which may be trees
  - b) determine combinations of tree species and crop succession that will lead to maximum profitability over a range of site and climatic conditions
  - c) allow the removal of some marginal lands from cultivation and keep them economically productive
  - d) reduce the level of wind and water erosion
  - e) increase landscape diversity
  - f) improve wildlife habitat
  - g) build equity in farmland.
3. Research Area 3.2 - Site Productivity and Tree Production  
To further refine existing tree species-site interactions through the development of site index curves that will:
  - a) allow for the mass production of trees for short or long-term profit on lands currently considered agriculturally marginal
  - b) allow for the reclamation of seriously degraded lands with trees

**TITLE:** MANAGEMENT OF FINE TEXTURED POORLY DRAINED SOILS FOR INTENSIVE AGRICULTURE

**STATUS:** Proposal

**PROJECT**

**ORGANIZATION:** Dr. J.A. Stone, Harrow Research Station, Principal Researcher.  
Aspects of this proposal have been coordinated with a similar proposal being submitted by researchers from the Dept. of Land Resource Science, UofG, to facilitate extrapolation of results to the various soils and climatic conditions across the province.

**DURATION:** 2 years 9 months

**REQUESTED**

**FUNDING:** \$13,832.53 - 9 months; \$21,735.34 - Year 2; \$22,796.43 - Year 3

**OBJECTIVES:**

1. To contribute to the development of a row crop management package which will improve and maintain soil structure through -
  - a) the selection and evaluation of several legume - grass forage mixes relative to which will provide the most improvement in soil structure in the shortest time (1988-90)
  - B) the determination of the minimum amount of tillage required to obtain yields equivalent to conventional tillage (fall mouldboard plow) in a corn-soybean rotation and determination of the effect of reduced tillage on soil structure (1988-91)
  - C) the evaluation of corn polyculture (intercropping corn with legume and grass forages) under conventional and conservation tillage systems relative to improvements in soil structure, reduction in nitrogen requirements, and effects on yield (1989-91).

**EXPECTED**

**BENEFITS:**

1. To minimize losses in soil productivity and environmental hazards resulting from erosion, runoff, and compaction.
2. To improve the market position of Ontario farmers by providing more efficient use of fertilizer and by lowering fuel costs associated with tillage.

**LAND STEWARDSHIP RESEARCH PROGRAM**

**//LS8806-P002**

**TITLE:** DEVELOPMENT OF A SOIL INTERPRETIVE GUIDE FOR SUBSOIL  
COMPACTIBILITY ASSESSMENT

**STATUS:** Proposal

**PROJECT**

**ORGANIZATION:** Dr. R.A. McBride, LRS, UofG, Principal Researcher

**DURATION:** 3 years

**REQUESTED**

**FUNDING:** \$22,375 - Year 1; \$55,750 - Year 2; \$28,375 - Year 3

**OBJECTIVES:**

1. To develop a soil interpretive guide for subsoil compactibility assessment based on a validated model which is capable of estimating soil porosity change under a given wheel loading for any combination of initial soil conditions.

**EXPECTED**

**BENEFITS:**

1. The soil compaction guide would permit both farmers and extension personnel to make assessments of the maximum allowable wheel loading before significant soil compression will occur in the subsoil.

**TITLE:** NITROGEN CONSERVING FARMING SYSTEMS

**STATUS:** Proposal

**PROJECT**

**ORGANIZATION:** Dr. R.G. Kachanoski, LRS, UofG, Principal Researcher. There is a NSERC scholarship for the PhD program - \$12,500/yr x 3 years

**DURATION:** 3 years

**REQUESTED**

**FUNDING:** \$31,330 - Year; \$70,000 - Year 2; \$70,000 - Year 3

**OBJECTIVES:**

1. To determine and characterize the variability of crop response at a field scale, to applied fertilizer N on different soil and climatic conditions in Ontario and different tillage systems.
2. Quantify the relationship between maximum economic rate of fertilizer N applied and the rate of NO<sub>3</sub><sup>-</sup> movement to the groundwater.
3. To determine the minimum information necessary to implement a field specific nitrogen management system.
4. Establish on-farm, field scale research/ demonstration sites to promote and investigate proper N fertilizer management under different tillage systems.

**EXPECTED**

**BENEFITS:**

1. To provide quantitative information regarding fertilizer N management groundwater quality and tillage systems.
2. To develop the proper management procedures to insure that agriculture and environment concerns are complimentary.

**LAND STEWARDSHIP RESEARCH PROGRAM****//LS8806-P004**

**TITLE:** SOIL STEWARDSHIP CROPPING SYSTEMS FOR CORN AND SOYBEAN PRODUCTION IN ONTARIO

**STATUS:** Proposal

**PROJECT ORGANIZATION:** Dr. B.D. Kay, LRS, UofG, Principal Researcher

**DURATION:** 3 years

**REQUESTED FUNDTNG:** \$64,058 - Year 1; \$232,530 - Year 2; \$228,126 - Year 3; \$225,328 - Year 4

**OBJECTIVES:**

1. To develop cropping systems which will improve soil structure and sustain or increase soybean production on soils of different texture.
2. To define the red clover establishment procedures, the subsequent management of the red clover, and the primary tillage following the legume, which give the greatest soil structural enhancement and nitrogen benefits to succeeding corn crop when red clover is underseeded in cereals and corn.
3. To evaluate different forage species, relative to red clover for soil improvement and financial feasibility when direct seeded and underseeded in cereals.
4. To identify the mechanisms controlling the rate of change of soil structure on different soils under different tillage and cropping practices and thereby develop the capability of both extrapolating the results from the above studies to a broader range of soil conditions as well as identifying potential new and innovative ways of adjusting tillage and cropping systems to improve soil structure.

**EXPECTED BENEFITS:**

1. New cropping systems which provide rapid improvement in soil structure will contribute to decreased erosion and long term sustainable productivity.
2. Decreased costs of production through reduced tillage and decreased nitrogen requirements.

**LAND STEWARDSHIP RESEARCH PROGRAM**

**//LS8806-P005**

**TITLE:** CROP ROTATION EFFECTS ON CROP YIELDS AND SOIL PROPERTIES IN SOUTHWESTERN ONTARIO

**STATUS:** Proposal

**PROJECT**

**ORGANIZATION:** D.S. Young and C.K. Stevenson, Principal Researchers, C.S. Baldwin and B.R. Doidge, RCAT.

**DURATION:** 3 years

**REQUESTED**

**FUNDING:** \$53,200 - Year 1; \$91,500 - Year 2; \$100,450 - Year 3

**OBJECTIVES:**

1. To study the effects of red clover plowdowns left for various lengths of time on -
  - a) succeeding yields of corn
  - b) chemical and physical soil properties
  - c) economics of crop production in the rotation
  - d) the change in nutrients found in the soil
  - e) the change in uptake of different nutrients by crops
  - f) nitrogen rates to succeeding crops.
2. To study the effects of different crop rotations on -
  - a) succeeding crop yields
  - b) chemical and physical soil properties
  - c) economics of crop production with different rotations
  - d) the change in nutrients in the soil
  - e) the change in uptake of different nutrients by crops.

**EXPECTED**

**BENEFITS:**

1. The reduction of soil erosion and the benefits derived from not losing soil will maintain the surface water of the province.
2. The use of different crop rotations which use a legume crop will decrease the need for purchased nitrogen for succeeding crops.
3. The increase in yield of crops grown in rotation will affect the profitability of the crop which is being grown and the yield increase may represent what could be a large portion of the profit in a field.

**TITLE:** SOIL STRUCTURE MODIFICATION THROUGH THE APPLICATION OF SELECTED ALGAE INOCULUMS

**STATUS:** Proposal (was submitted to the Agriculture and Food Fund)

**PROJECT**

**ORGANIZATION:** Dr. R.L. Thomas, Land Resource Science, UofG, Principal Researcher. Cooperating with Bio Field Technologies Inc.

**DURATION:** 3 years

**REQUESTED**

**FUNDING:** \$24,905.60 - Year 1; \$24,905.60 - Year 2; \$24,905.60 - Year3

**OBJECTIVES:**

1. To determine the growth rate of the algae following application of the inoculum.
2. To assess the amount of polysaccharide produced during the growth of the algae.
3. To estimate changes in structural stability of the surface layer.
4. To determine the extent to which growth of the algae has improved infiltration of water.
5. To determine the reduction in erodibility of the surface layer of the soil.

**EXPECTED**

**BENEFITS:**

1. If the algal inoculum is effective, land users will gain another technique with which to counteract soil degradative processes.

**TITLE:** THE EFFECTS OF A PARAPLOW ON CROP PRODUCTIVITY AND SOIL STRUCTURE

**STATUS:** Proposal

**PROJECT**

**ORGANIZATION:** G.A. Garland, Principal Researcher, CCAT

**DURATION:** 4 years

**REQUESTED**

**FUNDING:** \$18,950 - Year 1; \$13,700 - Year 2; \$14,400 - Year 3;\$15,200 - Year 4

**OBJECTIVES:** 1. To evaluate the long term benefits and cost effectiveness of Paraplowing.

**EXPECTED**

**BENEFITS:**

1. Improved drainage on tilled and untilled land: earlier planting; more uniform planting conditions; lower moisture content at harvest.
2. Fracturing of subsoil layers will result in lower energy usage for other tillage.
3. Bulk density of subsoils are decreased therefore the water holding capacity of soil is increased: crops will grow quicker and reach maturity sooner and yield more (5 to 10%).
4. Paraplowing will compliment other Conservation Tillage practices such as No-Till planting. The Paraplow will be used one year out of four.

TITLE: SHELTERBELT AND INTERCROPPING APPLICATIONS OF SUGAR MAPLE  
(ACER SACCHARUM)

STATUS: Proposal

PROJECT

ORGANIZATION: Prof. Alan Watson, Deputy Director and Prof. Keith Ronald, Director, The Arboretum, UofG, Principal Researchers

DURATION: 3 years

REQUESTED

FUNDING: \$217,173 - Year 1; \$217,173 - Year 2; \$217,173 - Year 3

OBJECTIVES:

1. To study the productivity of fruit trees, shrubs, and herbaceous fruit plants when they are planted between rows of selected, known provenances of sugar maple (Acer saccharum).
2. To determine the optimum combinations of crops, trees and soil conditions which would be suitable for intercropping of sugar maple Acer saccharum.
3. To investigate physiological, climatological and physiographic constraints to profitable multi-cropping of agricultural and forest crops.

EXPECTED

BENEFITS:

1. To return the lower class lands to commercial production and aesthetic value in the many non-productive areas in the province.
2. To provide a demonstration maple intercropping unit in Canada.

**TITLE:** SOIL CONSERVATION IN THE UNITED COUNTIES OF  
PRESCOTT-RUSSELL, GLENGARRY AND STORMONT

**STATUS:** Proposal

**PROJECT**

**ORGANIZATION:** Claude Weil, P.Eng. and Pierre-Yves Gasser, ACAFT, Principal Researchers

**DURATION:** 3 years

**REQUESTED**

**FUNDING:** \$95,000 - Year 1; \$73,000 - Year 2; \$73,000 - Year 3

**OBJECTIVES:**

1. To reduce soil losses from farm land in the Alfred region as well as pesticide and nutrient leaching in the water system while maintaining the profit margin of the producers. All systems will be implemented the first year and initial results will be available within two years.

**EXPECTED**

**BENEFITS:**

1. Reduced soil losses on farm land in the Alfred region.
2. Improved water quality in the same region.
3. Reduced financial risks for farm producers willing to adopt soil conservation practices.
4. Sustained crop production by providing farmers with a proven alternative which surpasses or at least equals returns on investment and labour in comparison to conventional tillage systems.

**TITLE:** MANAGEMENT OF FINE TEXTURED POORLY DRAINED SOILS FOR INTENSIVE AGRICULTURE: CHARACTERIZATION OF A FORAGE FACTOR WHICH ENHANCES THE GROWTH OF CORN IN ROTATION - PART I.

**STATUS:** Proposal

**PROJECT ORGANIZATION:** Dr. Ann Oaks, Plant Physiologist, McMaster University, Principal Researcher for Part I. Cooperating with Dr. J.A. Stone, Soil Physicist, Harrow Research Station, Principal Researcher for Part II.

**DURATION:** 1 year 2 months

**REQUESTED FUNDING:** \$41,074.28

**OBJECTIVES:**

1. To contribute information pertaining to the development of a row crop management package which will improve and maintain soil structure. The results will establish which forage crop will enhance the growth of the subsequent corn crop and whether any of the forage crops will influence the sheath forming ability of the seedling root.

**EXPECTED BENEFITS:**

1. To minimize losses in soil productivity and environmental hazards resulting from erosion, runoff, and compaction, and hence improve the long term market position of Ontario farmers.

**TITLE:** MANAGEMENT OF FINE TEXTURED POORLY DRAINED SOILS FOR INTENSIVE AGRICULTURE: CHARACTERIZATION OF A FORAGE FACTOR WHICH ENHANCES THE GROWTH OF CORN IN ROTATION - PART II.

**STATUS:** Proposal

**PROJECT**

**ORGANIZATION:** Dr. Ann Oaks, Plant Physiologist, McMaster University, Principal Researcher for Part I. Cooperating with Dr. J.A. Stone, Soil Physicist, Harrow Research Station, Principal Researcher for Part II.

**DURATION:** 1 year 2 months

**REQUESTED FUNDING:** \$41,074.28

**OBJECTIVES:**

1. To contribute information pertaining to the development of a row crop management package which will improve and maintain soil structure. The results will establish which forage crop will enhance the growth of the subsequent corn crop and whether any of the forage crops will influence the sheath forming ability of the seedling root.

**EXPECTED BENEFITS:**

1. To minimize losses in soil productivity and environmental hazards resulting from erosion, runoff, and compaction, and hence improve the long term market position of Ontario farmers.

**TITLE:** DEVELOPMENT OF A SOIL INTERPRETIVE GUIDE FOR SURFACE AND SUBSOIL COMPACTIBILITY ASSESSMENT

**STATUS:** Proposal

**PROJECT**

**ORGANIZATION:** Dr. R.A. McBride, Dept. of Land Resource Science, UofG, Principal Researcher

**DURATION:** 2 years

**REQUESTED**

**FUNDING:** \$62,000 - Year 1; \$62,000 - Year 2

**OBJECTIVES:**

1. To develop a soil interpretive guide for surface and subsoil compactibility assessment based on a validated model which is capable of estimating soil porosity changed under a given wheel loading for any combination of initial soil conditions (i.e., organic matter content, texture, moisture content, initial dry bulk density).

**EXPECTED**

**BENEFITS:**

1. The soil compaction guide will permit both farm managers and extension personnel to make assessments of the maximum allowable wheel loading before significant soil compression will occur in the topsoil and subsoil.

**TITLE:** DIFFERENCES IN SOIL CONSERVATION BETWEEN OPERATOR-OWNED AND RENTED LAND

**STATUS:** Proposal

**PROJECT**

**ORGANIZATION:** Dr. W. van Vuuren, Dept. of Ag. Economics and Business, UofG, Principal Researcher

**DURATION:** 17 months

**REQUESTED**

**FUNDING:** \$15,300 - Year 1; \$6,700 - Year 2

**OBJECTIVES:**

1. To compare soil management practices affecting soil erosion or its prevention between rented and owner-operated land.
2. To examine whether or not there are differences in management practices among tenants, and if so whether these differences are related to the contract.
3. To examine how well the stewardship lease under the Land Stewardship Program is working.  
In all cases the analysis will be control for soil quality. The information provided by the analysis is crucial to -
  - a) identify what effect tenancy has on soil conservation
  - b) identify what the relationship is between the content of the lease and soil management practices
  - c) to design optimal contract terms in case certain tenancy forms have negative effects on soil conservation and others have a positive effect.

**EXPECTED**

**BENEFITS:**

1. To confirm whether or not significant differences exist in soil management practices as was found eight years previous.
2. To determine whether remedial measures are necessary for contractual agreements with tenants.

**LAND STEWARDSHIP RESEARCH PROGRAM //LS8901-P013**

**TITLE:** COMPACTION OF FINE TEXTURED SOILS

**STATUS:** Proposal

**PROJECT**

**ORGANIZATION:** Claude Weil, ACAFT, Principal Researcher. Cooperating with McGill University, Montreal; Agriculture Canada, Ottawa; Silsoe College, Bedford, Great Britain; and OCFMFPT, Chatham

**DURATION:** 3 years

**REQUESTED**

**FUNDING:** \$28,087 - Year 1; \$27,566 - Year 2; \$28,694 - Year 3

**OBJECTIVES:**

1. To reduce the level of compaction of fine textured soils using a subsoiling implement in order to improve crop yields.
2. To measure the effects of soil compaction on crop growth and yield on a Bearbrook fine textured soil.
3. To select a subsoiler implement in function of the depth and extent of the compaction observed.
4. To evaluate the effectiveness of subsoiling in improving soil structure between depths of 20 cm to 60cm. This is to be done for a range of soil moisture content above and below the plastic limit.
5. To measure the moisture content at which Bearbrook soils are most susceptible to compaction. This is to be done using the proctor compaction test.
6. To analyse the soil physical properties such as bulk density, soil structure, soil aggregate stability, total and drainable porosity in compacted vs. loosened soils.
7. To present the results of this project in the form of guidelines on the use of subsoiling for fine textured soils.

**EXPECTED**

**BENEFITS:**

1. With a better understanding of the nature of the compaction observed in Bearbrook clays, OMAF staff will be in a position to advise farmers on the choice and proper use of subsoiler implements with respect to type, depth, timing and speed.

- TITLE:** IMPROVING THE DEGRADED STRUCTURE OF FINE TEXTURED SOILS WITH DEEP TILLAGE AND GRASS AND LEGUME CROPS
- STATUS:** Proposal
- PROJECT ORGANIZATION:** Claude Weil, ACAFT, Principal Researcher. Cooperating with McGill University, Montreal; Agriculture Canada, Ottawa; Silsoe College, Bedford, Great Britain; and OCFMFPT, Chatham
- DURATION:** 3 years
- REQUESTED FUNDING:** \$28,087 - Year 1; \$27,566 - Year 2; \$28,694 - Year 3
- OBJECTIVES:**
1. To reduce the level of compaction of fine textured soils using a subsoiling implement in order to improve crop yields.
  2. To measure the effects of soil compaction on crop growth and yield on a Bearbrook fine textured soil.
  3. To select a subsoiler implement in function of the depth and extent of the compaction observed.
  4. To evaluate the effectiveness of subsoiling in improving soil structure between depths of 20 cm to 60 cm. This is to be done for a range of soil moisture content above and below the plastic limit.
  5. To measure the moisture content at which Bearbrook soils are most susceptible to compaction. This is to be done using the proctor compaction test.
  6. To analyse the soil physical properties such as bulk density, soil structure, soil aggregate stability, total and drainable porosity in compacted vs. loosened soils.
  7. To present the results of this project in the form of guidelines on the use of subsoiling for fine textured soils.
- EXPECTED BENEFITS:**
1. With a better understanding of the nature of the compaction observed in Bearbrook clays, OMAF staff will be in a position to advise farmers on the choice and proper use of subsoiler implements with respect to type, depth, timing and speed.

**TITLE:** RIDGE TILLAGE IN COMPARISON WITH CONVENTIONAL TILLAGE ON TWO DIFFERENT SOIL TEXTURES WITH VARIOUS ROTATIONS

**STATUS:** Proposal

**PROJECT**

**ORGANIZATION:** Claude Weil, ACAFT, Principal Researcher. Cooperating with Land Resource Dept., UofG

**DURATION:** 3 years

**REQUESTED**

**FUNDING:** \$40,768 - Year 1; \$40,594 - Year 2; \$43,980 - Year 3

**OBJECTIVES:**

1. To reduce soil erosion and soil compaction due to soil structure degradation on two Eastern Ontario soils: Bearbrook clay and Rubicon sandy loam. This is to be achieved by evaluating ridge tillage as a substitute for conventional tillage (plowing-disking).
2. To measure the evolution of soil physical parameters over three years, as they relate to changes in the soil structure, on fields tilled with ridges and conventionally plowed. This is to be conducted on two different soil textures.
3. To measure biological parameters which relate to soil biomass production on the same sites.
4. To measure chemical parameters which relate to soil chemistry on the same sites.
5. To measure the yield performance of corn, soybeans and cereal rotation on the experimental sites.
6. To perform a cost analysis for each of the tillage practices versus rotation.

**EXPECTED**

**BENEFITS:**

1. To aid in maintaining and improving soil structure, thus alleviating the effects of compaction and erosion on conventionally tilled soil.
2. In the long run, organic matter content can be increased with proper crop residue management.

**TITLE:** CROP ROTATIONS AND COVER CROP EFFECTS ON EROSION CONTROL, TOMATO YIELDS AND SOIL PROPERTIES IN SOUTHWESTERN ONTARIO

**STATUS:** Proposal

**PROJECT**

**ORGANIZATION:** R.W. Johnston, Ag. Chemistry Section, RCAT, Principal Researcher

**DURATION:** 3 years

**REQUESTED**

**FUNDING:** \$88,300 - Year 1; \$86,300 - Year 2; \$94,300 - Year 3

**OBJECTIVES:**

1. To enhance and maintain the physical and chemical properties of coarse textured soils suitable for vegetable production, and to find cost effective water and wind erosion control measures to reduce soil degradation.

**EXPECTED**

**BENEFITS:**

1. The impact of adopting stewardship cropping practices in vegetable production on coarse textured soils will be the preservation and enhancement of the soil resource.
2. Improved structure and organic matter reduce problems due to root rots (vegetable crops are very susceptible to this). Better soil structure will result in more even crops and growth. This should result in higher yields and lower production costs resulting in higher profitability for the farmer.
3. The use of appropriate soil conservation measures within the vegetable production systems will help to reduce wind and water erosion on the farm as well as off site.

**TITLE:** A COVER CROPPING STRATEGY FOR FIRST EARLY POTATO PRODUCTION

**STATUS:** Proposal

**PROJECT**

**ORGANIZATION:** Dr. A.W. McKeown, Horticultural Experiment Station, Principal Researcher

**DURATION:** 3 years

**REQUESTED**

**FUNDING:** \$14,795 - Year 1; \$16,993 - Year 2; \$18,653 - Year 3; Total = \$50,441

**OBJECTIVES:**

1. To evaluate the effects of the following on emergence, yield and diseases of early potatoes:
  - a) several broadleaf and grass species as cover crops
  - b) early July and September sowings of cover crops
  - c) a single fall disk to partially turn under cover crop vs. all soil preparation in spring.

**EXPECTED**

**BENEFITS:**

1. Answer some of the questions on soil management for early potato production.
2. Identify potential problems with alleopathic effects of cover crops to save growers considerable dollars.
3. Identify potential disease problems or benefits due to cover cropping practices.
4. Better cover cropping practices will lead to sustainable production and less environmental damage from soil management practices for early potatoes in Ontario.

**FOOD SYSTEMS 2002 - PEST MANAGEMENT  
AND LAND STEWARDSHIP  
RESEARCH PROGRAM**

**//FS8903-NCA009 &  
& LS8903-P017**

**TITLE:** WEED CONTROL STRATEGIES FOR ASPARAGUS USING FALL-SEEDING RYE

**STATUS:** Proposal (this proposal was submitted for funding under both Food Systems and Land Stewardship Research Programs)

**PROJECT**

**ORGANIZATION:** Dr. J. O'Sullivan, Horticultural Experiment Station, Simcoe, Principal Researcher

**DURATION:** 3 years

**REQUESTED**

**FUNDING:** \$7,950 - Year 1; \$8,330 - Year 2; \$8,720 - Year 3; Total = \$25,000

**OBJECTIVES:**

1. To develop efficacy data for alternatives to paraquat, such as low rates of glyphosate or linuron plus additives, for control of fall-seeded rye, and glyphosate for control of perennial weeds.
2. To determine the influence of mulch and minimum tillage on weed population dynamics in asparagus.
3. To evaluate the efficacy of herbicide systems for weed control in a rye-mulch/minimum tillage system of asparagus production.

**EXPECTED**

**BENEFITS:**

1. Reduction in amount of herbicides used in asparagus production.
2. Reduction in direct cost of herbicides, resulting in a saving to the grower.
3. Improved long term weed management.
4. Reduction in wind and water erosion.
5. Increased water infiltration and conservation of soil moisture.
6. Improved crop quality and increased marketable yield.
7. Protection of the environment by preventing herbicide contaminated soil blowing into neighbouring fields and getting into rivers and streams.

**TITLE:** IMPROVING THE DEGRADED STRUCTURE OF A CLAY LOAM SOIL WITH DEEP TILLAGE AND GRASS AND LEGUME CROPS

**STATUS:** Proposal

**PROJECT**

**ORGANIZATION:** W. Curnoe, KCAT, J. Culley, L. Heslop and N. McLaughlin, Agriculture Canada, Principal Researchers

**DURATION:** 2 years

**REQUESTED**

**FUNDING:** \$41,400 - Year 1; \$41,400 - Year 2; Total = \$82,800

**OBJECTIVES:**

1. To develop agronomic practices which restore the productivity of fine textured soils which have been seriously degraded as a result of continuous corn cropping with conventional tillage.

**EXPECTED**

**BENEFITS:**

1. To provide primary producers with good quality information from which they will be able to evaluate benefits and costs related to crop-based and tillage-based remedial measures for improving degraded soil tilth.

**TITLE:** TILLAGE AND COMPACTION EFFECTS ON CROP YIELDS AND SOIL PROPERTIES IN SOUTHWESTERN ONTARIO

**STATUS:** Proposal

**PROJECT**

**ORGANIZATION:** D. Young, RCAT, Principal Researcher

**DURATION:** 3 years

**REQUESTED**

**FUNDING:** \$19,050 - Year 1; \$20,000 - Year 2; \$21,100 - Year 3; Total = \$60,150

- OBJECTIVES:**
1. To enhance and maintain the quality of the soils of Southwestern Ontario, and find cost effective crop rotations which maintain soil quality and reduce soil degradation.
  2. To study the effects of different compaction and tillage practices on:
    - a) yields of corn
    - b) selected soil chemical and physical properties
    - c) the change in selected plant nutrients found in the soil over time
    - d) the change in uptake of different nutrients by corn.

**EXPECTED**

- BENEFITS:**
1. To provide a better understanding of soil compaction which could allow producers to alter traffic patterns over the soil surface to reduce the area compacted.

**TITLE:** THE USE OF CROP INSURANCE YIELD DATA TO PREDICT AGRICULTURAL PRODUCTIVITY

**STATUS:** Submission

**PROJECT**

**ORGANIZATION:** Dr. G.J. Wall, Ontario Institute of Pedology, Principal Researcher. Cooperating with Crop Insurance Commission of Ontario, OMAF Soil and Water Management Branch

**DURATION:** 1 year 3 months

**REQUESTED**

**FUNDING:** \$21,000 - Year 1; \$29,000 - Year 2; Total = \$50,000

**OBJECTIVES:**

1. To assess the feasibility of using Ontario crop insurance yield data to rate soils and management systems in order to promote cost effective soil and water conservation measures.

**EXPECTED**

**BENEFITS:**

1. Assist OMAF extension staff in promoting soil conservation of farmland.
2. Provide soil/yield data for use in farm conservation planning.
3. Expand the use of soil survey maps in agricultural extension activities.
4. Make recommendations to the Crop Insurance Data Commission to optimize current data collection.

**TITLE:** NITROGEN RESEARCH WITH CORN USING CONSERVATION TILLAGE

**STATUS:** Submission

**PROJECT**

**ORGANIZATION:** C.K. Stevenson, RCAT, Principal Researcher. Proposal has been sent to OCPA, TFIO, PPIC and Pioneer Hi-Bred Ltd. OCPA and Pioneer have indicated that they are willing to fund the project for \$4,000 per year each, for five years.

**DURATION:** 5 years

**REQUESTED**

**FUNDING:** \$8,000 - Year 1; \$8,000 - Year 2; Total = \$16,000

**OBJECTIVES:**

1. To evaluate response to rates of N using conservation tillage.
2. To compare three sources of N - urea, ammonium nitrate - urea (UAN) solution and anhydrous ammonia (AA) using conservation tillage.
3. To compare various methods and times of incorporating UAN solution compared to urea worked in and AA knifed in application, using conservation tillage.
4. To compare preplant and sidedress application of N using conservation tillage.
5. To study the interaction effects of the above factors.

**EXPECTED**

**BENEFITS:**

1. To utilize conservation tillage practices in order to keep as much residue as possible on the soil surface to reduce soil erosion losses. This research will involve methods of applying nitrogen under conservation tillage, in order to minimize volatilization losses.

**TITLE:** INTERCROPPING CORN AND SOYBEAN FOR HIGH PROTEIN SILAGE PRODUCTION WITH REDUCED INTERCROPPING DETRIMENTS

**STATUS:** Submission

**PROJECT**

**ORGANIZATION:** Dr. D.L. Smith, Macdonald College of McGill University, Principal Researcher

**DURATION:** 3 years

**REQUESTED**

**FUNDING:** \$67,230 - Year 1; \$68,230 - Year 2; \$70,230 - Year 3; Total= \$205,690

**OBJECTIVES:**

1. To determine the effect of maturity and protein content of different soybean cultivars on LER's and protein yield and quality.
2. To determine the optimum N fertilizer placement so as to maximize corn production while minimizing the suppression of soybean N<sub>2</sub> fixation.
3. To determine the effect of a nitrification inhibitor on fertilizer uptake of corn and N<sub>2</sub> fixation soybean, when N fertilizer is side dressed in a broad band next to corn in a corn-soybean intercrop.
4. To determine the silage quality produced by intercrops of corn and soybean at various protein contents.

**EXPECTED**

**BENEFITS:**

1. To improve the protein content of the silage and the efficiency of land use, allowing more productivity from the same amount of land.
2. Intercrop production of corn and soybean has the potential to lessen the need for insecticide and fungicide inputs, and to reduce the erosion damage associated with corn production.

TITLE: AN INVESTIGATION OF THE POTENTIAL TO OVERCOME LOW ROOT TEMPERATURE INHIBITION OF NITROGEN FIXATION BY SOYBEAN (GLYCINE MAX [L.] MERR.)

STATUS: Submission

PROJECT

ORGANIZATION: Dr. D.L. Smith, Macdonald College of McGill University, Principal Researcher

DURATION: 3 years

REQUESTED

FUNDING: \$46,270 - Year 1; \$49,270 - Year 2; \$51,270 - Year 3; Total= \$146,810

- OBJECTIVES:
1. To determine the exact threshold for low root temperature inhibition of soybean N<sub>2</sub> fixation.
  2. To determine the events in nodulation and N<sub>2</sub> fixation that are most sensitive to low temperature inhibition.
  3. To determine whether low root zone temperature inhibition is due to disrupted functioning of the soybean, the bacterium or some specific aspect of the symbiotic relationship in which both physiologies are effected.
  - 4a. To determine if the bacterium proves to be the low temperature susceptible organism, to screen a widerange of Bradyrhizobium japonicum accessions to identify those most tolerant to low root zone temperature, OR
  - 4b. To determine if the plant proves to be the low temperature susceptible organism, to screen a wide range of Glycine maxaccessions to identify those mosttolerant to low root zone temperature.
  5. To field test the best B. japonicumand/or G. maxgenotypes.

EXPECTED

- BENEFITS:
1. Determination of the cause of low root temperature inhibition of soybean N<sub>2</sub> fixation could lead to more effective expression of the soybean N<sub>2</sub> fixing symbiosis at low soil temperatures, which would allow greater yield of soybean in more northerly production areas without increased dependence on N fertilizer.

**LAND STEWARDSHIP RESEARCH PROGRAM**

**//LS9003-P024**

**TITLE:** IMPACT OF SOIL COMPACTION ON THE PRODUCTION OF PROCESSING VEGETABLES AND OTHER CASH CROPS

**STATUS:** Submission

**PROJECT**

**ORGANIZATION:** C.K. Stevenson, RCAT, Principal Researcher

**DURATION:** 4 months

**REQUESTED**

**FUNDING:** \$15,000

**OBJECTIVES:**

1. To conduct a literature review on the effect of soil compaction on the production of processing vegetables (i.e., tomatoes, sweet corn, green peas and green and wax beans) and other cash crops and to survey the state of the art for the prevention and relief of this problem.
2. The summary of research findings would help to illustrate the significance of and improve the awareness of soil compaction among growers.
3. The literature review could act as a stepping stone to applied research on soil compaction.

**EXPECTED**

**BENEFITS:**

1. To create a current state of the art knowledge base. From this base future research strategies could be better targeted to modify current production practices.
2. Information gathered can be used to emphasize the importance to extension workers and farmers, of the serious effects that soil compaction has on the soil when intensive cash cropping occurs.

**TITLE:** IMPACT OF CONSERVATION TILLAGE ON INSECT AND DISEASE COMPLEXES - LITERATURE REVIEW

**STATUS:** Submission

**PROJECT ORGANIZATION:** A. Schaafsma, RCAT, Principal Researcher

**DURATION:** 4 months

**REQUESTED FUNDING:** \$14,690

**OBJECTIVES:**

1. To conduct a literature review on insect species and disease pathogens most likely to pose problems under Ontario conditions.

**EXPECTED BENEFITS:**

1. To provide a better understanding of insect and disease complexes in conservation tillage.
2. To assist in the development of recommendations, and the adoption of conservation tillage practices.

**LAND STEWARDSHIP RESEARCH PROGRAM**

**//LS9003-P026**

**TITLE:** THE RESPONSE OF THE SOIL MICROFLORA AND FAUNA TO SPRING  
PLOWING OF ZEROTILL AND PASTURE SOILS

**STATUS:** Submission

**PROJECT**

**ORGANIZATION:** V.G. Thomas, LRS, UofG, Supervisor. P. Neave, LRS, UofG, Principal  
Researcher

**DURATION:** 1 year 5 months

**REQUESTED**

**FUNDING:** \$12,387.56

**OBJECTIVES:**

1. To examine the effect of plowing on the soil microflora and fauna in zerotilled and pasture soils.
2. To examine what differences exist between the pasture and zerotill soils (plowed and unplowed) in terms of biomass, number of organisms and their diversity.

**EXPECTED**

**BENEFITS:**

1. To help better understand the complex soil community.
2. To provide further insight into agricultural management decisions.

**LAND STEWARDSHIP RESEARCH PROGRAM**

**//LS9003-P027**

**TITLE:** LITERATURE REVIEW AND APPLICATIONS PAPER: AGROFORESTRY  
POTENTIAL FOR SOUTHERN ONTARIO

**STATUS:** Submission

**PROJECT**

**ORGANIZATION:** A.M. Gordon, Env. Biology, UofG, Principal Researcher

**DURATION:** 1 year

**REQUESTED**

**FUNDING:** \$14,975

**OBJECTIVES:**

1. To examine the potentials and problems of agroforestry systems and how they can be integrated into various southern Ontario farming situations.
2. An extension of the literature review will be to look at agricultural systems on a regional basis by physiography, and discuss the current and potential use of agroforestry systems and how they can be more effectively integrated into existing agricultural systems with resultant benefits.

**EXPECTED**

**BENEFITS:** 1. NONE PROVIDED

**LAND STEWARDSHIP RESEARCH PROGRAM**

**//LS9006-P028**

**TITLE:** NITROGEN CONSERVING FARMING SYSTEMS

**STATUS:** Submission

**PROJECT**

**ORGANIZATION:** R. Gary Kachanoski, Land Resource Science, UofG, Principal Researcher.  
Cooperating with The Fertilizer Institute of Ontario

**DURATION:** 3 years

**REQUESTED**

**FUNDING:** \$60,000 - Year 1; \$60,000 - Year 2; \$60,000 - Year 3; Total= \$180,000

**OBJECTIVES:**

1. To determine and characterize the variability of crop response at a field scale, to applied fertilizer N under the different soil and climatic conditions.
2. Determine the relation between a spring NO<sub>3</sub>-N test and the response of the crop to N fertilizer.
3. Determine the influence of field specific nitrogen management systems on NO<sub>3</sub> transport out of the rootzone.
4. Examine the relationship between the economic rate of fertilizer N and the maximum acceptable rate of fertilizer N with respect to nitrate contamination of groundwater.

**EXPECTED**

**BENEFITS:**

1. The development and calibration of a Nitrogen soil testing system which will allow the variation of Nitrogen fertility from site to site and year to year to be determined.

**LAND STEWARDSHIP RESEARCH PROGRAM**

**//LS9006-P029**

**TITLE:** CROPPING AND SOIL MANAGEMENT EFFECTS ON THE DYNAMICS OF CROP RESIDUE DERIVED-N ON THE COARSE-TEXTURED SOILS IN SOUTHERN ONTARIO

**STATUS:** Submission

**PROJECT**

**ORGANIZATION:** R. Paul Voroney, Dept. Land Resource Science, UofG, Principal Researcher. Cooperating with Agriculture Canada, Delhi

**DURATION:** 2 years

**REQUESTED**

**FUNDING:** \$16,704 - Year 1; \$16,704 - Year 2; Total = \$33,408

**OBJECTIVES:**

1. To study the fate of the nitrogen in plant residue (N) and measure soil organic matter dynamics in a coarse-textured soil cropped to tobacco-fall rye, continuous corn and to wheat-soybeans using conventional and zero-till soil management techniques.

**EXPECTED**

**BENEFITS:**

1. This research will result in the generation of extremely important, new information about the nature of the dynamics of the soil organic matter and the maintenance of soil structure in these coarse-textured soils. The knowledge obtained will compliment the N leaching studies in progress at Delhi and will form the basis of developing a N soil test on these soils.

**LAND STEWARDSHIP RESEARCH PROGRAM**

**//LS9006-P030**

**TITLE:** RELATIONSHIPS BETWEEN SOIL FAUNA AND SURFICIAL SOIL  
STRUCTURE WITHIN VARIOUS TILLAGE AND CROP ROTATION SYSTEMS  
ON THE BROOKSTON CLAY

**STATUS:** Submission

**PROJECT**

**ORGANIZATION:** R. Protz, Dept. Land Resource Science, UofG, Principal Researcher

**DURATION:** 3 years

**REQUESTED**

**FUNDING:** \$20,400 - Year 1; \$20,400 - Year 2; \$20,400 - Year 3; Total= \$61,200

**OBJECTIVES:**

1. To determine the relationship between surficial soil conditions and the composition of soil faunal and microflora at key periods in various tillage and crop-rotation systems.
2. To quantify the key soil properties (pore and aggregate distribution) within these different niche conditions.

**EXPECTED**

**BENEFITS:**

1. An understanding of the interactions amongst soil biota, tillage, and crop rotation systems will lead to more efficient pesticide application regimes at reduced treatment rates, and estimates (measurements) of the impact of pesticide treatments on soil fauna and soil structure.

**TITLE:** IMPROVEMENT OF SOIL STRUCTURE, WATER INFILTRATION AND HOLDING CAPACITY BY MAXIMIZING FAUNAL ACTIVITY WITHIN SOIL CONSERVATION PRACTICES

**STATUS:** Proposal

**PROJECT**

**ORGANIZATION:** Richard Protz, Land Resource Science, UofG, Principal Researcher.  
Cooperating with Dr. A.D. Tomlin, Ag. Canada, London

**DURATION:** 3 years

**REQUESTED**

**FUNDING:** \$47,000 - Year 1; \$47,000 - Year 2; \$47,000 - Year 3

**OBJECTIVES:**

1. To measure influence of faunal activity on soil structure on a representative set of Ontario soils.
2. To devise soil management procedures on grassed waterways to maximize faunal activity for improvement of soil structure.

**EXPECTED**

**BENEFITS:**

1. May improve soil structure by allowing faunal to maximize their activity at low cost.
2. Increase life expectancy of grassed waterways.
3. May result in an industry for growing earth worms for specific soil conditions.

**TITLE:** THE POTENTIAL USE OF ARTIFICIAL MARSHES TO IMPROVE THE QUALITY OF AGRICULTURAL TILE DRAINAGE

**STATUS:** Proposal

**PROJECT ORGANIZATION:** Jeff Graham, Limnos Ltd, Pickering, Principal Researcher

**DURATION:** 6 months

**REQUESTED FUNDING:** \$14,400

- OBJECTIVES:**
1. To determine the anticipated improvement in water quality that could be achieved by marsh treatment systems, given the particular characteristics of tile drainage and the treatment potential of artificial marshes.
  2. To determine in what portion of the drainage system (i.e., municipal drains, collector drains, individual farm treatment) would marshes be best suited for improvement or treatment of tile drainage.
  3. To determine the degree to which practical opportunities are available to implement marsh treatment systems given the constraints of land availability, applicable legislation, land use constraints, costs, and design requirements.
  4. To determine the potential benefits and disadvantages of treating only the summer flows of tile drainage systems, in light of seasonal trends in the quality and quantity of tile drainage and the assimilative capabilities of receiving waters.
  5. To provide representative cost information and preliminary design parameters for construction and operation of suitable marsh treatment systems.
  6. If appropriate, identify further research needs including the requirement for demonstration studies.

- EXPECTED BENEFITS:**
1. The study will determine to what degree the use of marshes could improve tile drainage quality, or improve the quality of municipal or natural stream flows in southwestern Ontario.
  2. Recommendations will be made as to where marshes would be best located to provide optimum treatment at minimum costs. The constraints facing development of marshes will be reported including engineering and access constraints, land availability, and land costs.
  3. Cost estimates and design criteria will be provided for suitable marshes.

**TITLE:** TO INVESTIGATE THE ESTABLISHMENT, SUBSEQUENT GROWTH AND EROSION CONTROL POTENTIAL OF CERTAIN TREE AND SHRUB SPECIES ON GULLY AND STREAM BANKS

**STATUS:** Proposal

**PROJECT ORGANIZATION:** A. Skepasts, Head, Agronomy Section, NLCAT, Principal Researcher

**DURATION:** 2 years 4 months

**REQUESTED FUNDING:** \$15,271 - Year 1; \$15,271 - Year 2; Total = \$30,542

**OBJECTIVES:**

1. To show how gully/stream bank stabilization will prevent further erosion and consequent loss of arable soil. Little information is available regarding the effectiveness of tree or shrub species in stream bank/gully erosion control.

**EXPECTED BENEFITS:**

1. Loss of soil due to gully and stream bank erosion will be prevented, land slides curtailed and stream bed silting will be reduced.

- f) reclamation of abandoned or seriously degraded land
- g) design criteria for streambanks.

EXPECTED  
BENEFITS:

1. The benefits derived from the reintroduction of tree cover to presently poor and highly erodible soils in terms of dollars saved on maintenance of watercourses, and the prevention of the loss of planted cash crops from siltation or sandblasting (from wind borne soil particles) and in terms of dollars accrued by increasing yields on lands adjacent to tree crops as well as affording a crop (trees) of higher value than the abandoned land was initially providing, are indeed many.
2. The purifying nature of forest soils or sodded soils that allow water to filtrate through and slowly release a pure quality water; the habitat trees provide for many species avion and terrestrial, the potential food source trees can provide (nut crops, oil derivatives, forage feeds) as well as the aesthetics woodlots and windbreaks provide are all factors worthy of consideration in promoting the establishment of agroforestry ideals.

**TITLE:** IMPACT OF CROP MICROCLIMATE AND ITS MANIPULATION ON GROWTH RATE AND SURVIVAL OF YOUNG VALUABLE HARDWOOD TREES IN INTERCROPPED SYSTEMS

**STATUS:** Proposal to work in concert with project entitled: "Agroforestry Research and Development"

**PROJECT**

**ORGANIZATION:** K.M. King, Principal Researcher and T.J. Gillespie, Dept. of Land Resource Science, and A.M. Gordon, Dept. of Environmental Biology, UofG

**DURATION:** 3 years

**REQUESTED**

**FUNDING:** \$40,250 - Year 1; \$51,255 - Year 2; \$38,780 - Year 3

**OBJECTIVES:**

1. To determine growth rates and physiological activity of young hardwood trees and relate these values to the microclimates in established intercropped tree-crop systems in southern Ontario.
2. To determine response of young hardwood trees (black walnut, red oak and white ash) to controlled levels of radiation (shading) and soil water supply.
3. To develop effective ways of providing in intercropped systems the desired "microhabitats" for young hardwood trees that will optimize their growth rates and increase chances of survival.

**EXPECTED**

**BENEFITS:**

1. To increase our knowledge base on how to improve the growth and survival rates of valuable hardwood species when introduced into an intercropping system in Ontario.
2. To provide improved guidelines and practices for establishment and management of a successful intercropped tree-crop system.
3. To aid in development of good land stewardship practices in Ontario.

**TITLE:** AGROFORESTRY RESEARCH IN ONTARIO

**STATUS:** Proposal

**PROJECT**

**ORGANIZATION:** Mr. C. Nanni, Principal Researcher, Dr. C.S. Baldwin and Mr. B. Doidge, RCAT. Cooperating with Ministry of Natural Resources, Orono Nursery, Central Region, Orono

**DURATION:** 3 years

**REQUESTED**

**FUNDING:** \$94,700 - Year 1; \$99,345 - Year 2; \$104,406.75 - Year 3

**OBJECTIVES:**

1. To provide conservation benefits to landowners by -
  - a) reducing wind erosion
  - b) reducing water erosion
  - c) maintaining water tables
  - d) reducing spring runoff and potential flood damages
  - e) reducing streambank erosion
  - f) reducing sediment loadings
  - g) improving soil structure.
2. Provide direct and indirect benefits to the landowner by -
  - a) providing cash returns from the sale of wood products
  - b) providing wood products for own use (i.e., fuelwood, lumber, fence posts)
  - c) increasing the property value
  - d) providing crops for submarginal lands
  - e) improving the aesthetics of land they own
  - f) improving wildlife habitat
  - g) increasing crop yields and improving quality
  - h) reducing maintenance costs.
3. Afford the landowner the opportunity to diversify his farming operation in such manners as -
  - a) employing multicropping or intercropping systems
  - b) producing biomass for pulp or energy or feed
  - c) growing Christmas trees
  - d) sod farming
  - e) fuel wood production
  - f) maple syrup production
  - g) leasing land to hunters.

4. Provide information for factsheets on such areas as -
  - a) recommendations of intercropping systems
  - b) recommendations for marginal lands
  - c) income generated from woodlots, plantations, windbreaks and shelterbelts
  - d) ideal tree species for (c)
  - e) biomass production figures for S.W. Ontario
  - f) develop more benign, but profitable forms of agriculture for marginal lands (combinations of intercropping, grazing and forestry)
  - g) provide wood for sale and on-farm use.
4. Research Area 3.3 - Riparian Forest Plantations  
 To develop riparian systems of trees and other plants, in mono or multi-species combinations, and to develop implementation strategies for such system that will:
  - a) reduce nutrient and pesticide loadings to streams from adjacent farmed fields
  - b) reduce bank erosion and sediment loads
  - c) improve fish and wildlife habitat
  - d) provide wood for sale and on-farm use.
5. Research Area 3.4 - Windbreak and Shelterbelt Implementation Strategies  
 To develop shelterbelt systems of single or multi-rowed tree species and to develop implementation strategies for such systems that will:
  - a) reduce wind erosion
  - b) improve crop yields
  - c) increase landscape diversity
  - d) provide wood for sale and on-farm use.

EXPECTED  
BENEFITS:

1. To diversify farm incomes, improvement of long-term productivity, enhancement of landscape diversity and wildlife habitat, and a reduction in soil and chemical loads on waterways.
2. To increase the net productivity of marginal soils.

**TITLE:** LITERATURE REVIEW AND STATEMENT OF INTENT FOR WINDROWS AND SHELTERBELTS

**STATUS:** Proposal

**PROJECT**

**ORGANIZATION:** Dr. A.M. Gordon, Dept. of Environmental Biology, OAC, U of G, Principal Researcher

**DURATION:** 3 years

**REQUESTED**

**FUNDING:** \$38,030 - Year 1; \$39,931.50 - Year 2; \$41,928.08 - Year 3

- OBJECTIVES:**
1. To determine the effectiveness of using the photographic method of measuring windbreak porosity by comparing windbreak porosity as measured by Kenney's photographic method and as measured by actual windspeed reduction measurements taken in the field.
  2. To examine the effect of windbreak orientation to wind direction on windspeed reduction.
  3. To examine the possible correlation that exists between windspeed reduction and reduction in soil erosion behind a windbreak.

**EXPECTED**

- BENEFITS:**
1. By defining the relationship between porosity and windspeed reduction will provide data for southern Ontario on optimum porosity and windbreak efficiency.
  2. Two windbreaks of similar composition, width, porosity and age, but of widely differing orientations, would be constructed. Monitoring would be continual and would result in the creation of windroses for both sides of the windbreak. These would provide information on the effectiveness of the windbreak, depending upon belt orientation and wind direction.
  3. To reduce downwind soil erosion, thus resulting in improved land stewardship.