RESEARCH SUB-PROGRAM

DEVELOPMENT AND TESTING OF A "STATE OF AGRICULTURAL RESOURCES" REPORTING AND MONITORING METHODOLOGY FOR ONTARIO

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Prepared by: Gregory Geoscience Limited
Kanata Square, Suite 504
260 Hearst Way
Kanata, Ontario, K2L 3H1

On behalf of: Research Branch, Agriculture and Agri-Food Canada,
Pest Management Research Centre (London)
1391 Sandford St.
London, Ontario N5V 4T3

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This report is one of a series of COESA (Canada-Ontario Environmental Sustainability Accord) reports from the Research Sub-Program of the Canada-Ontario Green Plan. The GREEN PLAN agreement, signed Sept. 21, 1992, is an equally-shared Canada-Ontario program totalling $64.2 M, to be delivered over a five-year period starting April 1, 1992 and ending March 31, 1997. It is designed to encourage and assist farmers with the implementation of appropriate farm management practices within the framework of environmentally sustainable agriculture. The Federal component will be delivered by Agriculture and Agrifood Canada and the Ontario component will be delivered by the Ontario Ministry of Agriculture and Food and Rural Assistance.

From the 30 recommendations crafted at the Kempenfelt Stakeholders conference (Barrie, October 1991), the Agreement Management Committee (AMC) identified nine program areas for Green Plan activities of which the three comprising research activities are (with Team Leaders):

1. **Manure/Nutrient Management and Utilization of Biodegradable Organic Wastes** through land application, with emphasis on water quality implications
   A. Animal Manure Management (nutrients and bacteria)
   B. Biodegradable organic urban waste application on agricultural lands (closed loop recycling) (Dr. Bruce T. Bowman, Pest Management Research Centre, London, ONT)

2. **On-Farm Research**: Tillage and crop management in a sustainable agriculture system. (Dr. Al Hamill, Harrow Research Station, Harrow, ONT)

3. **Development of an integrated monitoring capability** to track and diagnose aspects of resource quality and sustainability. (Dr. Bruce MacDonald, Centre for Land and Biological Resource Research, Guelph, ONT)

The original level of funding for the research component was $9,700,000 through Mar. 31, 1997. Projects will be carried out by Agriculture and Agri-Food Canada, universities, colleges or private sector agencies including farm groups.

This Research Sub-Program is being managed by the Pest Management Research Centre, Agriculture and Agri-Food Canada, 1391 Sandford St., London, ONT. N5V 4T3.

Dr. Bruce T. Bowman
Scientific Authority

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prepared for:

Agriculture Canada
Research Centre
London, Ontario

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Development and Testing of a "STate of Agricultural Resources"
Reporting and Monitoring Methodology for Ontario

Executive Summary

Agriculture and forestry are two of the main renewable resources that sustain the Ontario economy. Agriculture has played this role since the very early days of settlement.

As with any renewable resource, it is imperative that it be managed properly to assure that it is sustainable. If not, the resource will be at risk of depletion leading to a major impact on the standard of living for Ontario in the future.

This research project is centered around the development and testing of a methodology to monitor the state of the agricultural resources in Ontario.

In the beginning, groups and individuals who might have an interest in a STAR program (stakeholders) were contacted to help define information requirements. In general, there was considerable interest shown by the stakeholders, however they provided little in the way of detailed requirements.

A search of possible data types and sources that might be used in a STAR program was carried out. It is preferable if data collected for other reasons are used so that STAR project costs can be kept to a minimum. Data were divided into three categories, each of which reflected a different component of the Agricultural resource (economic, social and environmental).

Samples of data were collected so that STAR indices could be developed and tested as possible components of a STAR program for Ontario. An indexing system is well suited for reporting and monitoring change. By selecting a base time period i.e. 1981 and equating the index value for that time to 100, subsequent values can be seen to move up or down relative to the base. The Consumer Price Index is a good example of this.

Many of the indices that were tested for STAR showed that in the short term the agricultural resource is sustainable. However, the longer term trends would indicate that changes are needed to maintain the resource. Some of the indices showed that these changes may be starting to take place, driven by the desire for environmental harmony.

A STAR monitoring and reporting program for Ontario would record the impact these changes will have and help agriculture in Ontario become environmentally and economically sustainable.
SOMMAIRE

L'agriculture et les forêts sont deux des principales ressources renouvelables qui assurent la viabilité de l'économie de l'Ontario. L'agriculture joue ce rôle depuis le tout début de la colonisation.

Pour assurer la durabilité de l'agriculture, comme celle de toute autre ressource renouvelable, il est impératif de pratiquer une gestion adéquate. Dans le cas contraire, la ressource risque de s'épuiser, ce qui aurait un impact majeur sur le niveau de vie futur de l'Ontario.

Ce projet de recherche porte sur la mise au point et l'essai d'une méthode de surveillance de l'état des ressources agricoles en Ontario.

Pour commencer, nous avons communiqué avec les groupes et les personnes susceptibles d'être intéressés à un programme STAR (programme réunissant divers intervenants) afin de connaître leurs besoins en information. En règle générale, ces intervenants se sont montrés fort intéressés, mais n'ont pas fourni beaucoup de détails sur leurs besoins.

Nous avons effectué une recherche sur les sources et les types de données pouvant servir à un programme STAR. Pour limiter le plus possible les coûts d'un tel programme, il est préférable d'utiliser des données recueillies à d'autres fins. Nous avons réparti les données dans trois catégories qui reflètent chacune un aspect différent des ressources agricoles (économique, social ou environnemental).

Nous avons recueilli des échantillons de données pour élaborer des indices et vérifier si ceux-ci pouvaient servir dans le cadre d'un programme STAR en Ontario. Un système d'indices est un bon outil pour surveiller l'évolution d'une situation et en rendre compte. En choisissant une année de référence, soit 1981, et en lui attribuant un indice d'une valeur de 100, on peut ensuite observer l'augmentation ou la diminution par rapport à cette base. L'indice des prix à la consommation en est un bon exemple.

Bon nombre des indices que nous avons vérifiés ont montré que les ressources agricoles sont viables à court terme. Toutefois, les tendances à plus long terme semblent révéler qu'il faudra apporter des changements pour assurer la pérennité de ces ressources. Certains indices ont laissé voir que des changements commencent à se produire sous l'effet d'un désir d'harmonie avec l'environnement.

En Ontario, un programme STAR de surveillance et d'information permettrait de rendre compte de l'impact de ces changements et aiderait les milieux agricoles de la province à devenir viables sur les plans écologique et économique.
Development and Testing of a "State of Agricultural Resources" Reporting and Monitoring Methodology for Ontario

1.0 INTRODUCTION

Agriculture and forestry are two of the main renewable resources that sustain the Ontario economy. Agriculture has played this role since the very early days of settlement.

As with any renewable resource it is imperative that it be managed properly to assure that it is sustainable. If not, the resource will be at risk of depletion leading to a major impact on the standard of living for Ontario in the future.

This research project is centred around the development and testing of a methodology to monitor the state of the agriculture resources in Ontario. It consists of four main components:

1. Define the information requirement of a monitoring methodology.
2. Define and collect the data needed to supply the required information, also define the resource modelling procedures required.
3. Test the methodology in two different parts of the province.
4. Define the implementation of the methodology for Ontario.

To meet these major objectives, the project team consulted with stakeholders in Ontario agriculture to define the needs of a reporting system. Based on the defined requirements of a STate of the Agricultural Resources of Ontario report (STAR), a list of data was defined and acquired.

Modelling of key agricultural indicators will be evaluated as possible inputs to a state of the resources report.

Based on the success of the tests, a possible province wide program will be defined. This provincial reporting mechanism should incorporate the results of other research that will be carried out under this monitoring program wherever possible.
1.1 Study Objectives:

1.1.1 General:

The general objectives of the project were to characterize the current state of the agricultural
resources and identify areas where the resources are at risk, and to provide a method to monitor
changes in the state of the resources and to report to all stake holders in the resources and the
public.

1.1.2 Specific:

1. Define the need and structure of a State of Agriculture Resource "STAR" reporting
system for Ontario.

STAR Reports should be used as input to things like:
- Ontario Environmental Farm Plan
- Municipal Land Administration
- Provincial Resource Management Policy
- Conservation Policy and Programs

2. Define STAR database

- Existing available data (may require update or modification)
- New data that must be acquired
- Database structure (tabular, GIS, relational, etc.)

3. Test STAR program in Ramsay Township and/or Kent County

4. Define STAR monitoring and reporting

- reporting Agency
- reporting mechanism
- reporting schedule
- monitoring schedule

1.2 Definitions

1.2.1 Agricultural Resources

In the strictest dictionary definition, "agricultural resource" means a method of supplying a
need, by tillage of the soil. However, for this project, "agricultural resource" is seen to have a much
broader meaning that looks at the economic, environmental and social aspects of the agricultural
resources. This composite look at the resource will show that as some aspects of the resource may
be positive, others are negative. Only by looking at all the components of the agricultural resources can the true state of the resource be determined and monitored.

1.2.2 Stakeholder

A stakeholder in the state of Ontario agriculture is any person or group that has direct or indirect concern in the resources.

Based on the long standing importance of agriculture to Ontario, this definition would include almost every Ontario resident. For this reason, stakeholders have been stratified into three groups based on their degree of dependence on the agricultural resource. Therefore, primary stakeholders are those individuals or groups that depend on agriculture for their living (farmers, food processors, local farm services, etc.). Those individuals or groups that gain a significant part of their living from agriculture or the rural economy, such as rural merchants, are defined as secondary stakeholders. While those individuals or organizations that have regulatory or administration authority over agriculture, rural development and environmental protection, such as the Ontario Ministry of Agriculture and Food, local municipal governments, conservation authorities, etc., are defined as tertiary stakeholders. A fourth level of stakeholders is the general population of Ontario. Although this group is rather distant from the agricultural scene in Ontario, as consumers of agricultural products they are affected by changes in the state of Ontario Agriculture.

1.2.3 STAR Indicators

A state of the agricultural resource indicator is a numeric value that records and measures the change of a particular aspect of agriculture in Ontario. The STAR indicators are based on data collected from several different sources. Simple indices measure a single aspect of the agricultural resource such as production, farm size, number of farms, etc. These simple indices can be grouped into three categories; 1) economic, 2) environmental, and 3) social. Although each of these indices will give insight into the state of one aspect of agriculture, they do not on their own provide a clear picture of the overall state of agriculture. For this reason we develop composite indices that combine several simple indices to show broad trends in the state of the agricultural resource. These composite indices can combine similar data types such as different economic indicators, or they may combine different types of data such as economic and environmental.

The key to successful indicators is a consistent source of data that is collected on an acceptable cycle and in a consistent format.

2.0 STAKEHOLDERS

2.1 Identification

Based on the definition of stakeholder in 1.2.2, individuals and groups were identified as possible stakeholders in the state of the agricultural resource in Ontario. They were preliminarily
assigned to one of the main stakeholder sub-groups (primary, secondary and tertiary). In identifying potential stakeholders it was important that each of the sub-groups be as well represented as possible.

The following list presents some groups and individual stakeholders identified to be interviewed for input into the definition of a STAR report system. Although marketing boards can be considered as tertiary stakeholders, they were also considered as representatives of their members who are all primary stakeholders.

Agriculture Canada
Apple Marketing Commission
Bean Producers' Marketing Board
Broiler Hatching Egg & Chick Marketing Board
Canadian Council of Ministers of the Environment
Canadian Wildlife Service
Chicken Producers' Marketing Board
Cream Producers' Marketing Board
Ducks Unlimited
Eastern Ontario Model Forest
Egg Producers' Marketing Board
Fresh Grape Growers' Marketing Board
Fresh Potato Growers' Marketing Board
Grape Growers' Marketing Board
Greenhouse Vegetable Producers' Marketing Board
Landowner Resource Centre, Manotick
Mississippi Valley Conservation Authority
Milk Producers' Marketing Board
National Round Table on the Environment and Economy
North American Wetlands Conservation Council Canada
Ontario Federation of Anglers and Hunters
Ontario Federation of Agriculture
Ontario Ministry of Agriculture and Food
Ontario Ministry of Natural Resources
Ontario Round Table on the Environment and Economy
Potato Growers' Marketing Board
Processing Tomato Seedling Plant Growers' Marketing Board
Rideau Valley Conservation Authority
Seed Corn Growers' Marketing Board
    Sheep Marketing Agency
    Soybean Growers' Marketing Board
    Statistics Canada
    Stewardship Information Bureau, Guelph
    Geomatics Canada, Natural Resources Canada:
    Land Information Network for Canada (LINC)
2.2 Contacts

A multi-phase contact strategy was developed to communicate with the identified stakeholders for the following reasons.

1. The definition of the STAR reporting system is to be defined on the basis of stakeholder input.

2. The stakeholders would have to be consulted several times as the definition of a STAR program becomes better defined.

3. The stakeholders would have to be prioritized and selected for more detailed input.

4. An interactive process of STAR program development will lead to a more useful product.

At the start of the project, contacts were not known for all the organizations identified as potential stakeholders. A general introduction letter was sent to these groups to outline the STAR project and request the names of potential contacts.

The stakeholders were then introduced to the STAR project by telephone. They were given a brief outline on the Project objectives and asked if they had an interest in participating. Each contact was asked to think about what the agricultural resource of Ontario meant to them and what aspects of the resource they would like to see monitored and reported. They were also asked if their organization might be a supplier of data for a STAR project and if they knew of any other individual or group that might be interested in participating in the project.

The second phase of stakeholder contacts involved a mailout to all those who expressed interest during the first phase. The mailout provided a description of the STAR project objectives and asked the stakeholder to provide information that would help us to define the nature of a STAR reporting system. The stakeholders were asked what type of information about the state of agriculture in Ontario was important to their organization as well as their personal interest.

They were asked what type of reporting schedule they would prefer for this type of information as well as what level of resolution they would prefer. It was also important to find
out at this stage whether the stakeholder would be solely a consumer of STAR information or if they could possibly supply data to this reporting mechanism. Those stakeholders that could supply data were once again contacted during the data source evaluation component of the project.

2.3 Response

The response to the initial telephone contact with most stakeholders was very encouraging. Most expressed great interest in the concept and a willingness to participate.

However, as communications became more specific and information was requested, the response from many potential stakeholders dwindled. The reasons for this could be:

1. The potential stakeholder had only marginal interest in the concept.
2. The potential stakeholder had no information that was pertinent to the project.
3. The contact did not have the authority to respond for the stakeholder group.
4. The STAR concept was not defined well enough.

3.0 DATA SOURCES

Data that can be used in a STAR reporting system come in several data types. If an operational STAR program is to be cost effective it is important that all possible existing data sources be evaluated for use. During the course of this project different data types that could be of use in the STAR program were categorized and investigated. The potential for application was evaluated.

3.1 Statistical Data

Statistical or numerical data have long been used to measure and monitor trends. In fact, Statistics Canada has the full time job of collecting and processing statistical data for the country. By collecting data in a numerical form, i.e. the number of cows per farm, the size of a farm, the farm income, etc., statistical processing can be applied to show if the average farm size is increasing or decreasing, or if the size of dairy herds is increasing or decreasing. Many of these numerical data sets are continuous with only minor changes from one data collection to the next. There are also many sets of statistical data that are collected for programs which have only limited duration (SWEEP, T2000). In general, these data provide only a snap shot of the state of agriculture.
3.2 Spatial Data

Spatial data use geographic locations as a key to relate different data attributes. Often these data are numeric in nature such as the crop yield within a defined polygonal area or the number of dairy cows at defined farm locations. Spatial data can also be descriptive in nature. They can describe the landuse activity for an area, or landuse changes. They can monitor tillage practices and crop rotation.

The power of spatial data is in the ability to relate multiple data sets and carry out complex analyses.

3.3 Text Data

Much information is collected and stored as descriptive text that can be stored in a database form. Such databases can be used to describe the physical and environmental character of a farming operation. An analysis of this type of database and comparison with defined standards can provide insight into the state of agriculture. An example of this type of data set is Crop Insurance data.

3.4 Classifications of Data Types

All three types of data can come in several states. In order to evaluate the usefulness of each proposed data type, a classification system must be developed that will define the type of data, the coverage area, the resolution and the quality of the data.

The types of data encountered in this project have been extremely inconsistent. Several descriptors have been applied to help categorize data types. With respect to the spatial and temporal collection of data there has been three types noted: continuous meaning collected in a temporally and spatially regular manner; variable - collected in a nonregular manner temporally and/or spatially; and finally single data meaning data collected for a one time project that has produced a 'snap shot' of the subject in time and/or space. The data itself may be either numerical or text.

It would appear that the least subjective data sources are those that are continuous numerical data. These data sources are proving to be extremely rare. The benefit of numerical data is the objectivity gained by numerical analysis. Continuous data allows trends to be noted through charting against time.

Examples of variable data are measurements taken by Environment Canada on water flow rates and turbidity of selected streams and rivers in Ontario. There is variance in and between monitoring stations regarding the type and time of monitoring.
Single data offer only a 'snap-shot' of the subject, with no means of judging whether there is a bias in that particular data set. There were no continuous text data sources determined. Text data such as literature reviews and government reports are examples of single text data sources.

Sources of continuous numerical data have been collected by Statistics Canada and Ontario Ministry of Agriculture and Food (OMAF). Statistics Canada's agricultural census offers data that are collected every five years in a format that stays relatively constant. OMAF produces an annual publication Agricultural Statistics for Ontario with a considerable volume of data. These two sources of data comprise the prime set of data for the study.

Other sources of continuous numerical data are OMNR nursery records: tree numbers, species and distribution.

An interesting source of single numerical data that ought to be continued but was part of a now completed greater study is an acreage tillage report. The report was produced under the SWEEP mandate and is a survey of Ontario addressing the acreage of selected crops under various till systems (no till, ridge till, etc.). This is an informative supplement to consistent data but the single nature of the study does not allow any trend to be determined. It is a start, however, and will serve as an important reference should another study follow.

Other sources of point numerical data are:

- Canadian Wildlife Service has many studies that are produced as one time studies or on irregular periods.

- A plethora of information will be available soon upon completion of selected Conservation Authorities' Clean Up Rural Beaches (CURB) reports which could be applicable to a monitoring program. This may not prove to be an efficient source of information as the reports are presently being submitted to a central body and there are no plans for a summary review of this collection.

Variable text and numerical data sources are relatively abundant. As discussed above, Environment Canada has many water flow and turbidity monitoring stations that may serve as important supplementary data. Another important source of variable data again comes from Environment Canada. State of the Environment reports contain valuable information on pollutants important to all aspects of agriculture. The principle drawbacks of this information is the scope of these studies. Many are pan-Canadian studies which offer but little resolution for Ontario. Continued consultation with this important stakeholder will hopefully prove fruitful in the near future.

Due to the ranging scope of interest of the stakeholders, it is apparent that different index scales will be needed for efficient transfer of information. Policy groups will need
provincial scale information while seed/fertilizer sales groups will need indicators reflecting regional trends.

Data from the Agriculture Census of Statistics Canada is available at a Township level but only if compiled by Statistics Canada people. If data is ordered by a private group many data are "X'd" out due to privacy constraints. Were persons within StatsCan to produce the necessary calculations then it may be possible to see high spatial resolution indices in the STAR report.

Presently, county scale data is being used in the STAR database. This is consistent with OMAF's Agricultural Statistics for Ontario report. Continued contact with stakeholders and increased response will help to define the need for resolution more specific than county.

Other types of data encountered along the path of data collection were text data such as reports produced within the scope of Soil and Water Environmental Enhancement Program (SWEEP) of southern Ontario. Such information is plentiful but of little efficiency until they are summarized into a comprehensive report or are at least written up into a series of abstracts.

There is also much data to be found in centres of research such as universities and government agencies. The volume and specificity of these studies requires that such data be summarized as a literature review before it can be of efficient value to a monitoring program.

3.5 Other Potential Data Sources

Best Management Practises (BMP's) are a set of manuals produced by Agriculture Canada and OMAF detailing the advantages of various sustainable agricultural practises. They serve as benchmarks to sustainable agriculture, by which present landuse practices can be compared.

The Ontario Environmental Farm Plan program, with some changes to protect confidentiality, would allow for regional and provincial analysis. This coupled with the BMP's could be an extremely valuable source of agricultural practise information.

State of the Environment (SOE) reports are potentially important sources of information for a monitoring program. There are however, many groups involved in the collection of this data and the production of the report. The study group has a concern of extensive bureaucracy in the pursuit of this information.

Wetland areas of Southern and Eastern Ontario have been compiled as have changes in wetland area since colonization. Much of the data is available in one report. Maps may be available in a digital format.
The Eastern Ontario Model Forest holds a large potential as data sources regarding wildlife habitat and cultural and industrial concerns. The studies taking place under its auspices are only in their early stages. Contact with representative groups has begun and will continue as the STAR program develops.

Official plans, old and new, of Ramsay Township are being sought. Study of these plans may reflect changes in ideologies regarding agricultural and sensitive landuse and protection.

Soil and Water Environmental Enhancement Program (SWEEP) reports hold a great deal of information. There needs to be some kind of summary report or at least an abstract collection of the reports made available.

Crop and livestock insurance data is seen as having great potential. For reasons not fully explained there was no offering of data from these sources towards this project. This expected wealth of information could help to devise an equation predicting productivity of various soils for various crops in specific regions.

4.0 STAR INDEX DEFINITION

4.1 STAR Index Concept

The idea of an index is to measure a common set of data at a particular date in time and compare it with a starting point that is taken as standard (equal to 100). By measuring an index value several times over a defined period, change can be measured, as well as the rate of change and the quality of change. There are many economic indices used today, such as the consumer price index, that give us valuable information on the state of the economy.

It is the objective of the STAR program to develop a set of indices that can be used to monitor different aspects of the state of Agriculture in Ontario. Different types of indexing systems have been evaluated for use in the STAR program. Based on this evaluation, a set of indices and their data requirements for a STAR program will be proposed.

4.2 Economic Indices

As mentioned in 4.1, economic indices have long been used to monitor the state of the economy. A subset of these economic indices have been developed for agriculture. Both Statistics Canada and the Ontario Ministry of Agriculture and Food have mandates to collect and report statistics for Agriculture in Ontario. Most of this data is reported in Publication 20 published every year by the Statistical Services Unit in the Policy Analysis Branch of OMAF. These data are fairly consistent from year to year although minor changes in unit definition do occur from time to time. Annex A lists the contents of the 1991 report, while Annex B shows the contents of the 1981 report. A comparison of the two will identify
minor changes in data reporting. As these two exhibits represent reports that coincide with Federal census years, there are additional agricultural profiles for each of the counties and districts in the province. These profiles are a summation of the census data collected for each area.

The information presented in the first two sections of Publication 20 are province wide summations that are used to track the change in the economic state of agriculture in Ontario and compare it with the rest of Canada. These data are well presented in a set of tables that show changes over time in factors such as farm cash receipts by commodity, farm operating expenses, net income, average commodity and livestock prices, number and size of farms, on and off the farm income, and number of farm bankruptcies. A number of indices can be developed with these data that will track the general state of agriculture in Ontario. It should be noted that if indices are produced using dollar values the data should be corrected for inflation using the consumer price index.

These annual agricultural statistics have been used to monitor the economic state of Ontario agriculture for many years. They have been developed for this task and are the only data that are required for a STAR overview report.

Section three of the Publication 20 presents data for each of the 51 counties grouped into 5 geographic regions. These data sets are well presented as tables in Publication 20, but also lend themselves well to geographic analysis.

The remaining sections of Publication 20 provide data both at the provincial and county levels for international trade, field crops, fruit, vegetables and specialty crops, livestock and poultry, and dairy.

These statistics provide much information on farm incomes, production, expenses, government assistance, etc. A number of these statistics can be used to monitor the changing economic state of agriculture in Ontario. Table 1 presents a number of these possible economic indices for five counties selected to represent different regions of the province. They have been calculated with 1981 as 100 and all dollar values have been corrected for inflation using the Canadian Consumer Price Index.

By graphing these indices we can observe changes in the economic State of Ontario Agriculture in different parts of the province. A graph of the total Gross Farm Receipts Index (TGRI) Figure 2 shows the United Counties of Prescott/Russell considerably higher than the other counties. A graph of the building and Land Capital Index (BLCI) Figure 5 shows that counties such as Durham and Wellington have considerable gain in Farm capital due to land value. The proximity of these counties to Metro Toronto is probably the reason for this type if increase.

In order to maximize the presentation of economic indices as well as spatial analysis, these data can be used in a Geographic Information System (GIS). By using GIS analysis
spatial relationships between the different data sets can be expanded. For example, the relationship of the BLCI and proximity to urban centres can be visualized. Also, relationships between data layers such as cropland and the Farm Chemical Index can be studied.

An effective STAR report will use all three of these presentation styles in order to maximize the information transfer.
### Table 1. Twelve Possible Economic STAR Indices

<table>
<thead>
<tr>
<th></th>
<th>1981 = (100)</th>
<th>Prescott/</th>
<th>Lanark</th>
<th>Durham</th>
<th>Wellington</th>
<th>Kent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Total Gross Farm Receipts</td>
<td>122.7</td>
<td>90.4</td>
<td>102.9</td>
<td>99.3</td>
<td>89.2</td>
</tr>
<tr>
<td>2</td>
<td>Total Farm Area</td>
<td>92.0</td>
<td>84.4</td>
<td>90.3</td>
<td>93.6</td>
<td>102.8</td>
</tr>
<tr>
<td>3</td>
<td>Total Number of Farms</td>
<td>84.0</td>
<td>87.5</td>
<td>83.8</td>
<td>88.5</td>
<td>88.1</td>
</tr>
<tr>
<td>4*</td>
<td>Selected Farm Expenditures</td>
<td>104.5</td>
<td>84.1</td>
<td>95.1</td>
<td>95.3</td>
<td>96.3</td>
</tr>
<tr>
<td>5</td>
<td>Farm Chemical Cost</td>
<td>133.2</td>
<td>73.1</td>
<td>118.5</td>
<td>118.1</td>
<td>108.7</td>
</tr>
<tr>
<td>6</td>
<td>Fertilizer Cost</td>
<td>90.0</td>
<td>63.0</td>
<td>67.0</td>
<td>69.7</td>
<td>73.3</td>
</tr>
<tr>
<td>7</td>
<td>Farm Wages &amp; Salaries</td>
<td>208.9</td>
<td>115.8</td>
<td>130.6</td>
<td>163.8</td>
<td>121.8</td>
</tr>
<tr>
<td>8</td>
<td>Machinery Repair</td>
<td>151.2</td>
<td>117.3</td>
<td>120.2</td>
<td>123.4</td>
<td>115.8</td>
</tr>
<tr>
<td>9</td>
<td>Total Farm Capital</td>
<td>76.4</td>
<td>85.9</td>
<td>135.9</td>
<td>115.2</td>
<td>51.5</td>
</tr>
<tr>
<td>10</td>
<td>Machinery &amp; Equipment Capital</td>
<td>90.4</td>
<td>89.7</td>
<td>91.1</td>
<td>92.1</td>
<td>80.1</td>
</tr>
<tr>
<td>11</td>
<td>Building &amp; Land Capital</td>
<td>78.2</td>
<td>91.6</td>
<td>145.9</td>
<td>126.7</td>
<td>47.8</td>
</tr>
<tr>
<td>12</td>
<td>Livestock Capital</td>
<td>55.8</td>
<td>55.3</td>
<td>62.6</td>
<td>64.8</td>
<td>60.1</td>
</tr>
</tbody>
</table>

* Includes: Rent, Wages, Feed, Seed, Fertilizer and Lime, Agricultural Chemicals, Custom work, Machinery Repairs, Building Repairs, Electricity, Fuel.
Figure 1. Graph of Table 1 Data
4.2.1 Indices Development

Total Gross Farm Receipts Index (TGFRI)

This index measures the trend in gross income realized for farm operations. A trend to lower adjusted farm receipts is not sustainable over the long term. Therefore, a TGFRI less than 100 indicates a negative trend for Ontario agriculture (Figure 2).

Selected Farm Expenditure Index (SFEI)

This index tracks the adjusted costs of operating a farm operation. Therefore, an index that is less than 100 indicates reduced expenditures. These reductions may be as a result of more efficient practices or neglect of routine maintenance. If efficiency is the reason then a low SFEI is a positive trend for Ontario agriculture (Figure 2).

A comparison of the TGFRI and the SFEI for our five selected counties should indicate that expenditures have reduced more than receipts. Therefore, the overall trend is positive.

Total Number of Farms Index (TNFI)

This index tracks the number of operating farms in the province. It is assumed that a constant or increasing number of farms is a positive trend for Ontario agriculture. Therefore, a TNFI less that 100 shows a negative trend in the state of agriculture (Figure 3).

Total Farm Area Index (TFAI)

This index tracks the number of acres reported as agricultural land (Figure 3). Therefore, similar to the TNFI a TFAI of less than 100 is a negative trend for Ontario agriculture.

It should be noted however, that a slight negative trend in these two indices may be due to the loss of the least productive farms and land. This might lead to a more efficient agricultural resource. To analyze this aspect, the quality of farm operation and land being lost should be assessed.
Figure 2. Farm Receipts and Expenditures
Figure 3  Number of Farms and Farm Area Indices
Farm Wage Index (FWI)

The FWI tracks the trend in wages being paid to farm labour. Wages can be a significant component of expenditure and are greatly influenced by the wage expectations of society in general. A FWI greater than 100 can be looked at in two ways for a STAR report. First, it can be considered a negative trend because of its impact on operating costs. Secondly, it can be a positive trend in that higher farm wages will attract and keep a stable farm work force. Therefore, a FWI greater than 100 is positive as long as the rate of change in the index is not too large Figure 4).

Machinery Repair Index (MRI)

The MRI tracks the costs of repairing and maintaining the machinery required to run a farm operation. As a major component of farm expenditures, any MRI over 100 can be considered to be a negative trend for the state of agricultural resources Figure 4).

Total Farm Capital Index (TFCI)

This index tracks the capital investment in the farming operations adjusted to constant 1981 dollars. An index greater than 100 is a positive trend for the state of the agricultural resources of Ontario in that capital volume is increasing. The graph of TFCI shows a wide range (51 to 135) for our five selected counties (Figure 5).

The TFCI can be broken down into three components, the Building and Land Capital Index (BLCI), the Livestock Capital Index (LCI) and the Machinery Capital Index (MCI). A study of these three indices indicates that the reason Durham and Wellington counties have positive TFCI values is because of high building and land components. The proximity of these two counties to Metro Toronto has undoubtedly increased land values and therefore the BLCI index. This increase in land value is due to non agricultural land use pressures and therefore may in fact be a negative trend for the agricultural resource. If only the livestock and machinery capital indices are used then all five counties have negative trends.
Figure 4. Wages and Machinery Repair Indices
Figure 5. Total Capital and Building and Land Capital Indices
Figure 6. Livestock and Machinery Capital Indices
4.3 Social Indices

With so much of the rural social fabric defined by agriculture, social changes can be key indicators of the state of Ontario agriculture. Some of these data can be acquired from the OMAF Publication 20, however, most of them will come from the Statistics Canada Census data.

Change in rural population is a good indicator of the changing social structure and implications to changes in the agricultural resources. Table 2 presents several population indices for our five selected counties. The indices use 1976 as a base year (= 100) and present data for 1981, 1986 and 1991. Change in the Rural Farm Population Index (RFPI) was less dramatic between 1986 and 1991. In contrast to the RFPI, the Rural Population Index (RPI) shows a steady increase in most counties. Kent County was an exception to this trend with a minor decrease in each of the study years. The Total Population Index (TPI) has a similar trend to the RPI. As expected a county such as Durham that is close to a large urban centre has the most dramatic increase in TPI and RPI. These indices as visualized in Figures 7 and 8, show a reduction in the population base that is maintaining the agricultural resource and increases in the population base that is pressing for changes to non-agricultural land uses. Once again these data can be presented in a GIS format (Maps 1 to 8).

Other population data that can be used to track rural social changes are age and gender information for Ontario farm operators. Figure 9 shows the age distribution of farm operators for 1991. As well, it gives information on single and multiple operator farms. By tracking these types of data in the future, the nature and long term viability of the farming system in Ontario can be monitored. If the age curve is seen to shift on average to an older farm operator, then the sustainability of the agricultural resource should be questioned. The gender and mother tongue information for Ontario farm operators will provide insight into the nature of the agricultural resource.

Other rural social indices that may provide information on the state of agriculture are:

- changes in rural medical services
- changes in rural retail services
- changes in rural educational services
- changes in farm services
  (distribution, inventory, location)
Table 2. Rural Population Indices

<table>
<thead>
<tr>
<th>1976 (100)</th>
<th>P/R</th>
<th>L</th>
<th>D</th>
<th>W</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural Farm Population 81</td>
<td>80.3</td>
<td>80.0</td>
<td>80.9</td>
<td>89.1</td>
<td>82.7</td>
</tr>
<tr>
<td>Rural Farm Population 86</td>
<td>63.7</td>
<td>68.6</td>
<td>67.0</td>
<td>77.7</td>
<td>69.6</td>
</tr>
<tr>
<td>Rural Farm Population 91</td>
<td>58.5</td>
<td>62.8</td>
<td>63.5</td>
<td>77.0</td>
<td>64.3</td>
</tr>
<tr>
<td>Rural Population 81</td>
<td>110.3</td>
<td>112.7</td>
<td>104.7</td>
<td>103.6</td>
<td>94.9</td>
</tr>
<tr>
<td>Rural Population 86</td>
<td>118.4</td>
<td>131.8</td>
<td>126.1</td>
<td>106.0</td>
<td>93.9</td>
</tr>
<tr>
<td>Rural Population 91</td>
<td>135.1</td>
<td>148.4</td>
<td>159.4</td>
<td>123.7</td>
<td>95.0</td>
</tr>
<tr>
<td>Total Population 81</td>
<td>108.1</td>
<td>103.3</td>
<td>114.6</td>
<td>104.6</td>
<td>100.8</td>
</tr>
<tr>
<td>Total Population 86</td>
<td>118.0</td>
<td>112.3</td>
<td>131.8</td>
<td>112.7</td>
<td>100.6</td>
</tr>
<tr>
<td>Total Population 91</td>
<td>137.6</td>
<td>124.0</td>
<td>165.3</td>
<td>129.0</td>
<td>103.6</td>
</tr>
</tbody>
</table>

P/R - Prescott/Russel  
L - Lanark  
D - Durham  
W - Wellington  
K - Kent
Figure 7. Total and Rural Farm Population Indices
Figure 8. Rural Population Index
Figure 9. Farm Operations Classified by Age
Map 1.

Map 2.
Map 3.

Map 4.

LEGEND

- 0 - 10%
- 10 - 20%
- 20 - 30%

1986
PERCENT RURAL FARM POPULATION

1991
PERCENT RURAL FARM POPULATION
Map 5. PERCENT RURAL POPULATION 1976

Map 6. PERCENT RURAL POPULATION 1981
Map 7. PERCENT RURAL POPULATION 1986

Map 8. PERCENT RURAL POPULATION 1991
4.4 Environmental Indices

It is now generally agreed that for agriculture to be sustainable it must be in harmony with the natural environment as much as is possible. Therefore, a successful STAR reporting program must include several key environmental indicators. Information on which environmental indicators can be developed is not as available as economic information. Also, much of the environmental data are more subjective than the data collected for yearly production statistics. The need to monitor the state of the environment has been identified over the past five years and a set of indices have been developed by Environment Canada.

4.4.1 Landuse Indices

One of these indices is the change in agriculture landuse. National trends from 1961 to 1986 show a slight decrease (3%) in total farmland. However, agricultural intensification has resulted in an 11% increase in cultivated land. As part of this change in cultivated land there has been a 31% increase in cropland, with an associated 25% decrease in summer fallow. A look at similar numbers for Ontario from 1971 to 1991 show a 15.6% reduction in the total farm area which included a 8.4% reduction in cultivated land. An analysis of the total cultivated land shows a 7.3% increase in cropland, a 16.6% decrease in summer fallow and a 58.7% decrease in pasture.

Changes in landuse practices associated with agriculture is a very useful source of information that can be used to track the state of agriculture.

The agricultural statistics collected by both Statistics Canada and the Ontario Ministry of Food and Agriculture report a great deal of information on the use of agricultural land in Ontario. These annual data provide county level information on the number and area of farms, farm size and major landuse classes. By using 1981 as a base year for landuse indices, trends in the state of the agricultural resource can be tracked.

Figure 10 presents five proposed STAR landuse indices plotted for the five selected counties and compared with the provincial totals. With a few exceptions all the indices are less than 100. From a broad perspective these trends would represent an unsustainable agricultural resource over the long term. As illustrated in Figure 10 the most dramatic change is in the reduction in improved pasture. This trend would indicate a significant change in the livestock industry of Ontario between 1981 and 1991.

These types of significant changes in indices should trigger more detailed investigations of the identified agricultural sector.

Although the trend in total land used for agriculture is negative, an evaluation of how the land is being used could illustrate a trend to more intensive landuse. Figure 11
illustrates that although there is a trend to less agricultural land in Ontario, the percent of land in crops is increasing. The percent cropland index is greater than 100 for each of the five selected counties. These trends toward more intense agriculture may reflect a move to economic sustainability. However, the impacts on the environment and rural social fabric should be monitored.

The trends in total farm area and average farm size between 1976 and 1991 are illustrated in Maps 9 to 16. These maps show that the trend to less agricultural land is being countered by a trend to larger farm operations that are using more intense agriculture practices.

In addition to these general landuse indices, much more detailed tracking of changing landuse can be carried out using the production data for field crop speciality crops, dairy, livestock and poultry.
LANDUSE CHANGE INDICES 1991

Figure 10.
Figure 11. Cropland and Cultivated Land Indices
Map 9.

Map 10.
Map 11.

Map 12.
Map 13.

Map 14.
Map 15.

AVERAGE CENSUS FARM SIZE 1986

Map 16.

AVERAGE CENSUS FARM SIZE 1991
4.4.2 Chemical Indices

One of the potential environmental impacts of agricultural intensification is the increased use of agrochemicals and fertilizers. The expenditure costs of these materials are reported in the agricultural statistics (see Table 1). After adjusting the dollar values for the cost of living we see that there has been an overall reduction in the Fertilizer Cost Index (FCI) at the provincial and selected county levels. In contrast, there is a general increase in the Farm Chemical Cost Index (FCCI) with only the County of Lanark showing a decrease in this index. Although these cost indices do not show the exact amounts of materials being used, they do show trends in the importance of these materials in Ontario agriculture.

The exact use of agricultural pesticide has been surveyed every five years starting in 1973. The surveys are carried out by the Ontario Ministry of Agriculture, Food and Rural Affairs. The results appear in "Survey of Pesticide Use in Ontario".

The reports deal with three aspects of pesticide use; field crop, fruit and vegetable crops and roadside spraying.

The 1993 survey shows a continued decline in the amount of agricultural pesticide use since 1973. In fact, there has been an overall decline of 28.2% for the 10 year period 1983 to 1993. Data for individual pesticides show major changes in use with both increases and decreases. These changes are due to modified application instructions, changes in alternative crops and the use of newly registered products. The use of new products such as fenoxaprop-p-ethyl, imazethapyr, etc. is one of the main reasons for the observed decline in use in that they are applied at gram per acre levels instead of kilogram per acre. The trend to using less pesticides is a positive environmental index. However, the impact of introducing new chemicals into the environment should be monitored.

Maps 17, 18 and 19 illustrate the distribution of use for herbicides, fungicides and insecticides for the 1993 data. These data should be collected in the future to provide key environmental STAR indices.
Agricultural Use of Other Herbicides
Ontario, 1993

Source: Ontario Ministry of Agriculture, Food and Rural Affairs

Map 17.
4.4.3 Manure Indices

Another important environmental issue is the production and disposal of manure. By using livestock statistics and formulas from the Agricultural Code of Practice, and a Manure Characteristics fact sheet, calculations on manure production can be made. Table 3 shows the resulting figures for selected counties. These same data can be used to calculate the nutrient value of the manure produced.

Proper and adequate disposal of manure is of considerable environmental concern. If excess manure is spread on the land, runoff will carry it into the drainage system and adversely effect wetland and aquatic environments. The Agricultural Code of Practice gives us relationships between the number of livestock units and the minimum acreage of land required for manure application. By computing the number of animal units per county and comparing that to the amount of cultivated land we can determine regions where manure production exceeds the land base for acceptable application (Table 4). Changes in this index over time will indicate increasing or decreasing environmental pressures.

Table 5 indicates that on average all of our selected counties have an acceptable land base for the disposal of the manure produced there. It should be noted however, that there are probably areas within each county where manure production may exceed the land base. In these cases transportation of manure to acceptable sites may be required. Another trend detectable in Table 5 is a general reduction in animal units per acres of cropland between 1981 and 1991, with significant changes between 1981 and 1986 for some countries. The environmental implications of this trend are positive, as long as individual application sites follow best management practices. These trends can also be seen in GIS maps 20 to 23.

Table 3. Total Manure Production (millions of L)

<table>
<thead>
<tr>
<th>YEAR</th>
<th>P/R</th>
<th>L</th>
<th>D</th>
<th>W</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976</td>
<td>1615.36</td>
<td>779.59</td>
<td>1425.84</td>
<td>2680.26</td>
<td>791.87</td>
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<tr>
<td>1981</td>
<td>108.66</td>
<td>506.14</td>
<td>1046.61</td>
<td>2630.65</td>
<td>791.88</td>
</tr>
<tr>
<td>1986</td>
<td>904.66</td>
<td>395.67</td>
<td>954.43</td>
<td>2324.31</td>
<td>648.14</td>
</tr>
<tr>
<td>1991</td>
<td>342.38</td>
<td>330.05</td>
<td>647.03</td>
<td>1902.40</td>
<td>703.71</td>
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</tbody>
</table>
### Table 4. Volume of Manure / per Acre of Cropland (L/acre)

<table>
<thead>
<tr>
<th>YEAR</th>
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<th>L</th>
<th>D</th>
<th>W</th>
<th>K</th>
</tr>
</thead>
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<tr>
<td>1976</td>
<td>8117.4</td>
<td>7894.7</td>
<td>6552.6</td>
<td>7783.5</td>
<td>1611.7</td>
</tr>
<tr>
<td>1981</td>
<td>5463.4</td>
<td>5157.2</td>
<td>4584.7</td>
<td>7273.1</td>
<td>1563.8</td>
</tr>
<tr>
<td>1986</td>
<td>4557.3</td>
<td>4584.7</td>
<td>4379.9</td>
<td>6758.3</td>
<td>1290.2</td>
</tr>
<tr>
<td>1991</td>
<td>1772.3</td>
<td>3970.9</td>
<td>3067.1</td>
<td>5512.6</td>
<td>1342.3</td>
</tr>
</tbody>
</table>

### Table 5. Number of Animal Units of Manure/Acre

<table>
<thead>
<tr>
<th>YEAR</th>
<th>P/R</th>
<th>L</th>
<th>D</th>
<th>W</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>.481</td>
<td>.567</td>
<td>.495</td>
<td>.755</td>
<td>.159</td>
</tr>
<tr>
<td>1986</td>
<td>.391</td>
<td>.504</td>
<td>.396</td>
<td>.470</td>
<td>.073</td>
</tr>
</tbody>
</table>

Note: For optimum utilization of the nutrient content of manure for crop production, the application rate should be one animal unit per acre. (Agricultural Code of Practice)

P/R  -  Prescott/Russel  
L    -  Lanark  
D    -  Durham  
W    -  Wellington  
K    -  Kent
Map 20.

1976
YEARLY VOLUME OF MANURE
PER ACRE OF CROP LAND

LEGEND
- 0 - 2000 l/acre
- 2000 - 4000
- 4000 - 6000
- 6000 - 8000
- 8000 +

Map 21.

1981
YEARLY VOLUME OF MANURE
PER ACRE OF CROP LAND

LEGEND
- 0 - 2000 l/acre
- 2000 - 4000
- 4000 - 6000
- 6000 - 8000
- 8000 +
Map 22.

Map 23.
4.4.4 Wetlands

Wetland and habitat preservation are key components of environmentally sustainable agriculture. The management and protection of wetlands are presently key provincial policies. All provincially significant wetlands have been mapped and are now protected from development (Ontario Wetlands Policy Statement). By using remotely sensed data on a prescribed schedule, changes in the known wetlands can be monitored. With existing protection there should be no loss of wetlands and possibly an increase. Also, as farmers are encouraged to return marginal land to a natural state, there should be a measurable increase in wetlands.

4.4.5 Wildlife

Wildlife habitat preservation is greatly dependent on the structure and nature of agriculture. A project we carried out for the Canadian Wildlife Service and the United States Environmental Protection Agency developed a simple classification system that uses remotely sensed data to monitor the degree of agricultural intensity. Using indicators such as land cover diversity and land cover parcel size, an index of farm intensity and diversity was developed. Research work showed a relationship between this farm intensity value and bird population data and habitat data (see Annex C). With more development these data could provide information on habitat diversity for other types of wildlife as we measure habitat connectivity and segmentation.

Presently, research is showing that remotely sensed data can also be used to provide information on changing tillage practices and plant residue management.

4.5 Tillage Practice Indices

In recent years it has been demonstrated that the implementation of proper tillage practices can lead to improved soil conservation, crop yields and reduced input costs. All of these are positive trends for a sustainable agricultural resource. Therefore, a set of STAR indices that track the trends in tillage practices is important.

Data for tillage practices are very hard to find. A very detailed tillage survey was carried out for Ontario in 1990. The results of this survey provide data at county, region and provincial levels. These data list the number of acres of land under different tillage practices for several major crop types. The county level data are summed and average at a regional level and a provincial level.

With only one set of tillage data, a set of indices could not be developed based on a time sequence. Therefore, it was decided that each county would be indexed against the regional and provincial averages to produce regional indices (RI) and provincial indices (PI). The five regions are the same as the regions used in OMAF Publication 20.
Tables 6, 7, 8 and 9 present the RI and PI calculations for conventional tillage practices in the southern, western, central and eastern regions. If the RI is greater than 100 then that county has a higher proportion of conventional tillage than the regional average. Similarly, if the PI is greater than 100 the county has a higher proportion of conventional tillage than the provincial average. If it is assumed that conversion to conservation tillage practices such as mulch till, ridge till, no till, etc. will help to sustain the agricultural resources of Ontario, then monitoring changes in either the RI or PI will track this trend.

In order to support these STAR tillage practice indices, a tillage survey program must be established to collect consistent data on a predetermined schedule. As changes in tillage practices do not happen that quickly, a five year survey schedule is probably acceptable.

By storing the tillage survey data in a county level GIS database, the spatial patterns of changes in tillage practices can be analyzed. The tillage practices can also be related to other geographic data such as soil type, rainfall and temperature data, farm size, machinery costs, etc. Maps 24 and 25 show an example of the provincial conventional tillage index for fall and spring seeded grain crops. Note that scores greater than 100 indicate the use of conventional tillage greater than the provincial average. Maps 26 and 27 show the regional conventional tillage index for fodder corn and grain corn. These indices show the relationship between the county and the regional averages. By monitoring these indices over time, trends towards sustainable agricultural resources can be tracked.
Table 6.
REGIONAL (RI) AND PROVINCIAL (PI) INDICES FOR CONVENTIONAL TILLAGE

SOUTHERN REGION

<table>
<thead>
<tr>
<th>Year</th>
<th>Region</th>
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<th>Corn, Grain</th>
<th>Grain, Spring Seeded</th>
<th>Grain, Fall Seeded</th>
<th>Soybean</th>
<th>Other</th>
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Tillage 2000

Gregory Geoscience Limited
November 1995
Table 7.
REGIONAL (RI) AND PROVINCIAL (PI) INDICES FOR CONVENTIONAL TILLAGE

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Tillage 2000

Gregory Geoscience Limited
November 1995
### Table 8.

**REGIONAL (RI) AND PROVINCIAL (PI) INDICES FOR CONVENTIONAL TILLAGE**

#### CENTRAL REGION

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Tillage 2000
### Table 9.

**REGIONAL (RI) AND PROVINCIAL (PI) INDICES FOR CONVENTIONAL TILLAGE**

**EASTERN REGION**

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Tillage 2000
Map 24.

PROVINCIAL INDEX GRAIN, FALL SEEDED

LEGEND
- 0.000 - 33.333
- 33.333 - 66.667
- 66.667 - 100.000
- 100.000 - 133.333
- 133.333 - 166.667
- 166.667 - 200.000

Map 25.

PROVINCIAL INDEX GRAIN, SPRING SEEDED

LEGEND
- 0.000 - 33.333
- 33.333 - 66.667
- 66.667 - 100.000
- 100.000 - 133.333
- 133.333 - 166.667
- 166.667 - 200.000
Map 26.

Map 27.
4.6 Soil Survey Data

The development of agricultural products in Ontario is based on the cultivation of soils. Therefore, information on the character and rate of change for the soils of Ontario are key to understanding the state of the agricultural resource.

Unfortunately, the mapping of the soils of Ontario at the county level has taken place over many years using ever evolving methodology. The result of this has left a patchwork of soil surveys that have different degrees of accuracy and completeness. There is little continuity of information from one soil survey to the next across county boundaries. For this reason, methods of soil survey upgrade were investigated. By upgrading all county soil surveys in the province to the same level of information using a common legend, the new soil surveys could provide important information for STAR reporting.

Soil survey upgrade was tested on two sites in Ontario (Ramsay Township in Lanark County and Howard and Harwich Townships in Kent County. A preliminary evaluation of the work has been carried out and is reported on by Ken Denholm (see Annex D).

The development of a standardized provincial soils GIS database that uses a single common legend will lead to many different ways to monitor the state of agriculture through the use of soils. An example of this would be to use the best management practices soil scoring (Table 10) that define suitability of tillage systems for different soil types to develop tillage suitability maps. The soil upgrade data for Ramsay Township were used in a GIS to develop tillage suitability maps (Maps 28 to 33). These maps show the best suited tillage systems for different soil conditions within the geographic area of interest.

Once these maps have been produced they can be cross correlated with actual landuse data, such as the distribution of conventional tillage areas derived from spring Landsat satellite remote sensing data. When this was done for Ramsay Township, it was shown that in 1991 over 54% of the land under a conventional tillage system were areas defined as "not well suited" or "not recommended" for conventional tillage. By tracking this type of information, trends toward more sustainable tillage practices can be monitored. These trends could be used as a STAR index to monitor the trend to soil conservation and a sustainable resource.

Other aspects of soil conservation can be monitored with landuse and best management practices data. For example, the erosion potential from water can be calculated and displayed (Map 34). When this map is compared with the landuse map derived from Landsat, it is determined that fully 82% of the area using conventional tillage practices are found on land that has a high to severe water erosion potential. Again, by monitoring these data, a trend towards soil conservation can be tracked.
Finally, expected changes in crop yield can be calculated with the soils data and best management practices information. Map 35 shows the expected changes in crop yield in Ramsay Township if a No-Till system is implemented.

All of these types of data can help the farm operators select the best tillage system for their operation all of which will lead to a sustainable agricultural resource.

4.7 Simple and Composite Indices

A simple index measures one and only one parameter. They are easy to understand and present in a report. Most of the indices described in this report are simple indices. Because the state of the agricultural resource is a very complex subject with many interrelated components, simple indices are often not adequate to present the whole picture. It is possible to present a number of simple indices in one table or graph to convey a more complex picture (Figure 1). However, it still may be difficult to decide on what a combined display represents in terms of changes in the state of agriculture.

Therefore, it is often necessary to develop and use composite indices. An example of this is the Dow Jones Composite Index on the New York stock exchange. A composite index is designed to use a number of diverse and related indices to produce a more complete and accurate picture as to the state of a subject. For agriculture, it is important that several key composite indices be developed. At this time it is proposed that a composite economic index, a composite social index and a composite environmental index be developed. It is also suggested that a combined composite index that will use data from all three of the major groups of data (economic, social and environmental) be developed. Such a combined composite index should indicate positive or negative trends toward a state of sustainable agriculture. The structure of possible combined composite indices will require more detailed study of all the proposed simple indices.
Table 10. Best Management Practices

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YIELD POTENTIAL
- I = Increase
- E = Equal
- D = Decrease
* Compared to moldboard plow

EROSION POTENTIAL
- S = Severe
- H = High
- M = Medium
- L = Low

SUITABILITY RATING
- 1 = Very Suitable
- 2 = Well Suited
- 3 = Moderately Suited
- 4 = Not Well Suited
- 5 = Not Recommended

* Coulters on planting equipment to till a narrow strip of soil will improve rating.

From Best Management Practices "Field Crops".

Gregory Geoscience Limited

November 1995
Map 28. Location Map for Ramsay Township, Lanark County.
Map 29. SUITABILITY RATING
CONVENTIONAL TILLAGE
FALL

LEGEND

Very Suitable
Well Suited
Moderately Suited
Not Well Suited
Not Recommended

Map 30. SUITABILITY RATING
CONVENTIONAL TILLAGE
SPRING

LEGEND

Very Suitable
Well Suited
Moderately Suited
Not Well Suited
Not Recommended
Map 31.

Map 32.
Map 33.

Map 34.
Map 35.

EROSION POTENTIAL FROM WATER

LEGEND
- Low
- Medium
- High
- Severe

Map 36.

YIELD POTENTIAL NO-TILL SYSTEM

LEGEND
- Increase
- Equal
- Decrease
5.0 STAR REPORTING

5.1 Report Structure

At the present time several report structure models are being evaluated. The key to a successful reporting mechanism is to get all the pertinent information to all interested stakeholders in a fast, efficient and accurate manner. Environment Canada has developed a state of the environment reporting program that features many characteristics that would work for a STAR reporting program. Also, Statistics Canada is developing new reporting methods that can be applied to a STAR report.

As the cost of collecting and processing data for any reporting program is so very expensive, it is important that a STAR report should make use of as much existing data as possible. Publishing and distribution is also an expensive component of a reporting program. A complete report of all the monitoring data such as the State of the Environment report, or the National Census is very expensive to produce. In these times of limited budgets, these costs may limit the number of stakeholders that have access to STAR information. In order to get important information in the hands of as many stakeholders as quickly as possible, the newsletter or fact sheet format should be used.

Many agencies such as Environment Canada and Statistics Canada are adopting this format. Examples are the INFOMAT weekly review of economic indices (Annex E), and the new VISTA Agri-food semi-annual newsletters put out by Statistics Canada. There are also the State of the Environment fact sheets that report on one selected indicator at a time.

It is proposed that the STAR reporting mechanism be structured in a fashion similar to the above examples. A complete STAR report should be scheduled to coincide with the collection of Census data which will supply much of the raw data. Remote sensing data collection and analysis should be scheduled to coincide with the collection of the statistical data, so that all data in the complete report can be correlated. Cost limitation may restrict the remote sensing analysis to selected areas that are representative of larger regions of the province.

In parallel to the preparation of the full STAR report, a series of STAR report fact sheets should be produced to provide information on specific aspects of Ontario agriculture. These fact sheets should be designed to be short and concise, using fact summations, statistical tables, graphs and charts. A brief analysis of the information in terms of the changing state of agriculture in Ontario should be presented. As well, a cross reference to other fact sheets and sources of information should be provided. The key to these STAR fact sheets is their flexibility in schedule and format and their lower costs. This should assure a wide distribution of information.
The structure of the complete STAR report should be much more rigid to permit long term comparison of data and information.

Another component of the report structure will be the level of resolution to be reported. At this time it is proposed that several levels will be used. At the first level, data will be reported at a provincial level. Cumulative data for Ontario will be reported and may be compared with other provincial and national data. In order that trends for different regions of the province can be monitored, data will be reported on a region or county level. For some key indicators a township level may be used. However, work with some township data indicates that there are data which cannot be accessed because of confidentiality.

For a very intense reporting level, selected townships may be defined as representative of a region of the province. Another possible intense reporting program would be to define model farming areas or even model farms. A model farming area would consist of a number of contiguous farming operations that represent a type of Ontario operation, e.g. eastern Ontario dairy farming or southern Ontario cash crop. A detailed database would be developed for each model area that would include statistical data and geographic data, in tables and GIS format. These later bases would include data on economics, production, the environment, the social fabric, etc. By updating the databases on a prescribed schedule, very detailed analysis about changes in the state of Ontario agriculture can be carried out. The selection of the model farm or farming area is extremely important as to how far the observations can be extrapolated.

Preliminary investigation of digital bulletin board service indicates that as a reporting medium LINC, through Natural Resources Canada, appears to be the only service capable of carrying graphic data. It is proposed to be operational by 1998. At this very early stage of development it is unclear how data contribution from groups outside of Geomatics Canada will be dealt with.

Another system that may be available in the next few years is the proposed Environmental Information Network (EIN) to be developed by the State of the Environment Section of Environment Canada. The following description of EIN has many of the same characteristics envisioned for STAR. Because of these similarities it is possible that STAR could be a subset of EIN and take advantage of the existing and developing infrastructure.

State of the Environment Reporting generates information products based on an ecosystem approach such as fact sheets, special reports, newsletters, environmental indicators and national reports. These products can either be electronic publications or hard copy publications and will incorporate written, graphed, mapped and illustrated information.
The EIN will reflect the ecosystem approach through the use of an ecological spatial framework. Ecological units - now being finalized in cooperation with other federal departments, provinces and territories - will serve as the primary collection and dissemination units for SOE information. The spatial framework will provide consistency and the flexibility to consider local, regional and national scales.

The concept of the EIN encompasses the whole of State of the Environment Reporting process including the acquisition of data, analysis and interpretation, generation of information products and information dissemination. The EIN is taking advantage of an existing array of technologies including GIS, telecommunications, database systems and user-interfaces. As a comprehensive State of the Environment Reporting system the EIN will: assemble a range of data from various sources (including outside organizations, universities, researchers, industries, other departments); allow for the effective integration of this data; provide tools for data interpretation and analysis; provide productivity tools that will allow rapid and improved processes for document creation (including a secure repository for all data and reports, work-flow, file and document management tools); and present information in a variety of ways through a range of media. Ultimately an end-user will have access to information within an ecosystem framework in a decision-support context.

As such, the EIN will comprise four major components:

1. **Information Assembly and Structure**: a relational database tool which will allow for the gathering of a variety of information and the display of meta-data in a user-friendly way;
2. **Research and Analysis Tools**: GIS, spreadsheets, statistical packages, modelling tools allowing researchers and analysts to interpret the data;
3. **Document Preparation Repository**: productivity tools including file and document management tools and work-flow management tools, a secure repository for data, work in progress and final versions; and
4. **Product Information System**: user enquiry tools to access finished SOER products (reports, bulletins, facts sheets, etc.).

The underlying principles in the design of the EIN should allow for a flexible system that accommodates and enhances but does not control the process; that operates from the individual to the organization level; that is not technology driven (technology will accommodate users needs, not vice-versa); that the capabilities of the system will evolve with technology; and that will be user-friendly to facilitate cultural change and acceptance of this new tool.
5.2 Report Scheduling

As eluded to in Section 5.1, STAR reports will be presented on different time schedules. The full STAR report should be scheduled to correspond to the National Census, to take advantage of data collection.

Scheduling for the STAR report fact sheets requires more detailed analysis. There are two main controlling factors to this scheduling. First, the availability of data will be a prime control on the schedule. In order to minimize costs STAR will use existing data where ever possible. In most cases data are not collected on a cycle shorter than one year. Some sales and production data are collected on a monthly bases. However, they tend to show seasonal trends to the market which may not reflect any significant change in the state of Agriculture. The other major control on scheduling is the requirement of the stakeholders. Many of the identified stakeholders require information at specific times in order to make decisions and policies.

At this time it is proposed that the STAR report fact sheets should be prepared on an annual basis. The timing of preparation will be controlled by data available and user needs.

5.3 Report Audience

The primary audience for a STAR report will be the stakeholder's groups as defined in Section 2.0. The STAR report will be designed to meet the defined information requirements of each of the major stakeholder groups. However, the audience should go beyond the stakeholders. The STAR report will summarize and present information in a format that will interest the media and the general population. By getting STAR information to this level a better educated population will be prepared to support a move to a healthier agricultural industry in Ontario.

5.4 Report Feedback

An integral part of the STAR reporting process will be a stakeholder's feedback mechanism. In order that the STAR reporting structure and schedule are optimum for use by the targeted stakeholder groups, a feedback system will be part of each report and fact sheet. It will be designed to be easy to use and require a minimum of the stakeholder's time. By using feedback information, the STAR report can be fine tuned to provide the information that is needed when it is needed.

5.5 Report Integration

As alluded to in Section 5.1, it is important that the series of STAR reports be cross referenced so that the end user can integrate data from a number of different
reports. Report integration should expand the functionality of the STAR program by allowing end users to customize the information to their own requirements.

In order to permit report integration, each report will be designed to present data in a similar manner, using common terms and reporting dates. As a part of each report, a cross reference section will identify which other STAR reports are available to the end user for integration and analysis. The report integration process will be refined based on the user feedback information.
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Cattle Herd by Type
Ontario, 1991

- Beef cows: 17.0%
- Beef heifers: 3.8%
- Slaughter heifers: 8.7%
- Steers: 14.6%
- Calves: 25.3%
- Dairy cows: 19.4%
- Dairy heifers: 10.0%
- Bulls: 1.2%

Total = 2.29 million head

Pigs, by Type, Ontario, 1991

- Under 20 kg: 30.9%
- 20 to 60 kg: 31.3%
- Over 60 kg: 26.8%
- Boars: 0.7%
- Sows: 10.4%

Total = 2.92 million head

Average Price for Steers & Hogs

|$/cwt


- A1.2 steers (Tor)
- Index 100 hogs

Area of Major Field Crops
Ontario, 1991

- Soybeans: 17.4%
- Corn: 27.4%
- Hay: 31.7%
- Mixed grain: 5.0%
- Barley: 6.0%
- Oats: 2.3%
- Wheat: 5.5%
- Other: 4.7%

Total = 8.1 million acres

Farms by Sales Class
Ontario, 1991

- $5,000 - $9,999: 12.0%
- $10,000 - $24,999: 18.5%
- $25,000 - $49,999: 12.5%
- $50,000 - $99,999: 12.2%
- $100,000 - $249,999: 18.2%
- Under $2,500: 10.5%
- $250,000 & over: 8.9%

Total = 68,633 farms

Production of Selected Dairy Products
Ontario, 1985-1991

- Creamery butter
- Cheddar cheese
- Other cheese
- Skim milk powder
ANNEX B
There are, in the world today, approximately 8600 different species of birds, out of which some 886 species occur in North America. Of these, 112 species were observed during a breeding bird survey conducted in 1980 and 1992 on three routes examined for this study. The area selected lies 30 to 50 kilometres west of Ottawa, Ontario and is comprised of three routes, forty kilometres long, with 50 survey sites per route spaced at 800 metre intervals. The area was chosen for its varied farming systems and landcover types.

Farmland constitutes an important breeding habitat for many bird species. Over the years, bird populations have had to adapt to the changing agricultural landuse and the intensification of farming systems which in turn have modified the nature of breeding bird habitats and their food supply. Gregory Geoscience Limited, in cooperation with Weston Graham and Associates Ltd., Environment Canada, the U.S. Environmental Protection Agency, and the Canada Centre for Remote Sensing have assembled a multidisciplinary team with expertise in avian and plant ecology, agricultural systems, remote sensing and GIS analysis, to study the relationship between agricultural systems, landcover change, nesting habitat structure and variations in abundance and species richness of birds and plants.

The study involved various work phases:

Phase 1.
Breeding bird survey data were collected in 1980 and

Phase 2.
A survey of agricultural systems and landcover was conducted in order to develop a classification system to

Phase 3.
Habitat structure was analysed at selected sites along the breeding bird survey routes. The selection was made so that each of the different farming systems was

Phase 4.
A survey of plant species composition was carried out

Phase 5.
An agricultural intensity map of the survey routes was produced for 1981 and 1991 using satellite remote

The results on the various aspects of the study were treated separately and together to provide information on the relationship between agricultural systems and bird
RESULTS

Agricultural and other landcover classes at each survey site on Route 3 were mapped from satellite data using a seven class system together with five subclasses of field size modifiers. Agricultural intensity values were calculated by assigning a weighting to the class and subclass and multiplying one by the other. Farming intensity increased at 32 survey sites, decreased at 2 survey sites and remained the same at 26 sites.

Agricultural intensity values were compared to the type of farming operation present at each site along Route 3 and were grouped into three categories of farming operations:

1. Commercial (Class 1)

These operations are defined by agricultural intensities greater than 19. They are often incorporated and characterized by large acreages, extensive use of fields and a modified environment to optimize farming. The use of chemical pesticides and fertilizers is common.

2. Family Farm (Class 2)

These operations are defined by intensities between 9.0 and 18.9. Typically, farm size has changed little over the years. The farm constitutes the main source of livelihood for the family and is often run by members of one family. Family farm operations are characterized by a slow change from mixed farming to more specialized farming with little change to the landcover. Field diversity is greater and use of chemicals is less common than in commercial operations.

3. Recreational (Hobby) (Class 3)

These operations are defined by intensities between 0 and 8.9. They are generally the same size or smaller than family farm operations. Farming is often not the only source of income for the operator. Recreational operations are usually low intensity systems and are represented by pasture land, grazing land and tree cover.

The change in agricultural intensity within the three groups indicates that Class 1 operations have become more intense during the ten year period considered. This intensification of farming was primarily due to the increase in the percentage of annual crops. On the other hand, family and recreational farms showed only slight change over the same period.
Areas where crop production is less intense (Class 3) sustain a more varied field composition and support a more diversified species composition. This can be explained partly by the presence of hedgerows, fencelines, woodlots, shelterbelts and isolated trees.

![Number of species per farming class](image)

On the other hand, landcover on recreational farms which is characterized by small field size, long grass fields and abandoned fields sustained

**Number and Composition of Plant Species in Farmland Habitats**

<table>
<thead>
<tr>
<th>Habitat Type</th>
<th>No. Sites Sampled</th>
<th>No. Species (Range)</th>
<th># Dominant</th>
<th>% Dominant</th>
<th>Group Spp.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ground</td>
<td>Trend</td>
<td>Shrub</td>
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<tr>
<td>BLOCK COVER</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Crop</td>
<td>18</td>
<td>3 - 16</td>
<td>0</td>
<td>8</td>
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<td>4</td>
<td>2 - 35</td>
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<td>31</td>
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<td>9</td>
<td>12 - 44</td>
<td>0</td>
<td>22</td>
<td>32</td>
</tr>
<tr>
<td>Old Field</td>
<td>3</td>
<td>19 - 47</td>
<td>9 - 12</td>
<td>16</td>
<td>50</td>
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<td>2</td>
<td>16 - 25</td>
<td>9 - 20</td>
<td>12</td>
<td>93</td>
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<td>4</td>
<td>13 - 24</td>
<td>3 - 18</td>
<td>12</td>
<td>100</td>
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<tr>
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<td>3 - 28</td>
<td>1 - 6</td>
<td>1</td>
<td>100</td>
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<tr>
<td>Herbaceous</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>0</td>
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<tr>
<td>Woody</td>
<td>16</td>
<td>9 - 36</td>
<td>3 - 22</td>
<td>31</td>
<td>52</td>
</tr>
</tbody>
</table>

Only groundflora species with > 5% cover averaged over 3.5 x 1m

C. Keddy,

The bird surveys conducted in 1980 and 1992 indicate a significant decline in bird abundance along the three routes examined partly due to the change in observer. Between 1980 and 1992, the average number of birds per station changed from 21.5 to 10.5 for Route 1, 11 to 9.5 for Route 2 and

![Change in bird abundance](image)
Omnivores made up approximately two thirds of the birds observed in the study area. Of these, nearly 70 percent were ground feeders. Omnivores have sustained the greatest reduction in number. A decline of 1414 birds was incurred amongst omnivorous species which represents 41% of their

The mean decrease in bird species was 3.5 for Class 1, 2.1 for Class 2 and 3.8 for Class 3 farming operations.

The reduction of insectivores is independent of farming classes with an approximate mean loss of 4.0 per group.

The reduction of omnivores has a distinct relationship to farm groups with mean reduction of 18.6 for Class 1, 10.9 for Class 2 and 4.7 for Class 3 farming operations.

The reduction in granivores is similar for Class 1 and Class 2, while there is almost no change for Class 3 farming operations.

It appears that habitat diversity, as well as the presence of adequate edges in the farmland (fencelines, hedgerows, etc.), are essential to support a varied species composition.

**FURTHER STUDIES**

Further studies on edges, using GIS modeling, would be useful to analyse, in more detail, their effect on bird abundance and species diversity.

A factorial analysis could be performed to determine the relative importance of each factor that influences the bird abundance (e.g. temperature change, use of chemical pesticides, land drainage, predation, loss of habitat and food supply, etc.).

Further research is also required to refine the methodology developed for this project and to verify its validity in other agricultural areas where breeding bird survey data are available.

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- U.S. Environmental Protection Agency
- Weston Graham & Associates

For further Information, please contact:

GREGORY GEOSCIENCES LIMITED
Kanata Square, Suite 504
260 Hearst Way
Kanata, Ontario K2L 3H1
Telephone: (613) 599-7465
Facsimile: (613) 592-9135
ANNEX C
ANNEX D
Soil Survey Upgrade

Methodology Assessment

in Lanark and Kent Counties

Prepared by

Ken Denholm

Land Resource Division
Agriculture & Agri-Food Canada
70 Fountain Street East
Guelph, Ontario
N1H 3N6

November 1995
1.0 INTRODUCTION

Inventories of agricultural soils have been conducted in Ontario since 1914. The earliest soil surveys were usually at a scale of 1:126,270 and later at 1:63,360. These surveys contained descriptions of soil materials and their suitability for the growth of specific field crops but lacked slope, drainage and stoniness information found in more recent soil surveys. Many of the earliest soil inventories, those mapped at a scale of 1:126,270, have been re-surveyed at a scale of 1:50,000.

These most recent county soil surveys contain comprehensive information on soil materials, slope and drainage and include laboratory analysis of the major soils of the county. The soil and landscape information has been used to interpret soil capability for common agricultural field crops (ARDA, 1965) and for specialty and horticultural crops (OIP 1987-1992). These data are available to users in either digital or hard copy formats.

The soil survey reports and maps of the counties of southern Ontario were rated on three categories by pedologists of the Ontario Centre for Soil Resource Evaluation (OCSRE): the adequacy of the soil boundaries; the adequacy of the slope information; and whether analytical soil analyses exist. The results of this assessment are presented in Table 1. Soil boundary lines are considered adequate where the soil boundary lines were located with stereoscoped airphotos. Adequacy for slopes implies that the slope class(es) is shown on the map polygon, and adequacy for lab data implies enough samples were collected and analyzed to characterize the major soils and to make capability interpretations. A rating of good (G) = adequate; fair (F) = questionable; and poor (P) = inadequate, was assigned to each county soil survey for each of the three categories -boundaries, slope and laboratory data (Presant, 1989 personal communication).

While the current soil survey data has been useful for regional interpretations, there are large gaps and inconsistencies in the information base, as Table 1 illustrates. These deficiencies in the content or quality of the information make the current data unsuitable for provincial land use decisions such as are required by the State of Environment reporting and the State of Agricultural Resources reporting as well as for assessments of soil capability, suitability and soil degradation. For example, counties which were mapped prior to the early 1960's often lack adequate boundary, slope and analytical information whereas, counties mapped in the period from the mid 1960's to the mid 1970's generally have adequate boundaries but are frequently lacking either slope information or analytical data or both. In order to improve the existing
Table 1. Adequacy of existing published soils information in southern Ontario for agricultural interpretations.

<table>
<thead>
<tr>
<th>County</th>
<th>Category*</th>
<th>Year Completed</th>
<th>Boundary</th>
<th>Slope</th>
<th>Data</th>
<th>Area (Ha)</th>
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<td>A</td>
<td>1994</td>
<td>G</td>
<td>G</td>
<td>G</td>
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<td>Haldimand-Norfolk</td>
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<td>G</td>
<td>G</td>
<td>G</td>
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<td>Niagara</td>
<td>A</td>
<td>1989</td>
<td>G</td>
<td>G</td>
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<td>G</td>
<td>G</td>
<td>P</td>
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<td>Ottawa Urban Fringe</td>
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<td>1977</td>
<td>P</td>
<td>P</td>
<td>P</td>
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<td>G</td>
<td>G</td>
<td>G</td>
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<td>Kent</td>
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<td>G</td>
<td>G</td>
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<td>Grenville</td>
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<td>P</td>
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<td>Grey</td>
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<td>1954</td>
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<td>P</td>
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<td>Location</td>
<td>Year</td>
<td>Scale</td>
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</table>

* Category A denotes a scale of 1:25,000 with a Minimum Sized Delineation (MSD) of 6 acres; Category B denotes a scale of 1:50,000 with a MSD of 25 acres; Category C denotes a scale of 1:63,360 with a MSD of 40 acres; Category D denotes a scale of 1:125,000 with a MSD of 156 acres; Category E denotes no information.

For provincial soil database for provincial applications there is a need to collect further information for the older surveys and to provide all the information in digital format.

Conventional county level soil resurveys produce completely new soil maps and reports. The original map and report are used to define ranges of soil properties and for legend building but are generally not correlated with the new map. Using a resurvey to upgrade the soil and landscape information of an area is undesirable considering the cost, time and manpower involved. It is thus important to develop cost effective methods of bringing all of the soil information across the province to a minimum standard level of detail and accuracy to allow interpretations of agricultural capability and suitability and for assessments of soil degradation. This level of detail would be suitable for regional planning needs but not suitable for subdividing.
parcels of land. These upgraded soil inventories will not match the accuracy and precision of the most recent 1:50,000 soil inventories, done at a Survey Intensity Level (SIL) 3 (Valentine and Lidstone, 1985), however, upgrading the soil information of areas of the province will create a continuous soil database at a standard level of detail and precision for the entire agricultural region of Ontario for use in a geographic information system (GIS). Clearly, the level of effort required to upgrade different areas of the province will vary from simple resampling within existing polygons to redefining soil boundaries combined with resampling.

Several approaches for acquiring the necessary information at a standard minimum provincial soil information level are found in the literature. Brus et al., (1992) describe methods of improving soil inventory information as revision, upgrading, revision plus upgrading and upgrading by two-phase sampling. Revision may change the classification of delineations or their boundaries or both, thereby increasing the purity and homogeneity of the map units. Upgrading involves statistical sampling within the existing map units, quantifying the variation within the units but not changing the classification of the map units or their boundaries (Brus et al., 1992). For the purposes of this project the term resurvey will be used to describe soil surveys at the scale and level of detail of the most recent soil survey activities in Ontario, namely the Elgin and Kent County soil inventories. As well, the term upgrade will be considered synonymous with Brus et al's., (1992) term revision.

Recent activities in Ontario have seen the development and testing of various schemes to upgrade existing soil and slope information. The use of GIS and Digital Elevation Models (DEM's) were used to derive slope information for soil map units in Oxford County (Lombard and Fitsgibbon, 1990). This work was carried further by Ecological Services for Planning (ESP) who developed a sampling methodology for upgrading and verification of slope information (ESP, 1995).

For upgrading soil information to a standard minimum level of detail, a methodology was developed and implemented in eastern Ontario by Gregory Geoscience Limited (Gregory Geoscience, 1993). Briefly, their approach was to conduct an intensive, aerial photo stereoscopic interpretation. Based on the aerial photo interpretation and on field soil inspections a new soil map of Ramsay Township was produced which included slope information. A map of agricultural capability (CLI) ratings was also produced for Ramsay township. This methodology is very similar to the Experimental Reconnaissance Soil Survey Upgrade Method (ERSSUM) developed by MacMillan et al., (1992). The rate of mapping was estimated to be twice as fast as conventional 1:50,000 mapping and resulted in achieving 70% of the reliability and 80% of the accuracy (MacMillan et al., 1992). In both upgrade approaches the success depends on the ability and experience of the photointerpreter to: 1) subdivide the landscape into soil-landscape models; and 2)
incorporate other information sources to replace field checking and sampling.

The objectives of this study were: 1) to assess the method developed by Gregory Geoscience to upgrade soil survey information for Ramsay township; and 2) to compare soil inventory interpretations between conventional soil survey and the soil survey upgrade methodology assessed in this study.

2.0 METHODS
2.1 Study Areas

Two 5,000 hectare study areas were selected from different parts of the province representing different soil, climate and landuse characteristics. The study areas are located in Kent county in south western Ontario and Lanark County in eastern Ontario and are shown in Figure 1. The soils of each study area were both resurveyed and upgraded. The resurvey for each county followed the conventional soil mapping methodology utilized in Ontario. The soil survey upgrade followed the methodology developed by Gregory Geoscience (Gregory Geoscience, 1993).

2.1.1 Kent Country

The study area in Kent County straddles the boundary between Howard and Harwich Townships and traverses the Blenheim moraine. The dimensions of the study area are approximately 5 kilometers by 10 kilometers. The original soil map was published in 1936 at a scale of 1:126,720. For the soil survey upgrade, stereo air photos were interpreted and 20 soil inspections were made. This intensity of sampling represents one inspection for every 250 hectares. The intensity of site inspections for a SIL 3 conventional soil survey range from 20 to 200 ha per site inspection (MSWG, 1981) and average one inspection for every 40 hectares in Ontario.
Figure 1. Study area locations.
The soils of Kent County were recently resurveyed by pedologists from the Ontario Centre for Soil Resource Evaluation (OCSRE). The soil mapping began in 1987 and the final maps and report will be published in 1996. The soil map legend developed for the recent soil survey was used for the upgrade mapping.

### 2.1.2 Lanark County

The study area is situated in Ramsay Township and abuts the western boundary of the Regional Municipality of Ottawa-Carleton. The dimensions of the area are approximately 5 kilometers by 9.5 kilometers. To avoid any biased, each mapping approach was conducted by different people. The soils of Ramsay township were upgraded using the Gregory Geoscience soil survey upgrade methodology (Gregory Geoscience, 1993). The study area was resurveyed in a conventional soil survey approach to enable a comparison of the upgrade methodology with traditional soil survey information.

The original soil survey maps and report for Lanark County were published in 1967 and although lacking analytical information, the slope information was considered fair and the soil boundaries were considered adequate according to the information presented in Table 1. However, pressure from local landowners and planners provided the incentive to conduct a soil survey upgrade which would satisfy the information requirements of regional planning and environmental assessment. This included changing the soil polygons resulting in a new soil map.

The resurvey was conducted in a manner similar to recent SIL 3 soil surveys in southern Ontario published at a scale of 1:50,000. Seventy-five site inspections were made in the study area of which 25 were sampled for detailed soil analyses. This represents one site inspection per 63 ha. Although the resurvey mapping was done for presentation at 1:50,000, the resurvey and upgrade soil maps were presented at the scale of 1:25,000, the scale of the air photos. The soil legend from the original soil survey maps and report was used for the resurvey.

For the upgrade of Ramsay township, 112 site inspections were made to cover an area of 26,090 ha. with no samples collected for analysis. This represents a site inspection intensity of one field inspection per 260 ha. The legend used in the soil survey upgrade was based on physiographic units and not on the original soil legend as was the resurvey. For the purposes of this study, however, soil map units will be identified using soil series names consistent with the original soil legend. This will provide consistency for the users and will facilitate correlation with the Regional Municipality of Ottawa-Carleton soil survey.
2.2 Map Comparison and Evaluation

Soil maps are evaluated on the basis of accuracy and precision (Mapping Systems Working Group (MSWG), 1981). Accuracy can be defined as the closeness with which the soils information presented on the map reflects the actual ground truth information (MacMillan et al., 1992), whereas precision is the range of the soil map unit. Bregt et al., (1992) have used reliability, relevance and presentation to compare the quality of different maps. Reliability refers to the purity, which in essence is the same as map accuracy. This could be useful for evaluating the reliability of capability and suitability interpretations. Relevance of the information as described by Bregt et al., (1992) is related to the maps utility for identifying potentially suitable areas correctly and for correctly eliminating unsuitable areas. Presentation or readability of the maps has also been identified as an important characteristic. Bregt et al, (1992) used the boundary index to evaluate quantitatively the readability of different map products. The Mapping Systems Working Group (MSWG) (1981), defined map delineation density (MDD), or map texture intensity, such that, ",... the average size delineation (total land area of the map divided by the total number of delineations) should be about 20 times bigger than the minimum size delineation. This gives a map delineation density of 5 \%.''

\[
MDD = \frac{\text{Minimum Size Delineation} \times 100}{\text{Average Size Delineation}}
\]

As the MDD increases the complexity of the map decreases.

The presentation of a map product is also influenced by the shape of the polygons. Buol et al., (1989) proposed a shape index for map units such that, ",... the soil boundary length is divided by the periphery of a circle of the same area as the soil body in question". Categories of this index are defined as: very simple = 1 to 1.3; simple = 1.3 to 1.7; moderately simple = 1.7 to 2.3; moderately complex = 2.3 to 3.7; complex = 3.7 to 5.5; very complex = > 5.5.

The first stage of comparing maps from each mapping approach is concerned with the degree of correspondence or similarity between the maps. This includes comparing the number of polygons, average delineation size, map delineation density and shape index. An indication of how closely the lines on the two maps correspond can be determined by overlaying the two maps and calculating the percentage of lines that coincide within a specified buffer distance. This approach only considers the position of the lines and does not address what the lines represent, thus no information on the attributes of the polygons or any correlation between maps or polygons is given in this stage of analysis.
The second stage evaluates the content of the map units, comparing the correlation of the polygon attributes between the two mapping methodologies. This second stage compares soil types, slope and drainage classes as well as other soil attribute information and is useful in identifying areas where the two mapping methodologies concur or differ. Even in areas where the mapping methods describe different soils, the interpretations may or may not be different. For example, in Kent County a washed phase of a Gobbles silty clay soil, developed on glacial till material with c class slopes, has a CLI rating of 2T. A Normandale very fine sandy loam soil, developed from glacio-lacustrine material with c class slopes also has a CLI rating of 2T.

The third stage of map comparison and evaluation is concerned with soil capability classification (CLI) for field crops. The soil lines on the map have already been compared and will not change for the capability interpretation except for removing lines between polygons which have the same CLI rating. No new lines will be added at this stage. The area and extent of the capability ratings will be compared.

3.0 RESULTS AND DISCUSSION

3.1 General Analyses
3.1.1 Number, Size and Shape of Soil Delineations

The number of polygons, average map unit size, range in size of polygons and shape of map units were compared for the upgrade and resurvey map for both study areas. These results are presented in Table 2. Intuitively one would expect the upgrade approach to result in fewer soil delineations and larger average soil polygon areas than the more intensive resurvey activity. In Kent County the maps were compared at a scale of 1:50,000. The Kent upgrade had 31% fewer polygons than the resurvey and the mean polygon size of the upgrade map was 32% larger. The comparisons in Lanark County were conducted at a scale of 1:25,000. In this analysis the Ramsay upgrade had 6.5% fewer soil delineations and the upgrade delineations were 8.6% larger in area on average.
Table 2. Comparison of map characteristics between soil survey upgrade and resurvey.

<table>
<thead>
<tr>
<th></th>
<th>Kent (1:50K)</th>
<th>Lanark (1:25K)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Upgrade</td>
<td>Resurvey</td>
</tr>
<tr>
<td>Number of Polygons</td>
<td>44</td>
<td>64</td>
</tr>
<tr>
<td>Average size (ha.)</td>
<td>107</td>
<td>73</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>159</td>
<td>29</td>
</tr>
<tr>
<td>Minimum Size (ha.)</td>
<td>0.6</td>
<td>0.02</td>
</tr>
<tr>
<td>Maximum size (ha.)</td>
<td>941</td>
<td>740</td>
</tr>
<tr>
<td>Map Delineation</td>
<td>0.6</td>
<td>0.03</td>
</tr>
<tr>
<td>Density (%)</td>
<td>1.5</td>
<td>1.4</td>
</tr>
<tr>
<td>Polygon Shape</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In both the Kent County resurvey and the Ramsay Township upgrade, the study areas were clipped from a larger map coverage. This accounts for the small minimum polygon size observed for these maps. Where the edge of the study area cuts off a polygon only a fragment of the original polygon is left within the coverage of the study area. The Kent County upgrade and the Ramsay Township resurvey, however, were both conducted within the respective study area boundaries thus eliminating the possibility of fragmented polygons and reducing the number of very small polygons.

3.1.2 Proximity Analysis

An overlay of the soil survey upgrade map on the soil resurvey map was done for each study area. The upgrade soil boundaries were buffered at 25, 50 and 75 meters to find the distance variation between the two mapping systems. A sample of the line buffering for Kent County is presented in Figure 2. The map unit delineations were 75% correlated at the 75 meter distance in Kent County (i.e. 75% of the upgrade lines were within 75 meters of a resurvey line). At a mapping scale of 1:50,000, 75 meters represents 1.5 millimeters on the map. The map unit delineations in Ramsay township were 85% correlated at the 75 meter buffer distance. This distance represents 3 millimeters on the map at a scale of 1:25,000. Both study area proximity analyses compared the map unit boundaries but did not compare the classifications or attributes of the polygons.

3.2 Ramsay Township

The map unit classification for Ramsay township was complicated by the fact that different classification systems were used for each mapping exercise. The upgrade approach used an open legend based on physiographic units. The map unit symbol was comprised of a landform designation and a soil texture classification in the upper part of the fractionated symbol, and an approximation of the drainage condition and slope in the lower part of the fractionated symbol (Gregory Geoscience, 1993). The resurvey used the legend from the original soil map. The map unit symbol was comprised of a single soil series name to
describe the origin and type (texture) of parent material as well as to indicate the drainage conditions. Slope information was included in the denominator of the fractionated symbol.

The method of comparison used in Ramsay township involved converting the soil series units of the resurvey map to the physiographic units of the upgrade map and then performing correlation analysis between the attributes of each map. Table 3 shows the correspondence between the soil series units and the physiographic units. The results of the comparisons are discussed in the following sections.
Figure 2
OVERLAY OF RESURVEY SOIL LINES ON BUFFERED UPGRADE SOIL LINES

--- Upgrade soil boundaries
--- Buffer of 25, 50 and 75 meters
--- Resurvey soil boundaries

Scale 1:50,000
Table 3. Correlation between soil series and physiographic units.

<table>
<thead>
<tr>
<th>Soil Series, Symbol</th>
<th>Soil Series Name</th>
<th>Physiographic Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asl</td>
<td>Allendale</td>
<td>Outwash Plain</td>
</tr>
<tr>
<td>Als</td>
<td>Almonte</td>
<td>Lacustrine Plain</td>
</tr>
<tr>
<td>F1</td>
<td>Farmington</td>
<td>Bedrock Plain</td>
</tr>
<tr>
<td>Grl</td>
<td>Grenville</td>
<td>Till Plain</td>
</tr>
<tr>
<td>Masl</td>
<td>Manotick</td>
<td>Outwash Plain</td>
</tr>
<tr>
<td>MsI</td>
<td>Monteagle</td>
<td>Till Plain</td>
</tr>
<tr>
<td>Mtl</td>
<td>Matilda</td>
<td>Till Plain</td>
</tr>
<tr>
<td>Ngcl</td>
<td>North Gower clay loam</td>
<td>Lacustrine Plain</td>
</tr>
<tr>
<td>TS1</td>
<td>Tennyson</td>
<td>Till Plain</td>
</tr>
<tr>
<td>Tws</td>
<td>Tweed</td>
<td>Till Plain</td>
</tr>
</tbody>
</table>

3.2.1 Contingency Tables and Cross Correlations

The analysis was conducted on a Tydac-Spans GIS system and involved an area correlation of individual attribute maps. The output consisted of a series of cross-correlation tables describing the degree of similarity between maps. A contingency coefficient determines the strength of the similarity between the two maps and is estimated from the chi-square statistic. The contingency coefficient varies between 0 and 1 with 0 indicating total independence and a value approaching 1, dependence. The coefficient is determined from the following equation;

\[
C = \left( \frac{P^2}{P^2 + n} \right)^{1/2}
\]  

[1]

where \( P^2 \) is the chi-square statistic and \( n \) is the sample size (Freund, 1979).

3.2.2 Attribute Comparisons

Comparisons of slope, texture and drainage did not demonstrate the same strength of correlation as comparisons of morphology. This could be due in part to the conversion of attributes from a soil series basis to a physiographic base before comparisons were made.
3.2.2.1 Morphology

The strongest correlations occurred with the morphological classification (C=0.74). Of the classes mapped as Muck on the upgrade map the resurvey was in agreement for 96% of the area. Similarly, 72% of the area mapped as lacustrine plain on the resurvey map was classified as lacustrine plain on the upgrade map and 55% of the area mapped as till plain on the resurvey were also identified as till plain on the upgrade map. There were several areas of confusion, however, which could represent serious concerns for the upgrade approach. For instance, of the area mapped as bedrock plain on the resurvey, 58% was mapped as till plain, 21% as lacustrine plain, only 11% as bedrock plain and 8% as outwash plain on the upgrade map. For the area mapped as fluvial plain on the resurvey map 48% was mapped as fluvial plain, but 42% was mapped as lacustrine plain on the upgrade map. The area mapped as outwash on the upgrade map corresponds to 34% bedrock plain, 26% till plain, 24% lacustrine plain and 15% muck on the resurvey map.

3.2.2.2 Slope

Slope information was compared on the basis of classes of percent slope. Complexity of the topography or slope length were not taken into consideration. Forty-eight percent of the Ramsay township study area was in agreement concerning slope classification between the two mapping approaches. The slope classes which differed most frequently were classes C (2-5%) and D (5-9%) with the upgrade under-estimating the slope more often than the resurvey. For example, of the area classified as C slopes on the resurvey, 68% were classified as C and 16% as B slopes on the upgrade. The same trend was observed for the area classified as D slopes on the resurvey map where only 17% of the area was classified as D slopes, 47% as C slopes and 21% as B slopes on the upgrade. Overall, approximately 15% of the study areas' slope classifications differed by more than two slope classes.

3.2.2.3 Texture

The contingency coefficient was 0.65 but there was only 11% of the study area which recorded similar textures. There was a far greater area where textures were very close such as very fine sandy loam, fine sandy loam, loam, sandy loam and loamy sand. Approximately 27% of the area's texture was mapped in the resurvey as coarse textured but mapped in the upgrade as fine textured. This poses serious concerns to the precision with which texture can be estimated from aerial photographs and minimal ground truthing. Also, textures from the resurvey were inferred from the soils series whereas there were more texture classes from which to choose for the upgrade map.
3.2.2.4 Drainage

For drainage comparisons almost 50% of the area was classified similarly. Confusion arose because of the class limits employed in both systems. For example, the physiographic classification has intergrades of drainage classes such as Imperfect/poor and good/imperfect where the soil series classification did not. This resulted in a decrease in the area considered as similar with respect to drainage. For example, of the area designated with a G/I drainage classification on the upgrade map, 55 % was mapped as well drained and 37 % as imperfectly drained on the resurvey map. Similarly, of the area designated with drainage intergrade I/P on the upgrade, 51 % was mapped as poor on the resurvey.

Of the area mapped as very poor on the resurvey map, 50 % was mapped as very poorly drained on the upgrade map. Of the area mapped as imperfect on the resurvey, 51 % is mapped as imperfect, 19 % as W/I and 17 % as well drained on the upgrade.

3.2.3 Soil Capability Ratings

The strongest correlations occurred with the capability for agriculture classification (CLI) (C=0.73). When the CLI classifications were grouped and then compared the contingency coefficient fell to 0.70 or below for various groupings. It is interesting to note that comparisons between the original capability ratings and the resurvey and upgrade capability ratings had contingency coefficients of 0.70 and 0.71 respectively.

The CLI ratings were grouped into categories representing CLI classes 1, 2 and 3 in group; CLI classes 4 and 5 in group 2; CLI classes 6 and 7 in group 3 and all the area not classified in group 4. Of the area mapped as group 1 on the upgrade map, 83% is similarly mapped on the resurvey map. Of the area mapped as group 1 on the upgrade map, 56 % is group 2 and 24 % is group 3 on the upgrade map. On the resurvey, of the area mapped as group 3, 44 % is group 3, 23 % is group 2 and 26 % is group 1 on the upgrade.

3.3 Kent County

The map analysis in Kent county was performed using the Arc/info GIS. The analysis was somewhat more difficult than the analysis for Ramsay Township because the map unit symbols may contain two soil series names and two slope class designations. The split between the two components of the compound map symbols is 60/40. Sixty percent to the dominant soil type and 40% to the subdominant soil type. Therefore, the area calculations were weighted for their spatial proportions. Based on this, a spatial analysis was carried out to determine
the degree of correspondence between the two mapping approaches.

3.3.1 Morphology

The material and mode of deposition were very well correlated between the two mapping approaches. Overall, the upgrade correctly identified the morphology over 82% of the area. The material type with the largest areal distribution is the Port Stanley Till which was mapped as the Murial - Gobbles - Kelvin soil association. The upgrade correctly mapped this association over 84% of the area for both the dominant and subdominant map unit components. The coarser textured sand and gravel deposits represented by the Kintyre - Highgate - Muirkirk soil association were correctly identified and delineated for 77% of the area. The other materials found and mapped in the study area did not match the resurvey soil map as accurately.

The area of glaciolacustrine materials mapped on the resurvey map were matched on the upgrade map for 64% of the area for the Bennington - Tavistock Maplewood soil association and for 45% of the area for the Brantford - Beverly Toledo soil association.

The subdominant map unit components were not as numerous as the dominant components and the degree of correlation between the maps was not as close. There was some overlap between the not mapped and organic delineations between the upgrade and resurvey maps. Of the area mapped as Organic on the resurvey map, 73% of the area on the upgrade map was similarly delineated and of the areas delineated as Not Mapped on the resurvey, 83% were similarly mapped on the upgrade.

3.3.2 Drainage

Overall, the drainage classes were 61% correct comparing the upgrade map to the resurvey map. For the dominant soil component, the area of well drained soils on the upgrade map matched the resurvey map for 64% of the area. The area of imperfectly drained soils on the upgrade map was correctly identified for 74% of the area. The poorly drained soils on the upgrade map matched the resurvey for 72% of the area.

The subdominant drainage component was correctly identified for 51% of the area mapped on the resurvey map compared to the upgrade. Of area classified as well drained on the resurvey map, 27% was mapped as well drained on the upgrade, Of the area mapped as imperfectly drained on the resurvey map, 40% was mapped as imperfectly drained on the upgrade and for the area on the resurvey mapped as poorly drained 87% was classified as poorly drained on the upgrade map.
3.3.3 Slope

The slope classes identified on the upgrade map were in accordance with the resurvey map for 82% of the entire study area. For the purposes of this analysis there was no distinction made between complex or simple slopes within any one slope category nor was slope length taken into account. The dominant slope component of the resurvey map units were correlated with the upgrade map in the following fashion. For b slopes (0.5 to 2% slope) 80% of the area mapped on the resurvey map was correctly matched by the upgrade map. The area of c slopes (2 to 5% slopes) mapped on the resurvey map were matched for 70% of the area. Only 27% of the area mapped on the resurvey as d slopes (5 to 9% slopes) was matched on the upgrade map.

The comparison of the subdominant slope component of the two maps yielded the following results. Of the area mapped on the resurvey as b slopes, the upgrade was correct for 84% of the area. For the area mapped as c slopes on the resurvey map 78% of the area was correctly mapped on the upgrade.

3.3.4 Soil Capability Ratings

The overall level of agreement between the upgrade and the resurvey was 68% of the area. For the dominant map component this breaks down to include 72% of the area mapped as class 1 on the resurvey was class 1 on the upgrade; 77% of the area mapped as class 2 on the resurvey was class 2 on the upgrade; and 67% of the area mapped as class 3 on the resurvey was class 3 on the upgrade. The upgrade assigned a poorer capability rating for 37% of the area. This was most dramatic for the area rated class 3 on the resurvey where the upgrade classified 55% of the area as class 2. As well, for the area classified as class 2 on the resurvey, 42% was classified as class 3 on the upgrade.

For the subdominant component of the map units, 53% of the area mapped as class 1 on the resurvey was classified as class 1 on the upgrade. Of the area rated as class 2 on the resurvey 65% was class 2 on the upgrade and of the area mapped as class 3 on the resurvey 75% was classified as class 3 on the upgrade.

4.0 CONCLUSIONS

The objectives of this study were to assess the soil survey upgrade approach proposed and applied by Gregory Geoscience. The need for a methodology for improving the soil database for Ontario is undeniable due to the inconsistencies in the quality and quantity of existing information. The extent or level of detail to which this database is to be taken will define the effort involved in assimilating new or additional information. To meet the immediate information needs, the attempt is to upgrade the
land resource data of the areas of the province where the provincial soils database is lacking information. This will not be entirely consistent, in terms of detail, with the most recent soil resource inventories but will allow consistent and reliable agronomic interpretations and environmental assessments to be made for the contiguous agricultural portion of the province at the regional planning scale.

The extent to which the soil survey upgrade methodology developed by Gregory Geoscience meets these requirements can be evaluated on several fronts,

1) The approach is very attractive considering the minimum time involved in field checking and the extensive use of other sources of information. Information such as surficial and bedrock geology maps, physiography maps, existing soil survey information, soil information from adjacent areas and stereo aerial photographs. As was seen from the analysis and discussion, the upgrade maps were within 60 % or greater agreement with the resurvey maps for many of the attributes.

2) One concern is the propagation of errors encountered when comparing one map to another map which has its own level of probability of error. For example, if the upgrade is 75% correlated with the resurvey but the resurvey has a 75 % level of confidence, the upgrade is then only 50% reliable. This uncertainty could be reduced with more field checking and with collecting samples of the major soils of the area for laboratory analysis and incorporating these activities in the mapping exercise and not as an add on activity after the field work is completed.

3) A major limitation to this approach is that the success is dependent on the skills and abilities of the photo interpreter. The requirements are that the person be a very experienced soil surveyor and have experience mapping in the area to be upgraded. If these requirements are observed then this approach has many applications, however, in other circumstances erroneous and misleading interpretations and results would be the outcome.

4) The approach outlined by Gregory Geoscience involves adopting a legend format which is very different to the way soils have been mapped in Ontario. Without debating the advantages or disadvantages of either system, for the time being soil series should be the approach. The reasons for this are that users of soil resource information are accustomed to dealing with soil series and that the rest of the province and the provincial soil database is set up using soil series. There is no interest or support to revise the entire soils database to an open, physiographic type reporting format at this time. Therefore, any future application of this mapping methodology should be consistent with the information on file.
Gregory Geoscience comments on the report conclusions.

With regard to the second conclusion, it is true that a degree of uncertainty is found in the results because two interpreted maps were compared. However, it is not right to put the upgrade map at 50% reliability because of the uncertainty in the resurvey map. It is possible that the upgrade map was correct where the resurvey map was wrong, and therefore it could be just as reliable as the resurvey map. The only way to resolve the uncertainty is to carry out comprehensive ground mapping to provide a ground true baseline to which both maps could be compared.

With regard to the third conclusion, it is true that quality of the survey upgrade is dependent on the ability of the airphoto interpreter. However, it must be remembered that airphoto interpretation is a key to the resurvey approach and that the landform features mapped in the upgrade method are often easier to identify than soil series boundaries.

With regard to the fourth conclusion, it must be stated that part of the research project was to develop and test a map legend that was consistent and continuous across the agricultural region of the province. Thus avoiding the problem of the same soil type having several different series names in different parts of the province. A second reason for looking at a different soil map legend was to make the soil resource information of use to a wider group than the present users. Physiographic features are more easily understood by people in engineering, environmental sciences, forestry, etc., than soil series. The proposed legend would still have reference to the soil series legend for agricultural applications.
Literature Cited


