RESEARCH SUB-PROGRAM

AN ASSESSMENT OF THE APPROACHES AND DATA CONCERNING FIVE GREEN PLAN PROJECT TECHNICAL REPORTS ON THE STATE OF AGRICULTURAL RESOURCES

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Prepared by: Mr. Michael Hoffman, AGPLAN LIMITED,
Guelph, Ontario N1H 4E9

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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FORWARD

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, C

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 grc

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
E-Mail: bowmanb@em.agr.ca

Green Plan Web URL: http://res.agr.ca/lond/gp/gphompag.html

The following report, approved by the Research Management Team, is reproduced in its entirety as received from the contractor, designated on the previous page.

AN ASSESSMENT OF THE APPROACHES AND DATA CONCERNING FIVE GREEN PLAN PROJECT "G"

TECHNICAL REPORTS ON THE STATE OF AGRICULTURAL RESOURCES

PREPARED FOR AGRICULTURE AND AGRI-FOOD CANADA

DR. K. BRUCE MACDONALD

PREPARED BY AGPLAN LIMITED

JUNE, 1997

EXECUTIVE SUMMARY

AgPlan Limited produced an unsolicited proposal and was subsequently given a contract to compare and contrast five different Green Plan Reports. The five contractors producing these reports were all responding to the same terms of reference provided by a single Request For Proposal. Therefore, it seemed appropriate to compare the five reports by:

- Identifying their common elements,
- Highlighting their unique characteristics and
- Suggesting how the collective information could be used to provide benefit and guidance for future work in the subject areas addressed by the five reports.

Given that the different Reports had a cross section of components, levels of detail (complexity) and area of focus, a framework of questions was derived and used to synthesize information. The questions in the framework were as follows:

- What variables or factors were used in the different projects?
- What similarities/dissimilarities arise in the physical resource data when the projects are compared?
- Are there reasons for these differences (if any) other than contractual arrangements, i.e., the terms of reference and proposals prepared for the work?
- What are the characteristics of the variables/factors used in the resource base? For example:
    - Are they single component or multiple component?
    - Are they calculations?
    - How feasible are the variables from the perspective of "cost" of collection, ie., public understanding, practicality as measurements or indicators, current availability (temporal and geographic), scale of measurement and/or application (field, farm, ecosystem)?
    - Are these factors direct or indirect (surrogates) - Do they seem appropriate?
    - What limitations, qualifiers are suggested for the variables/factors?
    - What kinds and degree of risk do these variables/factors distinguish?

The results of the review and evaluation have been summarized in matrices and answer two questions:

- What are essential data, variables or factors?
- What are desirable data, variables or factors?

The evaluation also considers scale (appropriate levels), availability and adequacy of data as well as limitations to application. Reference to the literature and/or practice (past and present) in agrology was made in support of the evaluation.

All of the consultant reports provide the information that their original proposals state. However, taken singly, the reports do not meet all of the objectives of the COA. Even as a group, the reports provide fragmented views of the system of agriculture and are not related to an ecosystem or ecosystems. This is not surprising given the state of scientific knowledge about ecosystems which tends to be broadly-based conceptually but limited to smaller, more specific pieces practically.

One can conclude that the reports provide a reasonable product given that they provide the information that they contracted to provide.

However, current questions remain outstanding:

(1) What links are possible with other databases (eg. update Richards *et al*, 1976)?
(2) What methods of database combination are available, what are their pros and cons, which ones would we prefer to use, and why?
(3) Where is data unavailable or sparse - geographically, in what subject areas?
(4) Given information from questions 1-3, which databases are best updated to provide geographic differentiation of agricultural sustainability?
(5) Given questions 1-4, which areas in Southern Ontario are more suitable and/or are at risk?

In summary, it is apparent upon review of all of the reports that the preparation of a data base for agriculture requires an additional framework which provides classification, integration and correlation. Without that framework, measurement of environmental/ecological change will be exceedingly difficult. Stated in other words, there are some issues that may benefit from additional discussion/study. These issues include:

- the variables needed to evaluate agriculture, how they are presented in classes or groups (classified) and whether they are necessary/mandatory or desirable;
- the scale at which information needs to be presented - planners tend to use information at regional scales, whereas farmers have a need for more detail in low input/variable input agriculture;
- the definition of variables.
- matters such as slope class, landscape, land use, and various interpretations from capability through to existing versus potential erosion would benefit from a single accurate, precise definition. It is not likely that consensus is possible for this set of accurate precise definitions; it will likely need to be imposed;
- the definition of areas at risk (risk of loss / risk of degradation in environment and for productivity; risk related to mortality, health of farmers and the public; risk to economic returns; risk to resource quantity/quality in what location; risk related to level of resilience - environment, economic;
- problems of duality/contradiction - a positive solution to one ecological component may negatively affect another input; and
- links to non-agricultural influences - sewers and other infrastructure that may affect agriculture directly or indirectly.

Sommaire

La société AgPlan Limited a présenté une proposition spontanée, qui a débouché sur l'adjudication d'un contrat, pour l'examen comparatif de cinq rapports de recherches menées dans le cadre du Plan vert. Comme les cinq entrepreneurs qui ont produit ces rapports devaient se conformer aux conditions exposées dans une demande de propositions, il paraissait approprié de comparer ces rapports, de la façon suivante :

- Relever les éléments communs à tous les rapports.
- Souligner les éléments uniques à chaque rapport.
- Proposer des façons d'utiliser l'information commune pour orienter les travaux futurs dans les domaines traités par ces rapports.

Étant donné le profil des rapports aux plans du contenu, du niveau de détail (complexité) et du sujet, on a formulé et utilisé un ensemble de questions afin de synthétiser l'information. Voici quelles étaient ces questions :

- Quelles variables ou quels facteurs ont été pris en compte dans les différents projets?
- D'après la comparaison des projets, quelles sont les similitudes et les dissimilarités entre les données sur les ressources physiques?
- S'il y a d'autres différences entre les rapports, outre celles ayant trait aux conditions contractuelles (c.-à-d. le mandat et les propositions élaborées pour l'exécution des travaux), comment s'expliquent-elles?
- Quelles sont les caractéristiques des variables et des facteurs pris en compte dans la base de ressources? Par exemple :
  - Ces variables et ces facteurs comportent-ils un seul ou plusieurs éléments?

- S'agit-il de calculs?
- À quel point les variables sont-elles réalistes du point de vue du « coût » de la collecte de données, c.-à-d. sont-elles compréhensibles au public, peuvent-elles servir de mesures ou d'indicateurs, sont-elles disponibles (variables temporelles et géographiques), quelles sont les échelles de mesure et/ou d'application (champ, ferme, écosystème)?
- S'agit-il de facteurs directs ou indirects (de substitution) et semblent-ils appropriés?
- Quelles limites et quels critères sont proposés pour les variables et les facteurs?
- Quels types et niveaux de risques ces variables et ces facteurs font-ils ressortir?

Les résultats de l'examen et de l'évaluation, résumés sous forme de tableaux, répondent à deux questions :

- Quels sont les facteurs, les données et les variables qu'il est essentiel de prendre en compte ou d'obtenir?
- Quels sont les facteurs, les données et les variables qu'il est souhaitable de prendre en compte ou d'obtenir?

De plus, l'évaluation portait sur l'échelle (niveaux appropriés), la disponibilité et le caractère adéquat des données ainsi que sur les limites à l'application des résultats, et les auteurs s'appuyaient sur la documentation existante et/ou les pratiques passées et courantes en agrologie.

Tous les rapports produits fournissent l'information telle que les propositions initiales l'indiquaient. Toutefois, considérés individuellement, les rapports n'atteignent pas tous les objectifs du Plan vert Canada-Ontario en agriculture. Même collectivement, ils présentent des portraits fragmentés du système agricole, et l'information qu'ils présentent n'est pas liée à un ou des écosystèmes. Cela n'est pas étonnant, étant donné l'état des connaissances scientifiques sur les écosystèmes, qui ont tendance à être générales sur le plan théorique, mais limitées à des composantes plus petites et plus circonscrites dans la pratique.

On peut conclure que la qualité des rapports évalués est raisonnable, ne serait-ce que parce qu'ils fournissent l'information commandée.

Toutefois, des questions demeurent :

1. Quels sont les liens possibles avec d'autres bases de données (p. ex. mise à jour de Richards *et al.*, 1976)?
2. Quelles méthodes de combinaison de bases de données sont disponibles, quels sont leurs avantages et leurs inconvénients, lesquelles devrait-on employer de préférence et pourquoi?
3. Dans quelle région et dans quels domaines les données sont-elles inexistantes ou rares?
4. D'après les réponses aux trois premières questions, quelles bases de données se prêtent le mieux à une mise à jour visant à présenter l'état de l'agriculture durable dans les différentes régions?
5. D'après les réponses aux quatre premières questions, quelles régions du sud de l'Ontario conviennent le mieux et/ou présentent des risques?

En somme, l'examen des cinq rapports montre que la constitution d'une base de données sur l'agriculture exige la mise en place d'un cadre supplémentaire assurant la classification, l'intégration et la corrélation des données. Autrement, il sera extrêmement difficile de mesurer les changements aux plans environnemental et écologique. En d'autres termes, il serait indiqué de pousser la réflexion et l'étude en ce qui touche certains problèmes, dont les suivants :

- les variables nécessaires à l'évaluation de l'agriculture, la façon dont celles-ci sont classées et la question de savoir si leur prise en compte est nécessaire/essentielle ou seulement souhaitable;
- l'échelle à laquelle l'information doit être présentée (les planificateurs ont tendance à utiliser l'information à l'échelle régionale tandis que les agriculteurs ont besoin d'un plus grand niveau de détail pour l'agriculture à faibles intrants ou à intrants variables;

- la définition des variables);
- il faudrait donner une définition unique et exacte d'aspects comme la classe de pente, le paysage, l'utilisation du territoire et différentes interprétations, depuis la capacité jusqu'à l'érosion réelle par rapport à l'érosion potentielle. Selon toute vraisemblance, il faudra imposer des définitions;
- la définition des zones exposées à un risque (risque de perte ou de dégradation de milieux naturels et de perte de productivité, risque lié à la mortalité et à la santé des agriculteurs et de la population ainsi qu'aux retombées économiques, risque quant à la quantité et à la qualité des ressources en des endroits déterminés, risque lié au niveau de résilience (écologique et économique));
- problèmes de dualité et de contradiction (une solution positive à un problème touchant un certain aspect écologique pourrait nuire à un autre aspect);
- liens avec des facteurs non agricoles (égouts et d'autres infrastructures pouvant avoir des effets directs ou indirects sur l'agriculture).

TABLE OF CONTENTS

1.0 INTRODUCTION 1
- 1.1 OBJECTIVES ASSOCIATED WITH THE GREEN PLAN 3
- 1.2 STUDY OBJECTIVES 4

2.0 FINDINGS 7

3.0 SUMMARY, CONCLUSIONS, RECOMMENDATIONS 19

4.0 REFERENCES 26

LIST OF TABLES

Table 1 Objectives Match Summary 9
Table 2 Agricultural Variables' Summary 21

LIST OF FIGURES

Figure 1 Green Plan Activity Process 24

LIST OF APPENDICES

Appendix 1 Documentation of Findings Relative to Report Review 31
Appendix 2 Green Plan Report Variables 58
Appendix 3 Green Plan Variable Characteristics 64
Appendix 4 Agricultural Variables in Other Reports or Policies 75

1.0 INTRODUCTION

AgPlan Limited produced an unsolicited proposal and was subsequently given a contract to compare and contrast five different Green Plan Reports. The five contractors producing these reports were all responding to the same terms of reference provided by a single Request For Proposal. Therefore, it seemed appropriate to compare the five reports by:

- Identifying their common elements,
- Highlighting their unique characteristics and
- Suggesting how the collective information could be used to provide benefit and guidance for future work in the subject areas addressed by the five reports.

Because the Green Plan Reports were produced as separate entities without specific direction with respect to correlation or comparison, a framework has been derived to assist in the comparison. Generally, this report makes certain assumptions about the gathering, analysis and use of information which have affected its methods and conclusions. Where possible, a scientific rational approach has been used.

Therefore, this report and the Green Plan follow a conventional model which includes a feedback loop. A relatively recent example of this model is described by Jarvis *et al* (1996) as the Driving Force, State, Response Model (DSR). Jarvis *et al* (1996) state that the model is crucial to the study of cause and effect and pose three questions:

- *First, what are the driving forces causing environmental change?*
- *Second, what is the state of the ecosystem?*
- *Third, what response is being taken to the changes in state?*

Each of these questions can be related to agriculture as an example of a specific environment or system. As well, the DSR model can be related to other theory. This theory has been defined and discussed by many authors and it is not the intention of this report to discuss this literature extensively.

A theory concerning the reasonable use of information will be used; however, to outline the assumptions, biases or position taken within AgPlan's report. The view is taken that decision-making should use current information in its formulation and that the information should be in a form that it can be used to monitor the effects of the decision. This perspective has been summarized by Hodge (1986) as follows:

> *Although the . . . process may not follow precisely the steps of the rational-comprehensive model, it proceeds with an underlying sense of rationality. This is largely attributable to the studies and analyses that have become a standard underpinning of the various steps in the process.*

Therefore, assumptions have been made as follows:

- That decision making should use current information in its formulation and that the information should be in a form that can be used to monitor effects of the decision; and
- That the information should assist all the participants in agriculture, particularly farmers and the farm community.

The review of five consultants' reports by AgPlan has been completed following the theory/context previously described and will be related to the Green Plan objectives which follow.

1.1 OBJECTIVES ASSOCIATED WITH THE GREEN PLAN

Originally, a request for proposals was issued as part of the Research Program Canada-Ontario Green Plan. The objectives of the Monitoring Research Program were outlined as follows:

(1) *Studies to characterize the current* ***state of the agricultural resources*** *(and non-agricultural areas within the zone of influence such as surface water bodies and urban areas) and identify areas where these resources are at risk.*

(2) Studies to determine the effect on agricultural resource quality of established agricultural systems in various locations with emphasis on the movement of chemicals and bacteria off/out of the rooting zone.

(3) Development of standard methodologies to characterize agricultural resource "fitness" which can be used to extend these studies to other areas and systems; emphasis to be placed on Resident Biomass and Organic Carbon.

(4) *Develop and test practical measurements (indicators) for application at the field and farm level to indicate the current agro-ecological status, predict the effects of continued or proposed land use and management, provide the basis for informing the public where the impacts are desirable and provide the basis for management and (self) regulation where the predicted impact is undesirable*.

After discussions with Agriculture and Agri-Food Canada, two of these objectives, which are printed in italics, are the subject of this report and were used to provide guidelines for the original research reports listed on page 4. The first objective was assumed to be predominant.

The report by AgPlan contains the results of the review, evaluation and integration of the approaches described in the original five research reports prepared by the consulting Companies.

1.2 STUDY OBJECTIVES

The AgPlan study team has provided information to meet the following objectives:

- To review the reports submitted and accepted;
- To evaluate those proposals in the context of and evolving research directions in the Green Plan and the Canada-Ontario Agreement (COA) respecting the Great Lakes Basin;
- To review literature to assist in the evaluation and the provision of context; and
- To establish a recommended approach based on the review, evaluation and literature.

Therefore, the review completed by AgPlan included the context as set out by the objectives of the COA as follows:

(A) To restore degraded ecosystems (RAPs);
(B) To prevent and control pollutant impacts;
(C) To conserve human/ecosystem health; and
(D) To integrate ecosystem management.

Each report listed in the following and currently funded under the Green Plan has used different scales and takes a different view of the soil resource base as well as some other agriculturally-related physical, economic and socio-cultural information bases.

Company	Proposal Name	Geographic Location
Ecological Services Group (ESPSLC)	Development and Application of Standardized Methodology for Sampling Soil Landscape Polygons	Haldimand-Norfolk, Brant, Middlesex, Essex Counties
Ecological Services Group (ESPOXF)	Upgrade of Soil Survey Information for Oxford	Oxford County

Company	Proposal Name	Geographic Location
Ecologistics Limited (ECOL)	Assess the State of Agricultural Resources: Improving the Land Resource Data Base	Whitchurch-Stouffville; Wilmot, Waterloo Region
Environmental Soil Services (ESS)	Monitoring Soil and Redistribution using ^{137}Cs	Southern Ontario, Kintore (Pilot) Watershed
Gregory Geoscience Ltd. (GGEO)	Development and Testing of a "State of Agricultural Resources" Reporting and Monitoring Methodology for Ontario	Ramsay Township in Lanark County, Kent County, Southern Ontario

Given that the different Reports had a cross section of components, levels of detail (complexity) and area of focus, a framework of questions was derived and used to synthesize information. The questions are as follows:

- What variables or factors are used in the different projects?
- What similarities/dissimilarities arise in the physical resource data when the projects are compared?
- Are there reasons for these differences (if any) other than contractual arrangements, i.e., the terms of reference and proposals prepared for the work?
- What are the characteristics of the variables/factors used in the resource base? For example:
  - Are they single component or multiple component?
  - Are they calculations?
  - How feasible are the variables from the perspective of "cost" of collection, ie., public understanding, practicality as measurements or indicators, current availability (temporal and geographic), scale of measurement and/or application (field, farm, ecosystem)?
  - Are these factors direct or indirect (surrogates) - Do they seem appropriate?
  - What limitations, qualifiers are suggested for the variables/factors?
  - What kinds and degree of risk do these variables/factors distinguish?

The results of the review and evaluation have been summarized in matrices and answer two questions:

- What are essential data, variables or factors?
- What are desirable data, variables or factors?

The evaluation also considers scale (appropriate levels), availability and adequacy of data as well as limitations to application.

Reference to the literature and/or practice (past and present) in agrology has been made in support of the evaluation.

2.0 FINDINGS

The terms of reference for the Green Plan, which preceded the reports and proposals by consultants, describe a relatively broad range of agricultural resources which may need to be studied to meet the objectives of the COA (already outlined in Section 1.1). Therefore, one of the first steps undertaken in this review has been to evaluate whether the work performed by the five consultants meets these objectives. In general terms, none of the reports meets Objectives 1 and 4 (see pages 2, 3). All of the reports characterize at least one component of the current state of agricultural resources but do not in themselves identify areas where these resources are "at risk". However, the reports do provide information which defines the relatively better from the poorer agricultural resources within the limits of the factors reviewed by the authors. None of the reports went to the extent of putting their work in context. In other words, they did not state where to go next or take a more holistic or universal view.

With respect to Objective 4, no reports "develop and test practical measurements at the field and farm level" and therefore no reports meet Objective 4. Scales of study for the five reports range from census information at the County/Region or Township level to field study providing information mapped at a scale of 1:50,000. At the most detailed (1:50,000), information presented by the consultants has a minimum mappable area of 10 hectares (25 acres) following Richards *et al* (1979). This scale would likely present some problems due to inclusions for practical application within farm fields. A scale ranging from 1:10,000 to 1:25,000 would have a minimum mappable area of 0.4 - 2.5 ha (1 - 6 ac), and would probably be more practical for application at the farm level.

The reports all use and present information appropriate for broader scale planning studies.

The Canada Ontario Agreement (COA) has other objectives which are outlined previously in the text and are labelled alphabetically. The first objective (A), which is to restore degraded ecosystems, does not relate well and specifically to the five research reports. The four reports that are soils-centred are too focussed to deal with ecosystems. The report by Gregory Geoscience takes a multi variable approach to agriculture as a component of an ecosystem. Therefore, that report partially meets the objective (A) by distinguishing the better from the poorer areas for a particular index or variable.

In contrast, all of the reports indirectly meet the second (B) and third © objectives which are to prevent and control pollutant impacts and to conserve human/ecosystem health. Each of the reports provides some information, either directly or indirectly, to indicate the potential for or current state of pollutant impacts. However, none of the reports deal with the control of those impacts.

In addition, all of the reports, by defining relative potential or existing differences amongst landscapes for factors such as erosion, assist by providing a means to conserve ecosystem health.

The final objective (D), to integrate ecosystem management, is not met by most of the reports in the sense that none of the reports integrate a broad range of variables which characterize an ecosystem. Only one report, by Gregory Geoscience, considers a broad range of agricultural variables but does not integrate them.

The review of objectives in the aforementioned is summarized in Table 1.

TABLE 1

OBJECTIVES MATCH SUMMARY

Company		Proposal Name	Geographic Location	Meets Objective					
				Green Plan		COA			
				1	4	A	B	C	D
I	Ecological Services for Planning Ltd. (ESPSLC)	Development and Application of Standardized Methodology for Sampling Soil Landscape Polygons	Haldimand-Norfolk, Brant, Middlesex, Essex Counties	X*			X	X	
II	Ecological Services for Planning Ltd.(ESPOXF)	Upgrade of Soil Survey Information for Oxford	Oxford County	X*			X	X	
III	Ecologistics Ltd. (ECOL)	Assess the State of Agricultural Resources: Improving the Land Resource Data Base	Whitchurch-Stouffville, Waterloo Region	X*			X	X	
IV	Environmental Soil Services(ESS)	Monitoring Soil and Redistribution using ^{137}Cs	Southern Ontario	X*			X	X	
V	Gregory Geoscience Ltd. (GGEO)	Development and Testing of a "State of Agricultural Resources" Reporting and Monitoring Methodology for Ontario	Ramsay Township in Lanark County, Kent County	X*		X*	X	X	X*

* partially

The following paragraphs outline AgPlan's findings with respect to questions listed in the original AgPlan proposal and follow the sequence used in that proposal.

- *What variables or factors are used in the different projects?*

A broad cross-section of different variables is used in each of the projects. These are listed in Appendix 2. The variables include some indices which may be calculated on a per unit area basis, proportionate to area basis, or change over time. The specific calculations for those indices which combine more than one variable are not always outlined specifically in a mathematical format in the five consultant reports and therefore have not been included in this review. The variables that are emphasized include soil physical and chemical characteristics, land use in different categories, economic measures as well as farm management practices and other farm/farmer characteristics.

- *What similarities/dissimilarities arise in the physical resource data?*

Four of the reports deal with soils and therefore contain some similar information. However, the specific nature of that information is not always a constant. For example, four of the reports (see Appendix 2) use slope data. However, the classes and descriptions used by the consultants are not constant.

All of the information categories or variables tend to use different wording making comparison between or among the reports difficult. There are 95 different variables measured and there is very little correlation among the reports. For example, no single variable is used in all five reports. Soil map unit name and slope class are used in three reports. Approximately 16 percent of the variables appear in two reports and the remaining variables appear only once.

- *Are there reasons for these differences (if any) other than contractual arrangements (ie., the terms of reference and proposals)?*

There are some reasons specified for the differences in the data bases. With reference to slope, the report by Ecological Services Group (ESP) states that "A" slopes could not be distinguished using their topographic information base. As well, this same report did not distinguish between simple and complex slopes. In contrast, the report by Ecologistics did distinguish between simple and complex slopes and outlined areas of "Aa" slope class (0-0.5%). Given that differences in simple and complex slopes affect soil capability ratings and that "A" slopes assist in delineating areas which are poorly drained, the methodology used by ESP is more limiting than that used by Ecologistics.

Slope information provided by Environmental Soil Services used gradient, aspect, down slope curvature, and cross slope curvature to produce a contour map. The contour map was subsequently classified into landscape units, into level or converging or diverging shoulder, back slope or front slope areas. As well, the report has slope classes mentioned in its Appendix 3 but does not correlate other information with these slope classes as has been done in reports by Ecologistics and ESP.

Therefore, slope information is not presented in a consistent way. The lack of consistency is related to the original terms of reference (proposal) of the work and the characteristics of data bases already available to the consultants.

C *What are the characteristics of the variables/factors used in the resource base? For example:*

  N *Are they single component or multiple component?*

  N *Are they calculations?*

- *How feasible are the variables from the perspective of "cost" of collection, ie., public understanding, practicality as measurements or indicators, current availability (temporal and geographic), scale of measurement and/or application (field, farm, ecosystem)?*
- *Are these factors direct or indirect (surrogates) - Do they seem appropriate?*
- *What limitations, qualifiers are suggested for the variables/factors?*
- *What kinds and degree of risk do these variables/factors distinguish?*

The resource base produced for the five consultant reports consists of single and multiple component variables. For example, in the report by Gregory Geoscience, there are indices which are calculations based on multiple components. The measure called "manure production index" consists of number of animals in all census categories (cattle, hogs, sheep, chickens, etc.) multiplied by animal units. Total animal units, as a surrogate for manure production, are subsequently compared to the land base available for manure waste disposal. As another example of a multiple component variable, the cesium isolines produced by Environmental Soil Services are a function of composite soil field samples analysed for ^{137}Cs and extrapolated on the basis of rainfall. Single component variables include land use categories such as woodland as well as economic indicators such as total farm capital. A number of variables interpreted as single component could be classified as multiple component. For example, soil texture has been derived as a single indicator of the relative proportion of different particle sizes found within a given soil mass and must be calculated. However, because it was created as a single indicator and has been in use that way for a relatively long time, it has been included as a single component variable.

Generally, the feasibility (ie., practicable, suitable, possible) of collecting the variables listed in the five consultants' reports is high given that the information base is available from different sources and need only be combined or recalculated throughout Southern Ontario. However, feasibility is low from a cost perspective, if government funding is not available for the work to combine or remap information to a constant set of variables or criteria.

All of the factors are understandable by the public and relate to variables already discussed as part of practices in planning and environmental assessment. However, if the results of the work should negatively affect individuals or interest groups, the desire of that audience to “understand” (accept) the database may diminish.

The majority of the variables used in the five reports are direct measurements. They are appropriate variables when considered in the context of the existing data base available and the scale at which the information is available. However, if considered in the context of farm level decision-making, the variables are less appropriate. For example, a farmer might want to use the updated soils maps from the reports by Ecologistics or Ecological Services to assist in defining which areas within a field needed relatively more or less fertilizer. It is probable that the maps would not assist as much as ones produced at a more detailed scale. As another example, the relative level of erosion extant within a farm or farm field as indicated by the Environmental Soil Services maps would be limited. Therefore, whether variables are appropriate is scale dependent.

The relative measurement of an “appropriate” variable is also a function of public understanding and perception. Therefore, those variables that result from a multi-component calculation are less likely to be appropriate from a general public perspective.

The relative kinds and degree of risk associated with different variables is difficult to qualify or quantify specifically. At a general level, risk has traditionally been divided into two categories - actual and perceived. Both categories are related to risk to human health and/or human life. Very little literature with direct application to agriculture is available. However, if one reviews the occupational health literature for agriculture, there are some relative indicators of risk to farmers. For example, Kinley (1989) states that 50% of all farm work fatalities are related to problems with tractors. Choiniere and Munroe (1995) discuss dust-related health problems for farm workers performing labour in livestock barns in Ontario.

Regardless, the literature does not provide detailed information that would allow for the differentiation of risk by agricultural sector and/or by geographic location within Ontario. It is not surprising therefore, that none of the variables used by the five consultants relate to risk defined by health/mortality.

Some interpretation of soil maps to indicate risk of erosion as well as risk of pollution as a result of transmissivity is included by the five consultants. Potential erosion prediction is well documented but transmissivity is not. Some of the problems associated with transmissivity are discussed further in Appendix 1.

Risk could also be interpreted in a way that relates to the loss of agricultural resources. Farmers are a resource and their loss due to health/mortality has already been discussed. However, loss of farmers due to economic hardship including bankruptcy could also be considered geographically, temporally and/or by agricultural sector. Alternatively, resource loss as well as risk of loss has most often been considered from the perspective of the amount and quality of the land base. While all five consultant reports consider land resource base quality or quantity, none of the reports address the actual risk of that loss.

All of the data is limited by scale, changing definition over time, amount of field verification, level of knowledge or scientific proof available, and variability in data significance or importance as defined by different public values.

The interpreted characteristics of variables/factors are summarized in Appendix 3. This summary indicates that:

- 72% of the variables are single factor and 28% are multiple factor;
- 14% of the variables are calculations and/or require laboratory work;
- Most of the variables are relatively easily obtained but some are limited because of factors such as natural fluctuations in level, difficulty in definition and observation, opposite or contradictory results varying with objectives;
- 18% of the variables are relatively indirect measurements, but most are relatively direct; and
- A number of variables have limitations due to scale, time, and method of measurement (ordinal versus ratio scale, for example).

- *What are essential data, variables, or factors?*
- *What are desirable data, variables, or factors?*

These questions are the most difficult ones to answer. What is essential or desirable can be considered from two different perspectives (or a combination of both of them).

The first perspective relates to science. Are there specific replicated or replicatable data which have been shown to predict the behaviour of ecosystems or ecosystem components? If there are specific variables which are predictors, then these variables would be essential data (rather like the canary used to predict the presence of mine gas).

The second perspective relates to public attitudes and expectations. Are there specific data which the public values highly and trusts as an indicator of ecosystem health? If such variables have been defined, then these clearly are essential.

The problem arises when one attempts to find information that defines indicators from either public or scientific perspectives. One way to find such information is through a review of the literature. The scientific literature, specifically that related to agriculture, does not provide an overview of multiple variable integrated analyses that defines important variables as indicators of ecosystem health. Rather, the literature makes it clear that there is difficulty in finding single indicators that give a consistent outcome. For example, Logan (1990) outlines some management practices in agriculture that may have positive results with respect to certain pollutants whilst having negative effects with respect to other pollutants. This viewpoint is supported by other authors such as Koo and Diebel (1996).

Alternatively, the practice of planning has included different lists of agricultural variables which are either included, or potentially included, in agricultural studies. Some of these variables result from public requests during acrimonious "debate" over undesirable facilities such as landfills or with respect to the need for specific planning policy. For example, a study of agriculture in 1972 by the Centre for Resources Development (CRD) at the University of Guelph, included a number of variables listed in Appendix 4. This list becomes more extensive in another CRD study in 1979 (Appendix 4). As part of planning and environmental assessment, the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) lists impact factors for a broad cross-section of agricultural characteristics (Appendix 4). This cross-section is reflected in more recent variable lists, one for the Interim Waste Authority (Ecologistics Limited, 1993; AgPlan Limited, 1993), and a second for the Great Lakes Commission, outlined in Appendix 4. All of the variables or agricultural factors lists tend to use some different language resulting in the need for some translation among the lists. Rather than complete that translation, a review of the lists shows that there are some common elements among them - all have a cross-section of different variables that includes measures of biological, production, physical/chemical, socio-cultural, and economic components, reflecting potential, actual, changes over time, or a combination thereof.

Given the nature of these lists and actual practice, AgPlan has reasonably assumed that a relatively broad cross-section of indicators is necessary to reflect the nature of agriculture and the different interests of people in agriculture.

On that basis, the variables/indicators in the five reports reviewed are all desirable. Whether or not they are necessary very much depends on whether one is asking the question in a political (ie., a broad public context which includes rational, irrational and non-rational viewpoints) or scientific context (these contexts are viewed as being mutually exclusive). In a political context, given the different viewpoints of stakeholders, all of the variables considered in the five reports are necessary. In a scientific context, there is insufficient information to state what is necessary. Unpublished work by Hoffman (1997) and AgPlan (1992) supports this view. Generally, when a number of different methods, indicators, or weights were used to test changes in an agricultural outcome and a regression was performed on the data variables relative to that outcome, no single variable or set of variables could consistently be shown to "explain" the variability in the outcome.

Stated differently, when the outcome had a single focus, or viewpoint (weight), certain variables predicted outcomes, but when one focus was compared to another, both foci had different variables as predictors of the outcomes. Therefore, it seems difficult to find variables which are necessary (in the sense that the variables are consistent predictors).

It is probably best that variable lists provide balance (see Mintzberg, 1996).

Additional comments by AgPlan concerning the reports relate to errors, omissions, or opinions and are described in Appendix 1.

3.0 SUMMARY, CONCLUSIONS, RECOMMENDATIONS

All of the consultant reports provide the information that their original proposals state. However, taken singly, the reports do not meet all of the objectives of the COA. Even as a group, the reports provide fragmented views of the system of agriculture and are not related to an ecosystem or ecosystems. This is not surprising given the state of scientific knowledge about ecosystems which tends to be broadly-based conceptually but limited to smaller, more specific pieces practically.

One can conclude that the reports provide a reasonable product given that they provide the information that they contracted to provide.

Based on AgPlan's review of the consultants' reports as well as a limited review of the literature, the following paragraphs discuss some possible next steps in the Green Plan initiative. "Where we might go from here" will consider two components:

- What are the variables in generalized categories that need to be included in the Green Plan data base?
- What process/steps could follow the current consultant reports?

The review indicates that the first component (variables) needs to include a balanced cross-section of information on current as well as potential conditions. The variables need to include all the components normally encompassed by a broad meaning of the word environment. Therefore biological, production, physical/chemical, socio-cultural and economic components are needed. The broad cross-section reflects current environmental assessment legislation at the federal and provincial levels and follows a more recent trend to cumulative assessment (see Shoemaker, 1994 for a review of cumulative environmental assessment (CEA)).

Given:

- Problems of language use and definitions which are associated with agricultural variables (which have already been discussed in the text);
- The potential for an infinite number of variables and variable combinations; and
- The lack of quantitative replicated data on the relative use of different variables in practice.

A generalized list of variables which subjectively are necessary or desirable has been compiled in Table 2.

Even with the expectation of large multi-variable assessments for measurement of sustainability, the five consultants' reports and other literature make it clear that much data is missing or available only at a broad scale. Data are available on a semi-detailed scale suitable for regional planning (scale 1:50,000 - 1:63,360) only for soils and agricultural land use. However, these data are not all available at the same level of precision or accuracy. Therefore, the data base needs to be completed to a level that is similar for each County or Region in Southern Ontario. For example, the methods employed by Ecologistics and ESP in Waterloo and Oxford respectively, need to be continued so that all soils maps always include more detailed slope information. The interpretation of this soils information for soil capability or soil suitability still presents some methodological problems (see AgPlan, 1991) and this needs to be addressed further.

Making soil maps more similar across the province seems to be a reasonable first step given that agriculture continues to be land-based.

TABLE 2

AGRICULTURAL VARIABLES SUMMARY

I. NECESSARY

BIOLOGICAL / ECOLOGICAL*	PHYSICAL (LAND)	SOCIO-CULTURAL	ECONOMIC	PRODUCTION
• Diversity • Fertilizer use (type, amount, location) • Pesticide use (type, amount, location) • Farm management (type, amount, location) • Climate (macro)	• Soil capability • Soil quality • Soil erosion (extent and potential) • Soil characteristics and landscape	• Farm population • Non-farm population • Farm population's age, and health	• Gross income • Net income • Number of farmers in upper income classes • Capital value in farmland, machinery, livestock	• Yield, area, gross amount (gravimetric) for all crops grown in Ontario • Number, gross weight of all livestock including egg and milk products

* Includes primary components which have displaced the ecosystem from its unmanaged state

II. DESIRABLE

BIOLOGICAL / ECOLOGICAL*	PHYSICAL (LAND)	SOCIO CULTURAL	ECONOMIC	PRODUCTION
• Water quality/quantity. surface and subsurface • Potential for water quality change • Climate (meso) • Potential for climate change • Climate (micro) • Air quality	• Soil compaction existing • Soil compaction potential	• Planning designation (type, amount, location) • Property size (mean, median, stand. deviation) • Land ownership • Stability (length of time) of tenancy	• Bank risk estimate (ease & cost of obtaining credit) • Number of bankruptcies by sector, location • Value of product exported and imported (by location) • Number of employees • Number of hours and value of hired labour	• Total biomass • Amount of product imported that could be grown in Ontario • Amount of product imported that cannot be grown in Ontario

Subsequent steps (where do we go from here?) are less easily implemented because data bases are currently relatively poor. For example, in the physical environment category, additions of fertilizer as to types, amounts, timing, and location are not available. Perhaps a program similar to the Farm Management Analysis Project or the pesticides use information gathered by OMAFRA would supply more specific information on fertilizer use.

Another area that does not have data differentiated on a geographic basis relates to the health of farmers. Farmers are clearly the primary resource of agriculture. It would be of assistance, therefore, if the relative sustainability of farmers' health could be mapped across the province.

Other links are necessary with information bases such as farm well water purity, water aquifer contamination, the acid rain soils data base, as well as information on planning designation, land parcel size, presence or absence of in-ground services (water, sewage) and other anthropogenic characteristics.

As mentioned previously, none of the five consultant reports discuss how much information can be combined to provide singular replicatable results on a geographic basis. Therefore, some discussion on combination methods (options, pros, cons, outcome, effects) also needs to be considered in meeting the objective of the Green Plan.

At this time, some information has been gathered within the five consultant reports to answer the questions:

(1) What data have we?
(2) What can we do to improve the "homogeneity" of some of the data we have (with specific reference to the land resource base)?

However, current questions remain outstanding:

(1) What links are possible with other databases (eg. update Richards *et al*, 1976)?
(2) What methods of database combination are available, what are their pros and cons, which ones would we prefer to use, and why?
(3) Where is data unavailable or sparse - geographically, in what subject areas?
(4) Given information from questions 1-3, which databases are best updated to provide geographic differentiation of agricultural sustainability?
(5) Given questions 1-4, which areas in Southern Ontario are more suitable and/or are at risk?

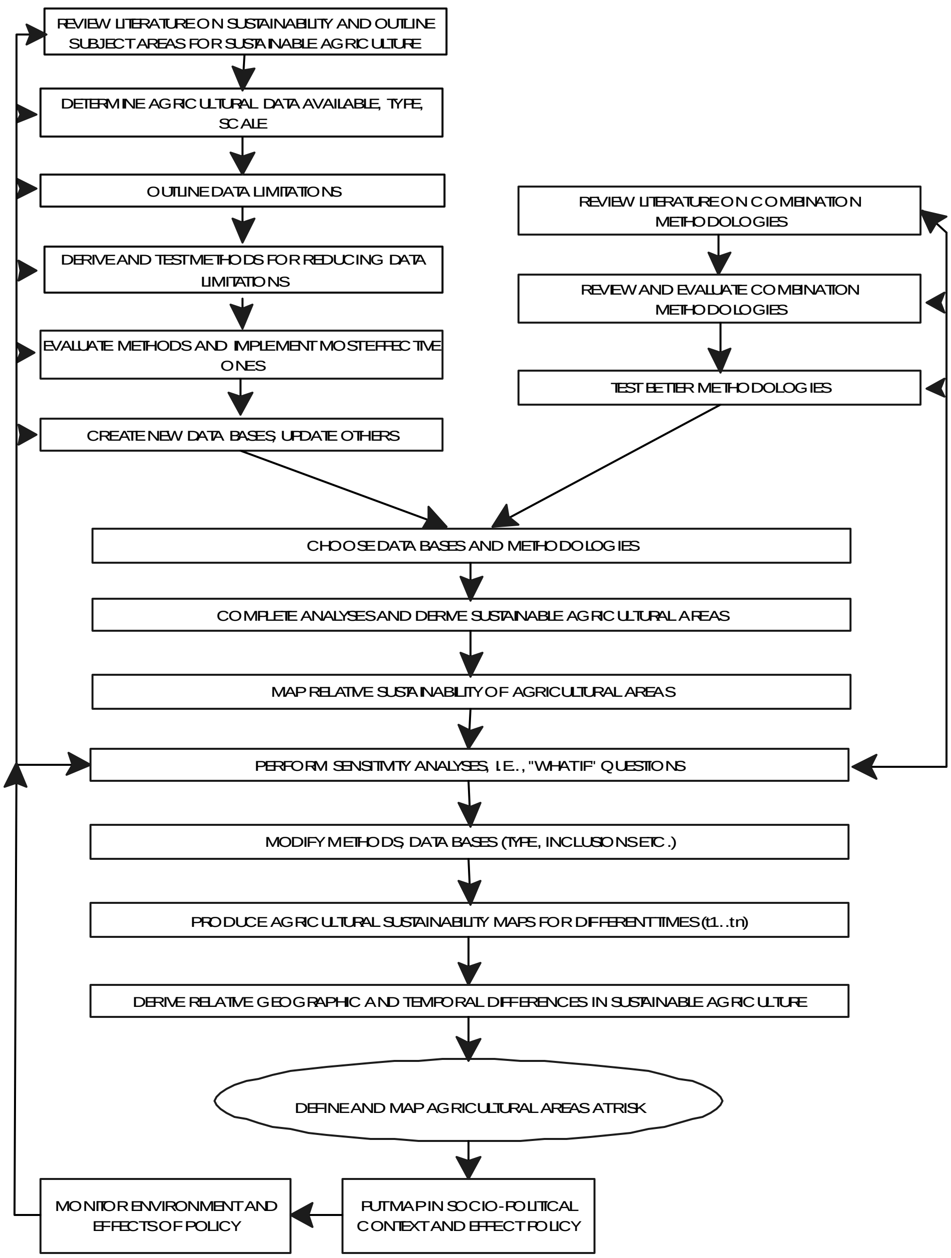
These questions form part of an inventory evaluation and mapping process related to the Green Plan COA. One outline of this process is shown in Figure 1. The five consultant reports relate to the first five steps in that process. Subsequent steps are related to questions 1-5 listed above and, on the basis of the consultant reports, remain to be addressed.

In summary, it is apparent upon review of all of the reports that the preparation of a data base for agriculture requires an additional framework which provides classification, integration and correlation. Without that framework, measurement of environmental/ecological change will be exceedingly difficult. Stated in other words, there are some issues that may benefit from additional discussion/study. These issues include:

- the variables needed to evaluate agriculture, how they are presented in classes or groups (classified) and whether they are necessary/mandatory or desirable;
- the scale at which information needs to be presented - planners tend to use information at regional scales, whereas farmers have a need for more detail in low input/variable input agriculture;
- the definition of variables.

FIGURE 1

GREEN PLAN ACTIVITY PROCESS



- matters such as slope class, landscape, land use, and various interpretations from capability through to existing versus potential erosion would benefit from a single accurate, precise definition. It is not likely that consensus is possible for this set of accurate precise definitions; it will likely need to be imposed;
- the definition of areas at risk (risk of loss / risk of degradation in environment and for productivity; risk related to mortality, health of farmers and the public; risk to economic returns; risk to resource quantity/quality in what location; risk related to level of resilience - environment, economic;
- problems of duality/contradiction - a positive solution to one ecological component may negatively affect another input; and
- links to non-agricultural influences - sewers and other infrastructure that may affect agriculture directly or indirectly.

The other area that requires some additional study is the integration of factors/indicators. None of the reports discuss or attempt this integration so that areas of relative sustainability can be identified. Hoffman's (1997) unpublished work does indicate that there are mathematical methods which will produce relatively consistent ratings for agricultural sustainability - provided that the data base is balanced with a cross-section of biological, production, physical/chemical, socio-cultural, and economic factors. Given public attitudes to mathematics, other methods will likely need to be explored.

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APPENDIX 1

DOCUMENTATION OF FINDINGS

RELATIVE TO REPORT REVIEW

Documentation of Findings Relative to Report Review

Introduction

The evaluation of the five consultants' reports required a review of each report. The comments from this review by AgPlan are summarized in this appendix and subsequently were supplied to each consultant for their action ,comment or suggestion. The results of this consultant dialogue, when it was available, have ben incorporated into AgPlan's report in two ways:

- firstly, as changes in the wording of AgPlan's report and/or review comments
- secondly, by including the written viewpoint of the consultant or the explanation provided by Agriculture and Agri-Food Canada.

Review Comments

Environmental Soil Services (Katchanoski, G. and P. von Bertoldi). 1996. Monitoring Soil Loss and Redistribution Using ^{137}Cs.

This is an interesting methodology for monitoring soil loss. However, it does raise a number of questions particularly with respect to integration with other studies.

1. While the soil series were identified and mapped for the Kintore Watershed this was not the case for the baseline site selection. The reason for this difference was not explained.

Reply by *Environmental Soil Services*

I strongly disagree. There should be no relationship between 137 Cs baseline amount and soil series. To spend the effort mapping soil series would have been a waste of time and resources. The process was a global atmospheric deposition in recent history. The sites were selected for no erosion. How can soil series possibly be useful? The work by deJong *et al.* published in the *Can J. Soil Science* as well as other published work clearly indicates this.

2. No reference is made to the extensive works in erosion studies by Wall and Dickinson. Is there no correlation? Numerous studies of soil loss in southern Ontario watersheds were conducted during the 1985 - 1992 period. Perhaps some mention of these would allow for comparative study.

3. An objective of the project is to "determine the redistribution of ^{137}Cs soil since 1965 within a watershed typical of <u>Ontario</u> conditions ...." as agreed with Agriculture and Agri-Food Canada. Unfortunately, no studies were conducted in northern Ontario's clay belts. With annual precipitation varying from about 750 mm in the Emo/Dryden areas to 1140 mm in the Timiskaming/Cochrane/ Kapuskasing areas, some remarkable differences might have been found.

4. The mapping produced by Environmental Soil Services is an extrapolation based on rainfall. The extrapolation is weakened because the regression on cesium variability is at best explained only 64% of the time by rainfall (alternatively, 36% of the variation is unexplained). This rainfall is "individual average monthly precipitation for the major deposition years" and is not clearly defined.

   As well, given that deposition could relate to <u>total</u> rainfall during the time of ^{137}Cs generation, some explanation, including scientific evidence, as to why individual monthly precipitation is a better predictor would be of assistance.

Reply by *Environmental Soil Services*

I disagree. An r^2=0.64 for correlation to an easily measured variable at the scale of southern Ontario is actually quite good. The map using this correlation must by definition have better accuracy than one used without it. It may be "intuitive" for the AgPlan reviewers that Cs deposition be related to Total Rainfall, BUT unfortunately their intuition is also incorrect. The atmospheric deposition measurements made at selected Canadian sites on a monthly basis during the major deposition years clearly indicates that the deposition came in certain months. This has been related to global circulation patterns and the timing of the nuclear testing. This is stated in the published works by deJong and others. Thus, individual monthly rainfall during the deposition years should be, and was, the most highly correlated to deposition.

5. The Kintore watershed soil samples described in the ESS report (Appendix 4) all show Ap surface horizons. Is this a typographical error? If not, there is no direct link between the undisturbed samples of the overview study and the Kintore watershed. Some undisturbed samples in the Kintore watershed would have acted as a "test" of the variability in the overview ^{137}Cs mapping.

7. Given that the objectives of the Green Plan include application at the field level, the scale of the baseline or overview mapping is limited by the broad scale of weather/climate data. Our own observations on the variability in rainfall on a micro and meso scale suggest that there is a great deal of variability within climate isolines defined on a macro scale. What literature/experience demonstrates that quantitatively- measured variability on a macro scale is not the same as, or less than, that found on a micro (on-farm) level?

Reply by *Environmental Soil Services*

This is irrelevant to our report. Of course there is always variability at a scale smaller than the scale you have mapped at. The objective was to produce a map at the scale of southern Ontario. The r^2=0.64 correlation to rainfall indicates that even if you know local rainfall very accurately, this is the best you can do. Table 1, Page 12, indicates a variability of 18% attributable to local scale. There are a multitude of reasons why a local value may be different from the value predicted from the baseline map, but the prediction will still be much more accurate than using an average value for the entire province.

8. How can the slope/landscape units (converging, diverging, shoulder, back, foot) be related to existing potential soil erosion models and to existing soil landscape units or landscape maps? The link would be of assistance in using existing information for extrapolating or interpolating.

Reply by *Environmental Soil Services*

Agree. However, there are an incredible number of different approaches to predict soil erosion. Depending on the approach, the topography data will be used differently. The value of the study is the creation of a database that can test a number of erosion models including tillage translocation. However, testing erosion models was not the purpose of the project. Interestingly, the cost of measuring the soil loss/redistribution in this study is probably less than that required to model the erosion. The Kintore field staff were "floored" when they saw the map of measured changes. They had been using GAMES to predict losses and the effort (cost) to do this (create the databases, etc.) was considerable.

Gregory Geoscience Limited. 1995. Development and Testing of a "State of Agricultural Resources" Reporting and Monitoring Methodology for Southern Ontario

1. This methodology includes all of the general indices, economic, social and environmental but makes no attempt to integrate them into one index. Perhaps such an index cannot be achieved but it would be helpful if an outline of how the data presented can be used to indicate the overall state of agricultural resources.

2. Many of the maps and graphs would benefit from some form of explanation in the manuscript. For example, maps 29 through 36 are not mentioned in the report nor is their significance explained.

3. The use of physiography as a means of updating/resurveying soil maps is dismaying. Soil morphology seems to be ignored as is mineralogy. In addition, there seems to be an implication that all loam tills, for example, would be included in the same cartographic unit. Other

physiographic units would be grouped across the province to provide a very generalized picture of agricultural resources.

4. There is a lot of material in the annexes which adds little to the report. Either some mention of these annexes should be made in the body of the report or they should be omitted. We would recommend that they be dropped.

5. This report needs a lot of work before a reporting and monitoring methodology for southern Ontario is achieved. The authors are moving in the right direction but they have a long way to go.

6. The information format and/or that received from stakeholders is not specific within the report. The report does not outline if the same questions were asked of all groups and what those questions were. As well, the specific responses by each stakeholder group are not reported. As a result, this component of the work is not traceable/trackable or replicatable.

7. The star index appears to measure change over time relative to a 1981 baseline. It is used by Gregory Geoscience in a way that the change over time and geographic differences (at the County/Region level) can be shown on a two dimensional graph.

   While this graph provides a useful summary, it may tend to emphasize change over time to the detriment of gross differences amongst Counties/Regions. This can be demonstrated by using the Machinery Capital Index (MCI) as an example as follows:

County	Machinery Value* ($) 1981	Machinery Value* ($) 1991	Index*
Prescott Russell	82,142,000	112,600,000	90.4
Lanark	37,559,000	51,100,000	89.7
Durham	90,301,000	125,800,000	91.1
Wellington	120,567,000	168,200,000	92.1
Kent	211,671,000	257,000,000	80.1

* Machinery value is taken from the Agricultural Statistics Publication No. 20. The Index value is taken from the Gregory Geoscience report.

The dollar value data from Publication 20 would seem to indicate that Kent has had the highest value relative to other Counties/Regions of farm machinery and equipment in 1981 and 1991 and that the dollar value (not "corrected" for inflation) has increased between 1981 and 1991. Adjusting dollars on the basis of the Consumer Price Index (as an indicator of inflation as outlined as an index by Gregory Geoscience) would suggest that Kent has the greatest loss of "relative" dollars when compared to other Counties/Regions. It seems that the index used by Gregory Geoscience would rate all Counties/Regions in the example as higher in value than Kent. However, Kent has had the highest value in actual dollars in 1981 and 1991 and it would seem that most bankers would see less risk for loans given to the farmers in Kent because they have higher assets as "back up" to loans that might be granted to those farmers.

Alternatively, using a grade school analogy such as a report card, Kent had student term averages ($) that were highest relative to the other Counties/Regions in 1981 and 1991. But Kent's term average did not increase between 1981 and 1991, therefore it is rated relatively poorer (even though it topped the class) because it didn't maintain or improve its average as indicated by the Gregory Geoscience index.

Given the aforementioned interpretation and analogy, the index method for farm machinery value is not one which AgPlan would want to use to differentiate the better from the poorer agricultural areas.

8. The report would have been improved by one or several calculations which showed raw data, consumer price index and final index value. A general formula showing the calculation would also make calculation methods more easily understood.

9. There appears to be a lack of correlation between descriptions of indices in the text and the graphic presentations made. For example, Machinery Repair Index (MRI) is not shown graphically. As well, Machinery Capital Index (MCI) may or may not correspond to MECI in Figure 1.

10. Discussions on the relative importance of the changes in indices over time can be misleading. Machinery Repair Indices (MRI) more than 100 are stated to be a negative trend. Considered in isolation, this is reasonable. If, however, machinery repair resulted in improved combine performance, higher product capture (effectively increasing yields) thereby improving gross farm receipts, the high receipts might be sufficient to exceed machinery repair cost. Therefore, some qualifiers, associated with those statements which are related to positive or negative trends, are desirable.

11. The indices are not all "running in the same direction". Therefore, a high number is not consistently better or an improvement. Stated differently, a higher number is not always related to higher impact. It sometimes indicates a lower impact. The indices could be calculated consistently (eg. high impact = high numbers) in order to reduce confusion.

12. Some of the information such as insecticide use is presented graphically in classes of use. The rationale for the boundaries between classes of use is not discussed. This is particularly important because the limits between the classes are discontinuous. For example, fungicide use (kg/ha) uses four classes and there is a gap between the values for the third and fourth class - class three is 0.10 - 0.35 kg/ha and the following (4th) class is >0.90 kg/ha. Are the class system boundaries used to suggest that the distribution of the rate of use is strongly skewed?

13. On page 10, there is a suggestion in the seventh paragraph that insurance data could be used for predicting productivity of soils. This work has been done (see Hoffman 1971, ARDA Report #4).

14. On pages 37 and 38, average census farm size is very large in areas where much of the land is not in agricultural use. This limitation to the data should be mentioned.

Ecological Services Group. 1996. Development and Application of Standardized Methodology for Sampling Soil Landscape Polygons

1. An interesting research project which would benefit from a stronger presentation of the historical background of soil survey in Ontario. Such information might help explain low levels of accuracy between the SLC polygon descriptions and the soil survey map information. Also, an explanation

for the "High" complexity rating for many of the Niagara and Haldimand-Norfolk polygons might be forthcoming.

Reply by *Ecological Services Group*

We don't believe that a historical review of soil survey in Ontario would properly explain the low levels of accuracy between the SLC polygon descriptions and the soil survey map information (DSM). The SLC used the most up to date soil mapping available to compile the polygons. Niagara and Haldimand-Norfolk both have some of the most detailed and recent soil data available and still it was shown that there was a low level of accuracy between the SLC and the DSM for the polygons we studied. However, we also feel that the level of accuracy in these two municipalities would improve if other polygons had been chosen.

In reference to AgPlan's comment that "an explanation for the 'High' complexity rating for many of the Niagara and Haldimand-Norfolk polygons might be forth coming", ESP does not rate any of the Niagara and Haldimand-Norfolk polygons as "high". We state that the SLC has rated a polygon (428) as high based on their definition which is:

> *Soil and landscape components are highly variable and unpredictable; dominant, subdominant, and inclusion components are present, each of which has been generalized from more than two classes of parent material or soil development, or both; use this class to warn of extreme oversimplification in any interpretation from the extended legend.*

We also state on Page 20 that for the polygons studied, only in one polygon (52) was the unit homogeneous enough to have a component with a percentage representative of a dominant component. All other polygons studied had components occurring in percentages representative of subdominant components and inclusions. This would indicate that most of the polygons are highly variable in terms of their composition (i.e., mode of deposition, texture of parent material, and soil development) and perhaps all of these should be considered to have a "high" complexity rating.

We don't believe that the low levels of accuracy reflects on the DSM rather it may suggest that a better method could have been used to delineate the SLC polygon boundaries and a methodology similar to that developed Ecological Services for Planning Ltd. could be employed to refine the SLC to more accurately reflect the constituents of the SLC polygons.

2. A section in the report should be provided which indicates which DSM data was used to prepare the SLC maps. The SLC soil polygons in Haldimand-Norfolk and Welland County could have come from old soil maps of 1:126,720 scale or the much more recent 1:25,000 soil surveys. Lincoln County soil maps are at 1:63,360 scale. These along with the Welland County soil maps form the Niagara section of the SLC. Thus, the amount of detail varies with map and scale and with time. The report states that the Oxford County soil maps are at the 1:63,360 scale and indicates that the correlation between DSM and SLC data improved significantly over that for the Haldimand-Norfolk and Niagara regions. Correlation or lack thereof, is not only related to detail of mapping but may also be the result of soil mapping techniques and/or the nature of the environment which is a function of soil forming processes. In the days when Oxford County was soil surveyed, soil polygons were recognized on the basis of the dominant soil type. Studies were conducted (1966) to determine percent inclusions in each map unit but these data were not published on the maps; they were used to develop the soil capability maps. In more recent times, there is a tendency to describe cartographic units in terms of soil complexes or associations. As a result, many of the polygons provide dominant and subdominant soil series but make no attempt to identify their location within the polygon. Thus, the opportunity to provide more detail at the 1:25,000 scale is lost and correlation between DSM and SLC data becomes less likely.

Reply by *Ecological Services Group*

The SLC data base contains information derived from the most recent soil survey information for Niagara, specifically The Soils of the Regional Municipality of Niagara, Report No. 60 of the Ontario Institute of Pedology, 1989 and the Soils of the Regional Municipality of Haldimand-Norfolk, Report No. 57 of the Ontario Institute of Pedology, 1984 (with maps published at a scale of 1:25,000). It does not contain information from old soil maps of Welland, Haldimand-Norfolk and Lincoln County. Map scale, detail, and relative timing should be similar for both Report No. 60 and Report No. 57 maps.

3. One more concern is the lack of attention being paid to northern Ontario. This part of the Province should not be ignored.

Reply by *Ecological Services Group*

Budgetary constraints limited the ability of this study to include larger portions of the province, however, we agree that, should the funds become available, a program that better defines the SLC polygons be established for all areas of Ontario.

4. The high complexity of Niagara, Haldimand-Norfolk is likely due to the presence of soil polygons in the DSM identified by means of soil associations rather than one dominant series. Discrepancies may also be due to the sources of the SLC data. A section of the report should be devoted to the foregoing “limitations of the research”.

Reply by *Ecological Services Group*

The SLC used the DSM data supplied by the recent soil maps of Niagara and Haldimand-Norfolk. There are a number of possible reasons for the high complexity observed in Niagara and Haldimand-Norfolk. AgPlan identifies one possibility. Another possibility is that the high complexity may be more related to the dominant modes of deposition in each area rather than the method used to map the areas. Oxford County is comprised of mainly tills whereas Niagara and Haldimand-Norfolk are highly influenced by lacustrine deposition.

5. The primary objective of the ESP report was to assess the quality of SLC data using a particular methodology. Central to the methodology was the comparison of data from three sources - SLC, DSM and field. The comparison is qualitative and quantitative. The quantitative comparison is based on statistical analyses - analyses which are not clearly outlined in the Report. For example,

the text (page 21) states that statistical methods “included the determination of coefficient of variation, the mean and standard deviation”. However, no tables are present which outline all of these analyses. Table 4 contains mean and standard error. The mean values in Table 4 do not outline the mean for comparison of polygons for pH or organic carbon excluding the influence of slope. Thus, some of the more general data does not seem to be presented.

Reply by *Ecological Services Group*

The results of the statistical analyses have mainly been summarized rather than incorporating a large amount of detailed statistical data which may or may not have been directly relevant.

The mean values for pH and organic matter for each soil, site, and soil group are contained in Appendix B. If readers require additional information, it can be generated from these tables

6. The text also describes a “Main Effect” and “No Significant Interaction”. Neither of these terms is defined statistically nor is there a statement that outlines which test or tests were used in support of Main Effect or Significant Interaction.

Reply by *Ecological Services Group*

An oversight, this information should have been included in Section 3.

7. There is some question also about the kind of tests that have been completed. For example, when the data set is subdivided to compare the mean value of organic matter for slope position 1 for polygon 52 vs. the same mean value of polygon 53, the number of samples would seem to be less than 30. Therefore, given the small sample size, and no discussion on the distribution characteristics of the data set, it would seem prudent to use some non-parametric tests in the evaluation of differences. There is no discussion (what, under which circumstances) about the use of parametric versus non-parametric statistics (a perusal of Appendix 3 suggests that there were

a total of 12 samples in lower slope positions for polygon 52; alternatively, polygon 53 seems to have 18 samples).

An expanded analysis section on the report with the tests and assumptions used with respect to statistical tests would assist in an interpretation of the different mapping and field results.

Reply by *Ecological Services Group*

Comparison of an unequal number of samples is not necessarily a basis for using non-parametric tests. If the sample size is large enough, as it is in this case, the use of parametric tests is appropriate.

8. Discussion in various sections (5.3, 5.4 and 6.1) suggests that there is better correlation between DSM map units and SLC ones for Oxford when compared to Niagara and Haldimand-Norfolk. As stated in the ESP report, the likely reason for the better correlation is the relatively general broad scale mapping of both DSM and SLC maps in Oxford. However, the test of a map's utility would seem to rest with its purity at a level where it can be applied. Given the objectives of the Green Plan which include application at the farm level, it is reasonable that the test of DSM and SLM maps should primarily involve the comparison of the maps to the specific results of the field work. The field data as presented supports the view that SLC map units are inaccurate. However, the field data has not been used to show the relative accuracy of DSM map units in Oxford, Niagara and Haldimand-Norfolk. One might ask the question "What is the probability that the field sample is the same soil (preferably series or phase) as identified by the SLC and DSM map units/polygons in which the field sample is taken"? The report does not supply a direct answer to this question: A single matrix could be prepared which would compare probabilities for both SLC and DSM maps for all 3 Counties.

Reply by *Ecological Services Group*

(a) A data source that has a scale of 1:1,000,000 is not ideally suited for use at the farm level.
(b) A test of probability with one sample within a Soil Landscape Polygon (at 1:1,000,000) and a Soil Map Unit (at 1:63,360) would have little validity. To properly assess what the probability is of a field sample being the same as that described in the SLC or the DSM, it would be necessary to take several field samples within the SLC polygon and the DSM polygon. While this may be a worthwhile effort, this exercise was not contained in the proposal and budgetary restrictions would have prevented this additional level of data collection.

9. On page 4, paragraph 4, last two sentences, there is a statement that soil samples were often taken in hedgerows and forested areas. It should be noted that in Ontario, profile descriptions were often taken in woodlots but soil samples for analysis were taken from hay/pasture fields.

Reply by *Ecological Services Group*

Review of several older soils reports, Oxford, Wentworth, Halton, etc., provide the description of a typical soil series and often include the lab analysis for this soil. The field descriptions are most often given what we assume is a forested site, since no Ap (ploughed horizon) is described. The laboratory results were stored in CanSIS data base and the CanSIS data base provided much of the information in the SLC data base.

Regardless of the differences in sampling procedures from one soil survey to another, the laboratory results, recorded in CanSIS, for some soil attributes, such as organic matter content, are more influenced by farm management factors than by any other factor or soil attributes. Different farm management systems can result in a wide range of values for organic matter content within a soil series and/or a soil group. Future changes to the SLC should consider the appropriateness of including all the attributes that it presently does or it should standardize appropriate methods for acquiring the data.

10. On page 19, paragraph 5, there is a discussion about soil polygons. Data sources for these polygons should be indicated because it is not stated directly whether the polygons originate in the "old" Welland County Map or in the "new" Niagara map.

Reply by *Ecological Services Group*

In **Section 2.2 Data Sources**, in the second paragraph which is on Page 5, it is stated that the Niagara and Haldimand-Norfolk soils data was used and that the scale of the mapping is at 1:15,000. The scale indicates that the data is derived from the more relevant, recent and more detailed information contained in the "newer" soils reports, not information contained in the "older", less detailed and no longer published mapping such as the Welland County Map.

11. On page 29, paragraph 2, a statement is made about scales of *mapped* soils. It should be noted that soils were mapped at scales different from the scales described in the ESP report but were published at the scales described by ESP.

12. On page 31, paragraph 2, there is some discussion about discrepancies between SLC and DSM parent material textural classes. Given that there are soils with a IIC such as Berrien, could some or any of the discrepancies be explained by these "double deposition" soils?

Reply by *Ecological Services Group*

The possibility of discrepancies due to "double disposition" would have been considered during our analysis. Also, both the DSM and the SLC recognize the IIC in their descriptions, so there should not be any discrepancies between the two data bases for this reason.

Ecologistics Limited, 1994. Assessing The State of Agricultural Resources: Improving the Land Resource Data Base

1. As with other studies in the Canada-Ontario Green Plan series, this report provides methods for changing soil polygons relative to scale and gathering additional data concerning pollution and erosion. Unfortunately, no method for integrating the data to provide one measure of the agricultural resources is presented. In the Whitchurch-Stouffville case study, updated CLI and slope data are used to indicate the state of the agricultural resources. The Bamberg Creek study

has several maps which present data for potential erosion, erosion management sites, soil capability etc., but no indication of how to put it all together for decision-making.

2. Some changes are made in the slope classification system without the support of research data. For example, is there a significant difference between 12% and 15% slopes? How much more erosion occurs on a slope of 15% as compared with 12%? or How much lower is common field crop productivity on 15% slopes compared to 12%? Perhaps the slope limits for each class should be rationalized across the Province to agree with the CSSC classification but it would help if data were provided which would indicate the significance of the change. Regardless, the objective of consistent slope class delineation was reached with the production of the 1:50,000 scale map.

Reply by *Agriculture and Agri-Food Canada*

Agriculture and Agri-Food Canada, Mr. E. Presant and Ecologistics discussed correlation needs and derived slope classes given the current slope class breakdown and the slope class system originally used in Waterloo. The group reached consensus on the allocation of the original slope designations to the current CSSC slope classes.

3. On page 14, paragraph 14, there is a description of the Waterloo County soils map slope classes. In the subsequent paragraph, it is stated that these slope classes are unique to Waterloo. This is not strictly the case. These slope classes were defined by CSSC prior to the publication of The Canadian System of Soil Classification (1978) (also the 1970 report) and, in some cases, soil mapping was completed using the same slope classes as for Waterloo.

4. On page 49, Table 13, there is a comparison of CLI ratings of the new map relative to the report by Hoffman and Noble, 1975. It should be noted that the old CLI information was based on the

original photostat of the 1:126,720 scale Waterloo County Soils Map. This fact accounts for some of the difference in CLI class relative amounts.

5. On page 50, section 2.36, the title indicates a comparison of two soil capability ratings. This is not the case - it is a comparison of the CLI capability rating with a suitability rating.

6. While the soil suitability system was developed as a replacement for the CLI soil capability classification, we are of the opinion that the land suitability classification for spring grain crops can not be compared to the soil capability ratings (pg. 50 - 52). "Suitability is an estimate of the fitness of a given type of land for a specified use" whereas capability is a measure of the potential of a soil for the production of common field crops.

   The capability system and the ratings were tested in Ontario and yields calculated for each class. Similar studies were conducted in the west thereby reducing the subjectivity of the ratings. In any case, these rating systems should not be compared. Where used, they should be used separately with a clear understanding of their applicability to agricultural resource studies.

Reply by *Agriculture and Agri-Food Canada*

As pointed out by AgPlan, the accepted definitions for capability and suitability would suggest that they assess different aspects of land quality. However, the comparison of the two ratings made by Ecologistics was done at the request of Agriculture and Agri-Food Canada because the Agronomic Interpretations Working Group which developed the Land Suitability Rating System (LSRS) specifically requested that these comparisons be carried out across Canada as one way to evaluate the sensitivity of the LSRS to conditions of soil, climate and landscape.

The introduction to the LSRS technical bulletin states that it was developed as an improved national system for rating land suitability for production of crops to address major weaknesses of the CLI system. The Working Group further state that "As the CLI ratings were designed for common field crops suited to the area, the two systems should be roughly similar."

While the concerns of AgPlan need to be recognized, it would appear that the criticism is more related to nomenclature rather than concept.

7. The Ecologistics Report is unique in that it takes information in two opposite directions with respect to scale. While the Ecologistics Report is correct in its statement that the 1:50,000 scale map is more commonly used in land use and resource management studies, additional qualifiers associated with the limitations in the usefulness of the 1:20,000 map could be stated.

8. The actual results of the field tests suggest that the generalization is a poor indicator of existing soils. Using Table 11 and comparing the group soil polygon name to the test area polygon name, reveals that the two names were the same only 8 out of 81 times. This can be used as an indicator of the low probability of finding a mapped soil type on the ground and indicate the limitations associated with the generalization.

   Ecologistics' report, as well as ESP's report, leads to a conclusion that their field data could have been used more effectively and that more field work is required for the production of information applicable at a farm scale.

   The Ecologistics report continues with a number of interpretations of the soil map - capability, suitability, erosion potential and transmissivity. Given the relationship between field data and mapped data, only those areas with detailed field checks should be used in the interpretation.

9. With respect to transmissivity, there are problems with the Ecologistics' model. The hydrologic class information provided by Ecologistics matches that already published by OMAF (R.W. Irwin, *Drainage Guide for Ontario*, 1986). This hydrologic class provides an "average" or range of

values for water movement through different soil series. AgPlan's work (unpublished) with measurements using the Guelph Pressure Infiltrometer shows no usable relationship between field saturated hydraulic conductivity and hydrologic class, soil texture, particle size, structure, drainage class or slope class. While this study by AgPlan is small (100 samples), it has results which are supported by other research. Reynolds (Agriculture and Agri-Food Canada, pers. comm. 1996) suggested that AgPlan's findings coincided with the literature (see also Springer and Cundy, 1987; Ragals and Cooper, 1993; Ewing and Mitchel, 1986). Additional references outlined by Reynolds are as follows:

Some references on the Use of Pedotransfer Functions

Gupta, S.C. and W.E. Larson. 1979. A model for predicting packing density of soils using particle size distribution. *Soil Sci. Soc. Am. J.* 43: 758-764.

Jabro, J.D. 1992. Estimation of saturated hydraulic conductivity of soils from particle size distribution and bulk density data. *Am. Soc. Agric. Engineers (ASAE)* 35: 557-560.

McBride, R.A. and E.E. Macintosh. 1984. Soil survey interpretations from water retention data. I. Development and validation of a water retention model. *Soil Sci. Soc. Am .J.* 48: 1338-1343.

Vereeken, H. 1992. Derivation and validation of pedotransfer functions for soil hydraulic properties. Pages 473-488 in M.Th. van Genuchten, F.J. Leij and L.F. Lund (eds.), *Indirect Methods for Estimating the Hydraulic Properties of Unsaturated Soils*. U.S. Salinity Laboratory, USDA and Dept. of Soil and Environ. Sci., Univ. of California, Riverside, CA.

Weston, J.H.M. 1996. Pedotransfer functions to evaluate soil quality. In E.G. Gregorich and M.R. Carter (eds.), *Soil Quality for Crop Production and Ecosystem Health*, Agriculture and Agri-Food Canada. (in press).

There are difficulties in using existing soil data bases (which are defined geographically using maps) as an indicator of transmissivity. Given the problem with transmissivity, the groundwater pollution potential mapping is limited. As well, because the groundwater pollution potential is also based on fertilizer and pesticide loadings that require the use of many assumptions, the loading component is hypothetical.

In addition, groundwater pollution will also be a function of surficial soil material characteristics, depth to water table, rate of saturated flow etc. There are several models which include a broader cross-section of variables. One model, called DRASTIC, uses 7 different characteristics to estimate potential. These characteristics are:

- Depth to water;
- Net recharge;
- Aquifer media;
- Soil media;
- Topography;
- Impact of the Vadose Zone Media; and
- Hydraulic Conductivity of the Aquifer.

The DRASTIC model has been criticized by Garrett (1991) because the model is an hypothesis without field testing. This comment corresponds to the findings of Kachanoski et al (1991) who states that there is little field measurement of dissolved solutes through unsaturated field soils. As well, the problem of measurement of solute movement in heterogeneous soils is not a lack of models, but a lack of field experimental data.

Garrett (1991) continues by stating that DRASTIC has been applied to a broad cross section of contaminants with specific gravities which are different from water. He concludes that a unified concept of potential pollution production may not be possible. This corresponds with findings previously reviewed by AgPlan.

Garrett (1991) also discusses the reliability of existing data sources and their use for the scores needed as input in the DRASTIC model. Given as an example, that any agricultural soil map unit is at best 75% pure (Acton, Pers. Comm., 1991) there can be reasonable amounts of error in estimating impacts for the vadose zone. Additionally, information on field variability for specific parameters such as topography or hydraulic conductivity found within single map units suggests that some broad-based soil classifications are inappropriate for use within the DRASTIC model.

The problem of scale of existing data bases relates to DRASTIC as well as to any model used to predict contaminant movement. For example, currently and historically, problems of scale difference, correlation, map unit variability, surveyor skill and accuracy as well as other factors, can affect the use of soil survey information in planning decisions (AgPlan Limited, 1991).

Garrett also mentions that recharge versus discharge zones were not considered in DRASTIC. Therefore the effects of dilution were not adequately considered.

Given the lack of specific field data and the limitations of more complex models such as DRASTIC, the simpler model used by Ecologistics may be inappropriate given that no transmissivity approach/method is currently supported by field data. Thus, use of the transmissivity interpretation is limited.

10. A review of the "relative" occurrence of soils in the grouped polygons for Wilmot Township (Tables A1 - A6) indicates that many of the polygons have a broad cross-section of different soil types. For example, polygon 5 has 21 different soil types; of which only 2 are identified in the test area polygon name (Table 11, Test Area 1). The complexity of some polygons is high and as a result, predicting the precise and accurate potential of transmissivity, erosion or other characteristics is low. The interpretive maps do not show which units are most complex and therefore which ones are most difficult to predict on a relative scale.

Ecological Services Group, July, 1996. Upgrade of Soil Survey Information for Oxford County

1. While this paper provides a good method for updating the Oxford County Soil Map as to slope, the relationship of slope to Soil Capability Class is neglected. Slope classes are provided that are similar but are not exactly the same as those in the soil survey manual. A comparison of those follows:

MANUAL		OXFORD UPDATE	
SLOPE CLASS	PERCENT SLOPE	SLOPE CLASS	PERCENT SLOPE
Aa	0.0 - 0.5	A	
Bb	0.5 - 2.0	B	0.0 - 2.0
Cc	2.1 - 5.0	C	2.0 - 5.0

MANUAL		OXFORD UPDATE	
SLOPE CLASS	PERCENT SLOPE	SLOPE CLASS	PERCENT SLOPE
Aa	0.0 - 0.5	A	
Dd	5.0 - 9.0	D	5.0 - 9.0
Ee	9.0 - 15.0	E	9.0 - 15.0
Ff	15.0 - 30.0	F	15.0 - 30.0
Gg	30.0 - 45.0	G	30.0 - 45.0

There are two problems although, in general, the differences are insignificant. Commonly slopes of 0 - 0.5 % are on soils that are poorly drained while those with 1 to 2 % slopes are imperfectly to well drained. This creates a problem when assigning capability classes. Poorly drained soils are Class 2 and imperfectly drained are Class 1. Thus, in the grouping of A and B, capability class could be incorrectly assigned. Similarly, no distinction is made between regular and irregular (complex) slopes which could result in capability classes being mis-assigned.

In addition, there is no indication of how the soil capability classes were assigned. Originally, soil capability classes were assigned on the basis of actual yield. In more recent days, it appears that the classes are assigned on the basis of soil characteristics assumed to affect yield. More quantitative data are needed before soil capability classes are adjusted one way or another.

The sections concerning soil capability are misleading and should be omitted unless more is done to show how the various classes were determined. If updating old soil surveys can be done by slope alone then this report has accomplished the task. However, it seems that the determination of variability within map units is highly subjective. Little has been done to show the relationship of slope to soil series. Although detailed physical analyses of soil profiles have been conducted, one is left questioning the usefulness of these data in updating the soil survey.

It should be emphasized that soils with 0 - 0.5 % slope can vary from Class 2 to Class 5 depending on soil texture assuming they are poorly drained. Therefore, slope alone may not be a criterion for providing soil class.

Reply by *Ecological Services Group*

In reference to AgPlan's comment that the slope classes used in the "Upgrade of Soil Survey Information for Oxford County" are not exactly the same as those in the "Field Manual for Describing Soils in Ontario, 4^{th} edition", our report explains the reason for this discrepancy. Digital Ontario Base Mapping (OBM) was used to digitally determine the slope percentages. As explained on Page 8, Paragraph 1, due to the lack of topographic resolution, slope class A (0 to 0.5 percent slope) and slope class B (0.5 to 2.0 percent slope) were combined for the purposes of this Report. Also, due to the lack of topographic resolution, it was not possible to consistently distinguish between simple and complex slopes.

AgPlan's comments state that only slope class was used to determine CLI soil capability for agriculture. In our draft July 1996 report, a generalized summary of percent are of CLI soil capability for agriculture was produced using only soil slope information. Since most of Oxford County contains well to imperfectly drained loamy soils, the assumption was made that most of the agricultural soils in Oxford County had no limitations other than slope. However, in our final December 1996 report, each soil polygon was assigned a CLI soil capability for agriculture class based on soil unit and slope class. The CLI classes were assigned using a combination of CLI interpretations performed in the surrounding soil survey reports (Middlesex, Elgin, Haldimand-Norfolk, Brant, and Waterloo) and original soil capability classes as assigned on the basis of yield but downgraded for slope class as outlined in "The Canada Land Inventory, Report No. 2: Soil Capability Classification for Agriculture". Each unique soil polygon was assigned a CLI soil capability class. The copy of the digital matrix (Oxuniq.dbf) has been forwarded to Agriculture and Agri-Food Canada.

2. As in other reports, the field work could have been used to characterize the homogeneity/variability of different soil polygons/map units. Some estimation of variability was made - on page 23, ESP states that the original map of Oxford was found to be correct 56% of the time. The data used to find this result is not outlined clearly within the Report. For example, page 10 states that 248 sample points in addition to 40 detailed descriptions were completed. This data could be presented in a matrix which compares Oxford County original mapped data with field observations / lab analyses (where possible). The data matrix could then be used to statistically analyse differences with respect to a number of variables ranging from series or slope class to drainage and texture.

Reply by *Ecological Services Group*

The soil data was analyzed using two digital data files. One of the files consisted of the filed soil and slope observations (Ksitecat.dbf), while the other file (Validity.dbf) consisted of digital Oxford County soil information (obtained from OMAFRA) and digitally generated slope information (interpreted from OBM's). All the field sampling points were geo-referenced using a Garmin Geographic Positioning System. The digital soil and slope file (Validity.dbf) was created by identifying the originally mapped soils and digitally generated slopes at the field sampling locations. The two digital files were then linked by the geo-referencing coordinates and the comparisons and the variability calculations were made. Copies of both these files have been forwarded to Agriculture and Agri-Food Canada.

3. On page 1, paragraph 5, there is mention about policies under the Planning Act. Given the number of changes in these policies in recent years, the date and/or specific policy should be specified in the report.

Reply by *Ecological Services Group*

The Planning Act (Bill 20) and the associated Provincial Policy Statement received Royal Assent on April 03, 1996. The Provincial Policy Statement came into effect on May 22, 1996.

4. On page 9, paragraph 2, Parkhill soils are noted as poor soils. They are rated as class 2 (or class 4 if there is a shallow phase) as described elsewhere in the report. The description of Parkhill soils needs to be modified.

Reply by *Ecological Services Group*

In the CLI soil capability for agriculture interpretations, Parkhill soils on B slopes were assigned a CLI class 2 capability rating.

5. On page 23, paragraph 5, there is a discussion about changes to soil capability which result from the new soil information. It is not clear what "rules" were used to place the newly digitized map into capability classes. The use of a matrix showing soil series and the relative change in capability due to slope would be of assistance. Such a matrix was supplied with the Ecologistics report.

Reply by *Ecological Services Group*

The CLI classes were assigned using a combination of CLI interpretations performed in the surrounding soil survey reports (Middlesex, Elgin, Haldimand-Norfolk, Brant, and Waterloo) and original soil capability classes as assigned on the basis of yield but downgraded for slop class as outlined in "The Canada Land Inventory, Report No. 2: Soil Capability Classification for Agriculture". Each unique soil polygon was assigned a CLI soil capability class. The copy of the digital matrix (Oxuniq.dbf) has been forwarded to Agriculture and Agri-Food Canada.

APPENDIX 2

GREEN PLAN REPORT VARIABLES

GREEN PLAN REPORT VARIABLES

VARIABLE	I (ESPSLC)	II (ESPOXF)	III (ECOL)	IV (ESS)	V (GGEO)
Agricultural Land Use		X	X		
Agricultural Land Use: Built-up			X		
Agricultural Land Use: Continuous row crop			X		
Agricultural Land Use: Corn system			X		
Agricultural Land Use: Grain system			X		
Agricultural Land Use: Grazing system			X		
Agricultural Land Use: Hay system			X		
Agricultural Land Use: Idle (5-10 years)			X		
Agricultural Land Use: Mixed system			X		
Agricultural Land Use: Pasture system			X		
Agricultural Land Use: Recreation			X		
Agricultural Land Use: Woodland			X		
Agricultural Use of Fungicides					X
Agricultural Use of Insecticides					X
Agricultural Use of Other Herbicides					X
Ap Thickness				X	
Area	X	X			
Area of Census Farm(s)					X
Average Census Farm Size					X
Best Management Practices Soil Scoring (Erosion, Tillage)					X
Building and Land Capital					X
Bulk Density				X	
Calcareousness of Parent Material	X				
Calcium Carbonate Equivalents	X	X			

GREEN PLAN REPORT VARIABLES
(continued)

VARIABLE	I (ESPSLC)	II (ESPOXF)	III (ECOL)	IV (ESS)	V (GGEO)
Catena Name			X		
Cesium Classes				X	
Crop area					X
Cultivated Land					X
Depth to Compacted, Consolidated, or Contrasting Layer (Dominant Only)	X				
Depth to Water Table (Dominant Only)	X				
Drainage Class (ie. Rapid, Well, Imperfect, Poor, Very Poor)	X		X		
Farm Chemical Cost					X
Fertilizer Cost					X
Fertilizer Loadings			X		
Farm Operations Classified by Age					X
Farm Wages and Salaries					X
Horizon Designation	X	X			
Improved Pasture					X
Indices for Conventional Tillage					X
Kind of Rock Outcrop or Other Material Surface	X				
Livestock Capital					X
Livestock Enterprise: Beef			X		
Livestock Enterprise: Dairy			X		
Livestock Enterprise: Horse			X		
Livestock Enterprise: Hobby			X		
Livestock Enterprise: Idle			X		
Livestock Enterprise: Mink			X		

GREEN PLAN REPORT VARIABLES
(continued)

VARIABLE	I (ESPSLC)	II (ESPOXF)	III (ECOL)	IV (ESS)	V (GGEO)
Livestock Enterprise: Swine			X		
Machinery and Equipment Capital					X
Machinery Repair					X
Manure Nitrogen Loadings			X		
Mode of Deposition	X	X			
Most Likely Slope	X				
Organic Carbons	X	X			
Particle Size Component	X	X			
Particle Size Composition	X	X			
Perimeter	X				
Pesticide Loadings			X		
pH	X	X			
Polygon Number	X	X			
Precipitation				X	
Selected Farm Expenditures					X
Slope (Class, Percent, Length, Simple, Complex)				X	
Slope Class	X	X	X		
Slope: Converging Back Slope				X	
Slope: Converging Foot Slope				X	
Slope: Converging Shoulder Slope				X	
Slope: Diverging Back Slope				X	
Slope: Diverging Foot Slope				X	
Slope: Diverging Shoulder Slope				X	

GREEN PLAN REPORT VARIABLES
(continued)

VARIABLE	I (ESPSLC)	II (ESPOXF)	III (ECOL)	IV (ESS)	V (GGEO)
Slope: Level				X	
Soil Association Group Number			X		
Soil Capability		X	X		
Soil Development (Soil Taxonomic Classifications)	X				
Soil Erodibility (Erosion Risk)		X			
Soil Erodibility (Potential)			X		
Soil Extent	X	X			
Soil Inclusion (Dominant, Subdominant)		X	X		
Soil Landscape Inclusion	X				
Soil Map Unit Name	X	X	X		
Soil Taxonomy	X	X			
Soil Transmissivity			X		
Stoniness	X				
Summer Fallow					X
Surface Form	X				
Surface Texture Class	X	X		X	
Texture Group of Parent Material	X	X	X		
Textural Class of the Parent Material	X				
Total and Rural Farm Population Indices					X
Total Farm Area					X
Total Farm Capital					X
Total Gross Farm Receipts					X
Total Manure Production Per Acre of Crop Land					X

GREEN PLAN REPORT VARIABLES
(continued)

VARIABLE	I (ESPSLC)	II (ESPOXF)	III (ECOL)	IV (ESS)	V (GGEO)
Total Number of Farms					X
Type of Compacted, Consolidated, or Contrasting Layer (Dominant Only)	X				

REPORTS: I - ESP Landscape; II - ESP Oxford; III - Ecologistics; IV - Environmental Soil Services; V - Gregory Geoscience

APPENDIX 3
GREEN PLAN REPORT VARIABLE CHARACTERISTICS

GREEN PLAN REPORT VARIABLE CHARACTERISTICS

[A] Single Component, Multiple Component, Calculations, Feasibility

Variable	Single Component	Multiple Component	Calculations / Laboratory	Feasibility
Agricultural Land Use	X	X		H
Agricultural Land Use: Built-up				H
Agricultural Land Use: Continuous Row Crop		X		H
Agricultural Land Use: Corn System		X		H
Agricultural Land Use: Grain System		X		H
Agricultural Land Use: Grazing System		X		H
Agricultural Land Use: Hay System		X		H
Agricultural Land Use: Idle (5-10 years)		X		L
Agricultural Land Use: Mixed System		X		H
Agricultural Land Use: Pasture System		X		H
Agricultural Land Use: Recreation	X			H
Agricultural Land Use: Woodland	X			H
Agricultural Use of Fungicides	X			H
Agricultural Use of Insecticides	X			H
Agricultural Use of Other Herbicides	X			H
Ap Thickness	X			H
Area	X			H

GREEN PLAN REPORT VARIABLE CHARACTERISTICS
(continued)

Variable	**Single Component**	**Multiple Component**	**Calculations / Laboratory**	**Feasibility**
Area of Census Farm(s)	X			H
Average Census Farm Size	X			H
Best Management Practices Soil Scoring (Erosion, Tillage)		X	X	L
Building and Land Capital	X			H
Bulk Density	X		X	M
Calcareousness of Parent Material	X			H
Calcium Carbonate Equivalents	X		X	M
Catena Name	X			H
Cesium Classes	X			H
Crop area	X			H
Cultivated Land	X			H
Depth to Compacted, Consolidated, or Contrasting Layer (Dominant Only)	X			H
Depth to Water Table (Dominant Only)	X			L
Drainage Class (ie. Rapid, Well, Imperfect, Poor, Very Poor)	X			H
Farm Chemical Cost	X			H
Fertilizer Cost	X			H
Fertilizer Loadings	X			H
Farm Operations Classified by Age	X			H
Farm Wages and Salaries	X			H

GREEN PLAN REPORT VARIABLE CHARACTERISTICS
(continued)

Variable	Single Component	Multiple Component	Calculations / Laboratory	Feasibility
Horizon Designation		X		H
Improved Pasture	X			H
Indices for Conventional Tillage		X	X	L
Kind of Rock Outcrop or Other Material Surface	X			H
Livestock Capital	X			H
Livestock Enterprise: Beef	X			H
Livestock Enterprise: Dairy	X			H
Livestock Enterprise: Horse	X			H
Livestock Enterprise: Hobby	X			H
Livestock Enterprise: Idle	X			M
Livestock Enterprise: Mink	X			H
Livestock Enterprise: Swine	X			H
Machinery and Equipment Capital	X			H
Machinery Repair Index		X	X	L
Manure Nitrogen Loadings		X	X	L
Mode of Deposition	X			H
Most Likely Slope	X			M
Organic Carbon	X		X	M
Particle Size Component	X			H
Particle Size Composition		X		H
Perimeter	X			M
Pesticide Loadings		X	X	L
pH	X			H

GREEN PLAN REPORT VARIABLE CHARACTERISTICS
(continued)

Variable	Single Component	Multiple Component	Calculations / Laboratory	Feasibility
Polygon Number	X			H
Precipitation	X			H
Selected Farm Expenditures	X			H
Slope (Class, Percent, Length, Simple, Complex)		X		H
Slope Class	X			H
Slope: Converging Back Slope	X			L
Slope: Converging Foot Slope	X			L
Slope: Converging Shoulder Slope	X			L
Slope: Diverging Back Slope	X			L
Slope: Diverging Foot Slope	X			L
Slope: Diverging Shoulder Slope	X			L
Slope: Level	X			H
Soil Association Group Number	X			H
Soil Capability	X			H
Soil Development (Soil Taxonomic Classifications)	X			H
Soil Erodibility (Erosion Risk)		X	X	H
Soil Erodibility (Potential)		X	X	H
Soil Extent	X			H
Soil Inclusion (Dominant, Subdominant)		X		L
Soil Landscape Inclusion		X		L
Soil Map Unit Name	X			H

GREEN PLAN REPORT VARIABLE CHARACTERISTICS
(continued)

Variable	Single Component	Multiple Component	Calculations / Laboratory	Feasibility
Soil Taxonomy	X			H
Soil Transmissivity		X	X	H
Stoniness	X			L
Summer Fallow	X			H
Surface Form		X		H
Surface Texture Class		X		H
Texture Group of Parent Material	X			H
Textural Class of the Parent Material	X			H
Total and Rural Farm Population Indices		X	X	L
Total Farm Area	X			H
Total Farm Capital	X			H
Total Gross Farm Receipts	X			H
Total Manure Production Per Acre of Crop Land		X	X	L
Total Number of Farms	X			H
Type of Compacted, Consolidated, or Contrasting Layer (Dominant Only)		X		H

[B] Direct, Indirect, Limitations, Degree of Risk

Variable	Direct	Indirect	Limitations	Degree of Risk
Agricultural Land Use	X		S,T	M
Agricultural Land Use: Built-up	X		S,T	M

GREEN PLAN REPORT VARIABLE CHARACTERISTICS
(continued)

Variable	Direct	Indirect	Limitations	Degree of Risk
Agricultural Land Use: Continuous Row Crop	X		S,T	M
Agricultural Land Use: Corn System	X		S,T	M
Agricultural Land Use: Grain System	X		S,T	M
Agricultural Land Use: Grazing System	X		S,T	M
Agricultural Land Use: Hay System	X		S,T	M
Agricultural Land Use: Idle (5-10 Years)		X	S,T	H
Agricultural Land Use: Mixed System	X		S,T	M
Agricultural Land Use: Pasture System	X		S,T	M
Agricultural Land Use: Recreation	X			M
Agricultural Land Use: Woodland	X			M
Agricultural Use of Fungicides	X			M
Agricultural Use of Insecticides	X			M
Agricultural Use of Other Herbicides	X			M
Ap Thickness	X			L
Area	X			L
Area of Census Farm(s)	X			L
Average Census Farm Size	X			L
Best Management Practices Soil Scoring (Erosion, Tillage)	X	X	BMP varies with objective	H

GREEN PLAN REPORT VARIABLE CHARACTERISTICS
(continued)

Variable	Direct	Indirect	Limitations	Degree of Risk
Building and Land Capital	X			L
Bulk Density	X		availability	L
Calcareousness of Parent Material	X		P/A	L
Calcium Carbonate Equivalents	X		availability	L
Catena Name	X			L
Cesium Classes	X	X	S	M
Crop area	X			L
Cultivated Land	X			L
Depth to Compacted, Consolidated, or Contrasting Layer (Dominant Only)	X			L
Depth to Water Table (Dominant Only)	X		S,T	H
Drainage Class (ie. Rapid, Well, Imperfect, Poor, Very Poor)	X	X	Q	L
Farm Chemical Cost	X			L
Fertilizer Cost	X			L
Fertilizer Loadings	X	X		H
Farm Operators Classified by Age	X			L
Farm Wages and Salaries	X			L
Horizon Designation	X			L
Improved Pasture	X			L
Indices for Conventional Tillage		X	S,T	H
Kind of Rock Outcrop or Other Material Surface	X			L
Livestock Capital	X			L

GREEN PLAN REPORT VARIABLE CHARACTERISTICS
(continued)

Variable	Direct	Indirect	Limitations	Degree of Risk
Livestock Enterprise: Beef	X			L
Livestock Enterprise: Dairy	X			L
Livestock Enterprise: Horse	X			L
Livestock Enterprise: Hobby	X			L
Livestock Enterprise: Idle		X		M
Livestock Enterprise: Mink	X			L
Livestock Enterprise: Swine	X			L
Machinery and Equipment Capital	X			L
Machinery Repair Index	X			H
Manure Nitrogen Loadings		X		H
Mode of Deposition	X			L
Most Likely Slope	X			L
Organic Carbon	X		availability	M
Particle Size Component	X			L
Particle Size Composition	X			L
Perimeter	X			L
Pesticide Loadings		X	S,T	H
pH	X			L
Polygon Number	X			L
Precipitation	X		S,T	M
Selected Farm Expenditures	X			L
Slope (Class, Percent, Length, Simple, Complex)	X	X	S	L
Slope Class	X			L

GREEN PLAN REPORT VARIABLE CHARACTERISTICS
(continued)

Variable	Direct	Indirect	Limitations	Degree of Risk
Slope: Converging Back Slope	X		S	H
Slope: Converging Foot Slope	X		S	H
Slope: Converging Shoulder Slope	X		S	H
Slope: Diverging Back Slope	X		S	H
Slope: Diverging Foot Slope	X		S	H
Slope: Diverging Shoulder Slope	X		S	H
Slope: Level	X			H
Soil Association Group Number	X			L
Soil Capability	X			L
Soil Development (Soil Taxonomic Classifications)	X			L
Soil Erodibility (Erosion Risk)		X	S,T	M
Soil Erodibility (Potential)		X	S,T	M
Soil Extent	X			L
Soil Inclusion (Dominant, Subdominant)	X	X		M
Soil Landscape Inclusion	X	X		M
Soil Map Unit Name	X			L
Soil Taxonomy	X			L
Soil Transmissivity		X	S,T data	H
Stoniness	X			L
Summer Fallow	X			L
Surface Form	X			L
Surface Texture Class	X			L

GREEN PLAN REPORT VARIABLE CHARACTERISTICS
(continued)

Variable	Direct	Indirect	Limitations	Degree of Risk
Texture Group of Parent Material	X			L
Textural Class of the Parent Material	X			L
Total and Rural Farm Population Indices	X	X		L
Total Farm Area	X			L
Total Farm Capital	X			L
Total Gross Farm Receipts	X			L
Total Manure Production Per Acre of Crop Land		X		H
Total Number of Farms	X			L
Type of Compacted, Consolidated, or Contrasting Layer (Dominant Only)	X			L

KEY:

X	=	yes	S	=	scale
H	=	high	T	=	time
M	=	medium	P/A	=	presence/absence
L	=	low	Q	=	qualitative

APPENDIX 4

AGRICULTURAL VARIABLES IN OTHER REPORTS OR POLICIES

DATA USED IN CRD AGRICULTURE PLANNING STUDY (1972)

- Acreages of Soil Capability Classes
- Capital Value of Census Farms
- Climatic Zone
- Costs of Production
- Farm Operator Age
- Land Use on Census Farms
- Land Values/Costs
- Level of Farm Specialization
- Relative Proportion of Improved and Unimproved Farmland
- Relative Proportion of Full and Part-Time Farmers
- Size, Number and Tenure of Farms
- Value of and Type of Products Sold on Census Farms

CRD SUMMARY OF AGRICULTURAL DATA (1979)

- Area in Specific Crops
- Area Owned and Area Rented
- Data Set Name
- Detailed Production Cost for Individual Livestock Enterprises
- Detailed Production Costs for Specific Crops
- Detailed Production Costs for Specific Livestock Products
- Environmental Information (Soil and Climate)
- Frequency of Collection
- Location of Farm or Address of Producer
- Number of Livestock by Type
- Operator Age
- Operator Socio-Economic Characteristics
- Population Size
- Quantity of Specific Livestock Products Sold
- Response Rate
- Sample Size
- Source Agency
- Total Farm Area
- Type of Data
- Value of Sales of Specific Crops
- Value of Specific Livestock Products Sold
- Yield of Specific Crops

IMPACT FACTORS ASSESSED FOR AGRICULTURE LISTED BY OMAFRA AS PART OF E.A. STATEMENT REQUIREMENTS FOR MAJOR PROJECTS

- Air, Noise, and Water Pollution
- Barriers Between Farmers
- Capital Investment in:
  - Building and Facilities;
  - Drainage;
  - Clearing;
  - Conservation;
  - Irrigation; and
  - Crops and Livestock.
- Demands for New Services
- Effects on Ingress and Egress to Farm Operations
- Existing Crops Acreage
- Feed Mills, Storage, Machinery Outlets
- Fragmentation of Fields
- Full- or Part-Time Farmer
- Homogeneity of Agricultural Community
- Impact on Farm Values
- Increase in Birds and Rodents
- Increase in Traffic (Effect on Farm Machinery Movement)
- Increase in Trespass and Vandalism
- Number and Location of Non-Farm Uses
- Number and Type of Livestock
- Official Plan Designations, Policies, Zoning
- Owner or Tenant Occupied
- Possible Changes in Growth Patterns
- Proposed Highways
- Restrictions on Farm Expansion or Management Practices
- Sewer Water Expansion
- Soil Capability for Agriculture According to CLI - % of Each Class on Site
- Soil Capability for Specialty Crops
- Surface and Subsurface Drainage
- Transportation Linkages
- Water Tables

EVALUATION OF SHORT LIST OF CANDIDATE SITES:
IWA STEP 6 - CRITERIA, INDICATOR, AND SUBINDICATORS

CRITERIA	INDICATOR	SUBINDICATOR
1 Compare potential for loss or displacement of agriculture on site	a) Loss or displacement of land resources	i) Soil capability index
		ii) Percentage of land in agricultural production
	b) Loss or displacement of agricultural infrastructure and investment	i) Index of the value of farm buildings, equipment, and quota
		ii) Index of the value of land improvements: tile drainage, soil conservation structures, and manure storage facilities
	c) Loss or displacement of farm operations with onsite headquarters	i) Index of farm operations lost or displaces where the farm operation headquarters is onsite
		ii) Index of the value of crops grown onsite, and livestock and poultry housed onsite.
	d) Potential displacement of farm operations with offsite headquarters but with some onsite land used for agriculture	i) Farmland displacement index
		ii) Index of the value of crops grown onsite, and livestock and poultry housed onsite
	e) Non-farm land use pressures	i) Property fragmentation index
		ii) Percentage of farmland worked by owner or under long-term tenancy
		iii) Residential unit index
2 Compare potential for disruption of agriculture in the offsite primary impact study zones	a) Area of land cropped	
	b) Number of livestock pastured	
	c) Number of farm operations	i) Index of farm operations with headquarters in the primary impact study zone
		ii) Index of farm operations with headquarters beyond the primary and secondary impact study zones with land used for agriculture in the primary impact study zone

EVALUATION OF SHORT LIST OF CANDIDATE SITES:
IWA STEP 6 - CRITERIA, INDICATOR, AND SUBINDICATORS
(continued)

CRITERIA	INDICATOR	SUBINDICATOR
2 Compare potential for disruption of agriculture in the offsite primary impact study zones (continued)	d) Vulnerability of agricultural product sales	i) Number of farm operation headquarters within the primary impact study zone with crop certification
		ii) Index of the value of quota held by farm operations headquartered in the primary impact study zone
		iii) Number of farm operations headquartered in the primary impact study zone with farm gate sales
	e) Area of crops to be harvested directly by the public (i.e. “pick-your-own” crops)	
	f) Area of land to produce crops used for direct human consumption (e.g. market garden crops, berries, orchards) excluding crops to be harvested directly by the public (i.e. “pick-your-own” crops)	
3 Compare potential for disruption of agriculture in the off-site secondary impact study zones	a) Area of land cropped	
	b) Number of livestock pastured	
	c) Number of farm operations	i) Index of farm operations with headquarters in the secondary impact study zone
		ii) Index of farm operations with headquarters beyond the secondary impact study zone with land used for agriculture in the secondary impact study zone

EVALUATION OF SHORT LIST OF CANDIDATE SITES: IWA STEP 6 - CRITERIA, INDICATOR, AND SUBINDICATORS
(continued)

CRITERIA	INDICATOR	SUBINDICATOR
3 Compare potential for disruption of agriculture in the offsite secondary impact study zones (continued)	d) Vulnerability of agricultural product sales	i) Number of farm operations with headquarters in the secondary impact study zone with crop certification
		ii) Index of the value of quota held by farm operations headquartered in the secondary impact study zone
		iii) Number of farm operations headquartered in the secondary impact study zone with farm gate sales
	e) Area of crops to be harvested directly by the public (i.e. "pick-your-own" crops)	
	f) Area of land to produce crops used for direct human consumption (e.g. market garden crops, berries, orchards) excluding crops to be harvested directly by the public (i.e. "pick-your-own" crops)	
4 Compare the character of agriculture within 1 km of the site	a) Strength of agriculture	i) Soil capability index for lands within 1 km of the site
		ii) Index of the value of farm buildings and equipment within 1 km of the site
		iii) Index of the value of crops grown within 1 km of the site, and of livestock and poultry housed within 1 km of the site
	b) Non-farm land use pressures	i) Property fragmentation index
		ii) Percentage of farmland worked by owner or under long-term tenancy agreement

EVALUATION OF SHORT LIST OF CANDIDATE SITES: IWA STEP 6 - CRITERIA, INDICATOR, AND SUBINDICATORS

(continued)

CRITERIA	INDICATOR	SUBINDICATOR
4 Compare the character of agriculture within 1 km of the site (continued)	b) Non-farm land use pressures (continued)	iii) Residential unit index
5 Compare potential for disruption of agriculture along preferred waste haul routes	a) Potential disruption to farm machinery/vehicle movement	i) Index of farm building complexes with direct access to waste haul routes
		ii) Number of farm service establishments with direct access to waste haul routes
	c) Potential impact on agricultural output	i) Linear extent of salt-sensitive specialty crops
6 Compare potential for disruption of agriculture along roads affected by local road closure(s)	a) Potential disruption to farm machinery/vehicle movement	i) Number of road closures
		ii) Index of farm building complexes along roads carrying rerouted traffic

AGRICULTURE PROFILE - VARIABLES

CATEGORY		ATTRIBUTE	UNIT
MAJOR	MINOR	DESCRIPTION	
1 Farmstead General	A) Number, Area, and Type	1) Total number of farms	Farms
		2) Total area of farms	Ha
		3) Average size of farms	Ha
		4) Approximate county area	Ha
		5) Farm land/county area	Ha
	B) Farmland Characteristics	1) Total cropland	Ha
		2) Total woodland (farms)	Farms
		3) Total woodland (acreage)	Ha
		4) Pasture land, all types	Ha
		5) Farm area rented/leased	Ha
2 Farm Economics	A) Farm Production Capital	1) Total capital	$
		2) Land and buildings value	Farms
		3) Land and buildings value	$
		4) Machinery and equipment	Farms
		5) Machinery and equipment	$
	B) Farm Expenses and Receipts	1) Farm production expenses	Farms
		2) Farm production expenses	$
		3) Seeds cost	Farms
		4) Seeds cost	$
		5) Commercial fertilizer	Farms
		6) Commercial fertilizer	$
		7) Agricultural chemicals	Farms
		8) Agricultural chemicals	$

AGRICULTURE PROFILE - VARIABLES
(continued)

CATEGORY MAJOR	CATEGORY MINOR	ATTRIBUTE DESCRIPTION	UNIT
2 Farm Economics (continued)	B) Farm Expenses and Receipts (continued)	9) Gas and fuel	$
		10) Hired farm labour (payroll)	Farms
		11) Hired farm labour (payroll)	$
		12) Interest Paid	$
		13) Gross receipts	$
	C) Market Value of Products	1) Corn for grain	$
		2) Wheat	$
		3) Soybeans	$
		4) Barley	$
		5) Oats	$
		6) Tobacco	$
3 Crop Production	A) Grains	1) Corn for grain	Farms
		2) Corn for grain	Ha
		3) Corn for grain	MT
		4) Barley for grain	Farms
		5) Barley for grain	Ha
		6) Barley for grain	MT
		7) Oats for grain	Farms
		8) Oats for grain	Ha
		9) Oats for grain	MT
		10) Rye for grain	Farms
		11) Rye for grain	Ha

AGRICULTURE PROFILE - VARIABLES
(continued)

CATEGORY		ATTRIBUTE	UNIT
MAJOR	MINOR	DESCRIPTION	
3 Crop Production (continued)	A) Grains (continued)	12) Canola and rapeseed	Farms
		13) Canola and rapeseed	Ha
		14) All wheat for grain	Ha
	B) Seeds, Hay, Forage, and Silage	1) Alfalfa hay	Farms
		2) Alfalfa hay	Ha
		3) Tame hay	Farms
		4) Tame hay	Ha
		5) All hay	Ha
		6) Corn for silage	Farms
		7) Corn for silage	Ha
		8) Corn for silage	MT
	C) Tobacco, Beans, and Peas	1) Tobacco	Farms
		2) Tobacco	Ha
		3) Tobacco	Kg
		4) Soybeans for beans	Farms
		5) Soybeans for beans	Ha
		6) Soybeans for beans	MT
		7) Dry edible beans	Farms
		8) Dry edible beans	Ha
		9) Sugar beets for sugar	Farms
		10) Sugar beets for sugar	Ha
	D) Vegetable	1) Asparagus	Farms
		2) Asparagus	Ha

AGRICULTURE PROFILE - VARIABLES
(continued)

CATEGORY		ATTRIBUTE	UNIT
MAJOR	MINOR	DESCRIPTION	
3 Crop Production (continued)	D) Vegetable (continued)	3) Head cabbage	Farms
		4) Head cabbage	Ha
		5) Carrots	Farms
		6) Carrots	Ha
		7) Cauliflower	Farms
		8) Cauliflower	Ha
		9) Cucumbers and pickles	Farms
		10) Cucumbers and pickles	Ha
		11) Lettuce and romaine	Farms
		12) Lettuce and romaine	Ha
		13) Dry onions	Farms
		14) Dry onions	Ha
		15) Green peas	Farms
		16) Green peas	Ha
		17) Hot and sweet peppers	Farms
		18) Hot and sweet peppers	Ha
		19) Irish potatoes	Farms
		20) Irish potatoes	Ha
		21) Sweet corn	Farms
		22) Sweet corn	Ha
		23) Tomatoes	Farms
		24) Tomatoes	Ha
		25) Turnips	Farms

AGRICULTURE PROFILE - VARIABLES
(continued)

CATEGORY		ATTRIBUTE	UNIT
MAJOR	MINOR	DESCRIPTION	
3 Crop Production (continued)	D) Vegetable (continued)	26) Turnips	Ha
		27) Snap (green) beans	Farms
		28) Snap (green) beans	Ha
		29) Broccoli	Farms
		30) Broccoli	Ha
		31) Nursery under glass	Sq M
	E) Fruits and Berries	1) Apple (total)	Farms
		2) Apple (total)	Ha
		3) Cherries (total)	Farms
		4) Cherries (total)	Ha
		5) Grapes	Farms
		6) Grapes	Ha
		7) Peaches	Farms
		8) Peaches	Ha
		9) Pears	Farms
		10) Pears	Ha
		11) Strawberries	Farms
		12) Strawberries	Ha
		13) Blueberries (total)	Farms
		14) Blueberries (total)	Ha
4 Livestock and Poultry Production	A) Cattle and Calves	1) Total cattle and calves	Farms
		2) Total cattle and calves	N
		3) Beef cows inventory	Farms

AGRICULTURE PROFILE - VARIABLES
(continued)

CATEGORY MAJOR	CATEGORY MINOR	ATTRIBUTE DESCRIPTION	UNIT
4 Livestock and Poultry Production (continued)	A) Cattle and Calves (continued)	4) Beef cows inventory	N
		5) Dairy cows inventory	Farms
		6) Dairy cows inventory	N
		7) Feeder (slaughter) beef	N
	B) Hogs and Pigs	1) Total hogs and pigs	Farms
		2) Total hogs and pigs	N
	C) Poultry	1) All chicken	Farms
		2) All chicken	N
		3) Total layers	N
		4) Broilers	N
		5) Turkeys	Farms
		6) Turkeys	N
	D) Others	1) Sheep and lamb inventory	Farms
		2) Sheep and lamb inventory	N
		3) Horses and ponies	Farms
		4) Horses and ponies	N
		5) Total goats	N
5 Chemicals / Fertilizers and Practices	A) Chemicals and Fertilizer	1) Commercial fertilizer	Farms
		2) Commercial fertilizer	Ha
		3) Herbicides	Farms
		4) Herbicides	Ha
		5) Insecticides or fungicides	Ha
	B) Irrigation	1) Farms irrigated	Farms

AGRICULTURE PROFILE - VARIABLES
(continued)

CATEGORY		ATTRIBUTE	UNIT
MAJOR	MINOR	DESCRIPTION	
5 Chemicals / Fertilizers and Practices (continued)	B) Irrigation (continued)	2) Irrigated land	Ha
	C) Tillage Practices	1) Conventional tillage	Ha
		2) Conservation tillage	Ha
		3) No till	Ha
		4) Total conservation tillage	Ha

- Annual growing degree days
- Surface materials in the Great Lakes Basin
- Slopes exceeding 9%
- Inherent soil quality - soil porosity, nutrient retention, physical rooting conditions, chemical rooting conditions
- Population density
- Rented/leased land
- On-farm woodlands
- Susceptibility to water erosion
- Risk of declining soil qualityx