Report of the Second National Consultation Workshop on Agri-environmental Indicators for Canadian Agriculture

Agriculture Canada

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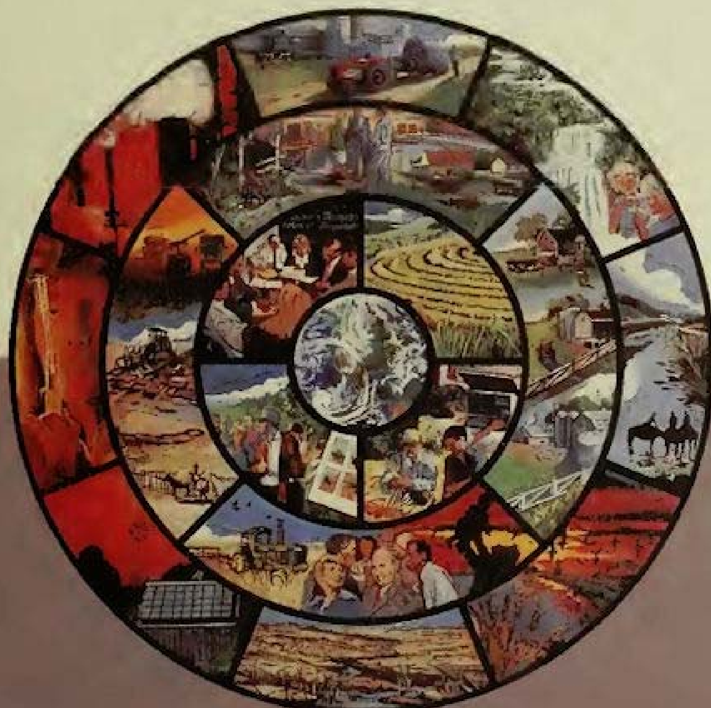

Environment

Bureau

REPORT OF THE SECOND NATIONAL CONSULTATION WORKSHOP ON AGRI-ENVIRONMENTAL INDICATORS FOR CANADIAN AGRICULTURE

Prepared by

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March 1995

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Rapport sur le deuxième atelier de consultation nationale sur les indicateurs agroenvironnementaux pour l'agriculture canadienne

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ACKNOWLEDGEMENTS

The second national consultation workshop on agri-environmental indicators for Canadian agriculture was a collaborative effort between Agriculture and Agri-Food Canada and the Eastern Canada Soil and Water Conservation Centre (ECSWCC) in Grand Falls, New Brunswick.

Many individuals collaborated at every stage of the preparatory process to ensure a successful consultation. Gratitude is therefore extended to the following persons:

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1.0 INTRODUCTION

This report summarizes the results of the second national consultation workshop on agri-environmental indicators (AEIs) for Canadian agriculture, held in Fredericton, New Brunswick on 9 and 10 February 1995. The first national consultation was held on 6 and 7 December 1993 in Aylmer, Quebec [1].

The Fredericton workshop was attended by some 70 participants (see Attachment 2), representing: eight provincial governments, four federal departments, numerous agricultural producers and farm organizations, conservation agencies, non-government organizations and the university community.

The objectives of the workshop were to:

- discuss, exchange and clarify ideas and approaches to developing relevant and credible
- agri-environmental indicators (AEIs) for Canadian agriculture;
- identify and explore opportunities for collaborating in their development;
- provide scientific and policy advice to Agriculture and Agri-Food Canada (AAFC) on the development of AEIs.

Officials and researchers from AAFC reported in plenary on progress achieved in advancing work on AEIs since the initial consultation seminar held in December 1993. This included a review of:

- objectives and uses for AEIs;
- design aspects of the indicator project;
- progress achieved in developing priority AEIs;
- plans for continued development of AEIs.

Indicator researchers also identified constraints and challenges encountered in their work and invited participants to consider how these might be addressed.

Officials from other agencies and jurisdictions, including representatives from non-government and farm organizations, gave a number of presentations in plenary session summarizing their initiatives and/or perspectives as related to AEIs for Canadian agriculture.

Two Breakout Group sessions were held. Breakout Session A focussed on substantive issues related to the development of specific AEIs. These discussions were based, in part, on a series of papers and questions identified by indicator researchers for their respective indicator(s) (see Attachment 4). In Breakout Session B, participants discussed broader questions concerning the overall approach proposed for developing AEIs, opportunities and mechanisms for collaborating in their development and their views on the priority uses and applications for the AEIs (see Attachment 5).

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[1] For the results of the Aylmer workshop see: McRae, T. and N. Lombardi. 1994. *Report of the Consultation Workshop on Environmental Indicators for Canadian Agriculture.* Agriculture and Agri-Food Canada, May 1994, Ottawa.

2.0 THE AGRI-ENVIRONMENTAL INDICATOR PROJECT

The Agri-Environmental Indicator Project of AAFC was initiated in 1993, in response to recommendations made by a number of agencies, organizations and special studies. The overall objective of the project is to support the larger policy goal of integrating environmental considerations into decision-making processes at all levels in the agri-food sector. In this sense, AEIs are part of a decision-making process that involves problem identification, assessment of severity, formulation of response options, implementation of selected options (i.e. policies, programs, actions, etc.) and assessment of the effectiveness of the actions taken. This information is then fed back into the decision-making cycle.

The project aims to develop a core set of regionally-sensitive national indicators that build on and will enhance the information base currently available on environmental conditions and trends related to primary agriculture in Canada. Key clients for the information include decision-makers in government and industry and other interested stakeholders.

The AEIs will yield several benefits, such as, for example:

- improving understanding about the nature, extent and location of environmental risks and benefits related to agriculture;
- facilitating the design and targeting of agri-environmental strategies, policies and programs;
- strengthening AAFC's capacity to assess the environmental impacts of its existing and new policies and programs by supporting the development of analytical tools (such as quantitative models) which can predict the directions of change of specific indicators;
- assessing the agri-food sector's progress towards environmentally-sustainable agriculture;
- facilitating communication with various public and institutional clients;
- supporting Canadian positions and strategies in areas such as international trade.

The AEIs are being developed in consultation with potential users and with a broad group of stakeholders. The focus of the Fredericton workshop was on the twelve priority AEIs identified to date in AAFC's AEI Project.

In general, the period prior to 1996 will focus largely on developing priority indicators and preparing interim or progress reports, with consultations and collaboration work to be ongoing. A comprehensive report on the project is scheduled for the period following the 1996 Census of Agriculture, although results for some indicators will be reported before then.

3.0 WORKSHOP RESULTS

The principal points raised by participants are presented in this section. Section 3.1 summarizes the main points made in response to the questions discussed in Breakout Group Session "B" (see Attachment 5). Section 3.2 lists the main points made in Breakout Group Session "A" on each specific AEI, in response to the discussion points identified for each indicator (see Attachment 4).

3.1 General Points

3.1.1 Conceptual Framework

Participants emphasized that:

- A conceptual framework for the indicators must clearly show how the indicators will link to decision-making processes at the federal, provincial and industry levels. While the Stewardship-State-Productivity framework provides structure to the project, other elements should also be explored. For example, it was suggested that to achieve agri-environmental sustainability, a re-design of farming systems will be required and that an indicator to measure re-design of production systems would be appropriate.
- The OECD Pressure-State-Response model was also identified as a useful model to adopt. In particular, a balance between behavioral or process indicators and environmental condition or state indicators is required, in order to measure the effectiveness of policy.
- A clearer linkage between AEIs and priority agri-environmental issues is required, such as soil and water quality.
- Consideration should be given to also developing AEIs that relate to the secondary food processing sector.

3.1.2 Agri-Environmental Objectives & Targets

- Participants emphasized that AEIs should provide accountability in terms of whether or not environmental goals and objectives are being achieved. Several suggested that the AEIs should be linked more directly to corresponding environmental policy objectives and targets for Canadian agriculture. Where such targets do not exist they should be developed.

3.1.3 Project Objectives & Uses of Indicators

Participants emphasized that:

- The objectives of the indicator project, and the uses that will be made of the AEIs, should be more clearly defined. It was suggested that the indicators could either be used as marketing tools or as information and evaluation tools. A range of potential uses were identified and discussed, ranging from: providing support to international trade negotiations, informing senior policy-makers of agri-environmental conditions and trends, using indicators as diagnostic tools for use in targeting programs, and farm-level indicators for use by producers.
- The AEI project had possibly been mis-represented as a tool that will address information needs at all levels. Many participants felt the federal government should focus on developing indicators at the broader level (eg. inform senior policy-makers of policy impacts, support international trade) while lower levels of aggregation might best be addressed by other agencies, such as the provinces. Others felt that higher-level indicators might not be useful to farm needs and that effort should concentrate on developing more spatially detailed indicators.
- The uses made of AEIs will influence the scale at which they should be reported. It was felt that priority uses and scales should be decided for each indicator as this will affect how design and development work is organized and proceeds on each.

3.1.4 Integration of Indicators

Participants emphasized:

- The inherent complexity of agroecosystems, in terms of linkages between farm management, impacts on resources and productivity, as well as the challenge of identifying a manageable number of indicators that reflect these linkages and which provide a useful model of conditions and trends within agroecosystems.
- That several of the 12 AEIs as proposed linked closely with one another and should be perhaps be more fully integrated or combined. Many participants felt that the number of indicators was too large and that between 4 and 6 should be identified for development, with minimal overlap among them.

3.1.5 Substantive Focus of the Indicators

- There was strong consensus that the adoption rate of best management practices (BMPs) should be measured as AEIs, as BMPs provide a direct signal of the farm community's efforts in moving towards environmentally-sustainable agriculture. However, several participants cautioned that careful selection of BMPs will be required and that they must be tailored to particular regions and production systems, which may be difficult to reconcile on a national basis.
- It was felt that AEIs were also required to measure the impacts (beneficial or adverse) of farm practices on the environment in order to inform decision-makers of whether use of BMPs and other management systems and approaches were having the desired effects.

3.1.6 Communications and Consultations

- All participants acknowledged the need to continue to work together collaboratively in the indicator development process. Participatory-Action-Research, additional consultation workshops and technical workshops and the National Agriculture Environment Committee (as a means of linking with the sector) were identified as possible mechanisms. Establishing linkages between national and international efforts in this area was also encouraged.
- It was also suggested that the AAFC indicator researchers needed to be much more proactive in reaching out to interested stakeholders and possible collaborators regarding the evolution of their work.

3.1.7 Costs of Developing AEIs

- Several participants raised concerns about the costs of developing AEIs and whether this work might compete with government resources aimed at promotion farm-level actions to achieve environmentally-sustainable agriculture. Other participants suggested that indicators are essential to the decision-making process/cycle and that a balance is required between analysis and supporting ground-level actions. It was also pointed out that indicators can be highly cost-effective as a set of representative indicators will eliminate the need for more detailed (and expensive) monitoring of activities and impacts in the environment.

3.2 Comments on Specific Agri-Environmental Indicators

3.2.1 Crop Yield and Variability

- Participants felt that on its own as an indicator, particularly at an aggregate level, yield could be very misleading and difficult to interpret. It was also pointed out that yield data was incorporated into other indicators, such as Input Use Efficiency and Nutrient Balance. On this basis most participants recommended that the yield indicator be dropped.

3.2.2 Input Use Efficiency

- The concept of developing input/output ratios for selected inputs in agriculture was endorsed. It was suggested that this indicator could be expanded to also include water as an input.

3.2.3 Nutrient Balance

- Some participants questioned whether current scientific understanding about nutrient dynamics in soils was sufficiently advanced to allow for development of this indicator; others pointed out that it was not the soil nutrient balance that was to be measured but the flows of nutrients into and out of soils, but that both elements are related.
- It was felt that nutrient balance was a better indicator that existing nutrient use and nutrient use intensity indicators. To proceed, an appropriate scale for calculating and reporting the indicator must be specified as this will influence the methodology adopted for development.

3.2.4 Pesticide Risk

- Discussion on the Pesticide Risk indicator focused on three suggested points: an indicator of reliance on pesticides is what should be developed; BMPs should be used as indicators to track risk from pesticides; a use factor combined with a risk factor was a useful and improved measure over current pesticide indicators, which tend to focus on use patterns only. The challenge and difficulty of developing a pesticide risk classification system was also mentioned. Overall, no consensus recommendation emerged on how to proceed with this indicator.
- The possibility of linking or integrating the indicator with other indicators was discussed, as was the need for better data on pesticide use.

3.2.5 Water Contamination Risk

- Participants agreed that an indicator which relates agriculture to water quality impacts was of high priority and supported continued work on the development of this indicator. Several specific suggestions were offered regarding the technical aspects of its development (in relation to selection of water quality objectives, grouping of pesticide compounds, aggregation of indicators of risk by contaminant, etc.). A broad regional approach for the indicator was suggested, complemented by more localized analysis in high-risk areas. The indicator should be verified with water quality monitoring data.

3.2.6 Soil Degradation Risk

- Participants supported continued development of this indicator and suggested that it be expanded to include soil compaction since this is a major form of soil degradation in areas of central and eastern Canada.

3.2.7 Agroecosystem Biodiversity

- Participants discussed the challenges involved in developing this indicator, including: how to define agroecosystems, selection of appropriate baseline conditions and how to interpret the significance of change in biodiversity that has occurred. It was commented that the indicator would require basic research and that the cost of monitoring biodiversity change could be substantial. It was suggested that biodiversity change could perhaps be addressed at the habitat level through the habitat availability indicator.

3.2.8 Agroecosystem Habitat Availability

- Habitat availability was seen as an appropriate indicator that should track changes to various habitat types in agroecosystems. Various data sources were discussed, as were the limitations of the Census of Agriculture as a source of habitat data. Fragmentation was identified as an important variable for the indicator. The potential for the habitat indicator to serve as a proxy for the agroecosystem biodiversity indicator was also discussed.

3.2.9 Soil Cover & Management

- This indicator was discussed in terms of its components. The cover component was seen as a component and data set for other indicators, particularly Soil Degradation Risk, and thus should perhaps be integrated into other indicators. The land management component was seen as essential, particularly in light of the strong endorsement of BMPs as useful agri-environmental indicators, and could perhaps be combined into a broader BMP indicator. A range of land management practices should be considered in addition to the present focus on tillage. Temporal trends should be established over as long a time period as possible and feasible.
- Questions and concerns were raised and discussed regarding the validity of the census of agriculture data on tillage practices in the Atlantic region.

3.2.10 Inputs Management

- The input management indicator was endorsed in the context of the larger endorsement of farm management indicators. Additional work will be required to identify and select key BMPs as indicators for inputs, such as fertilizers and pesticides. The farm community expressed an interest in participating in this work and felt that substantial progress had been made in this area.

3.2.11 Agroecosystem Greenhouse Gas Balance

- This indicator was endorsed for continued research and development.

3.2.12 Irrigation System Efficiency

- The utility of an indicator of irrigation efficiency was endorsed and participants considered the possibility of combining it with Input Use Efficiency without making any firm recommendations to that effect.
- Participants also suggested that water use efficiency as related to irrigation should be measured at various stages of the irrigation water development, delivery and use cycle.

3.3 Closing Remarks and Next Steps.

- The chairperson of the workshop (L. Ouellette) emphasized the broad scope and high quality of the discussions and her overall satisfaction with the results achieved.
- T. McRae of Agriculture and Agri-Food Canada summarized the main points and results of the workshop and responded to several of the concerns raised. The success of the meeting in engaging a broader group of stakeholders, including many representatives from the agri-food sector, was emphasized. Next steps were discussed, as follows:

    - the results of the workshop would be analyzed and distributed;
    - approaches and mechanisms for involving interested stakeholders more fully and frequently in the work to develop agri-environmental indicators would be explored;
    - adjustments to the approach being used for developing agri-environmental indicators would be considered and the draft implementation plan for the AEI project would be revised to:
    -
        - clarify the objectives and uses of the indicators, and, based on this, the scales of reporting;
        - review the proposed indicators in order to further integrate them into a smaller set of comprehensive indicators;
        - link the selected AEIs more clearly to agri-environmental issues and objectives; place more emphasis on farm resource management and the use of adoption of BMPs as indicators.

ATTACHMENT 1: WORKSHOP PROGRAM
THURSDAY, 9 FEBRUARY 1995

8:30 Opening Remarks

- L. Ouellette, Eastern Canada Soil & Water Conservation Centre (Workshop Chair)
- T. McRae, AAFC

9:00 National & International Perspectives on AEIs

- Developments Within AAFC, T. McRae, AAFC
- Developments at the Federal Level, I. Marshall, Environment Canada
- The International Context, T. McRae, AAFC.

10:15 Progress on Specific AEIs at AAFC

- Input Use Efficiency, S. Narayanan, AAFC
- Inputs Management, M. Spearin, AAFC
- Nutrient Balance, D. Moon, AAFC
- Pesticide Risk, D. Pelka, AAFC
- Water Contamination Risk, K.B. Macdonald, AAFC
- Crop Yield & Variability, S. Smith, AAFC
- Agroecosystem Greenhouse Gas Balance, P. Rochette, AAFC
- Agroecosystem Biodiversity, I. Smith, AAFC
- Agroecosystem Habitat Availability, T. Weins, AAFC
- Irrigation System Efficiency, T. O'Brien, AAFC
- Soil Cover & Land Management, S. Smith. AAFC
- Soil Degradation Risk, S. Smith, AAFC

15:30 Breakout Group Session "A" - Substantive Discussions on AEIs.

17:30 Poster Session

19:00 Reception

FRIDAY, 10 FEBRUARY 1995

8:30 Reports From Breakout Group Session "A"

10:15 Presentations & Perspectives on AEIs

- University of Guelph, G. Wichert
- Université Laval, S. Tessier
- Environment Canada Ontario Region, H. Shear
- National Agriculture Environment Committee, J. Wilkinson
- Ontario Farm Environment Coalition, R. George, J. Wilson
- Canadian Organic Advisory Board, G. Hamblin
- Pest Management Alternatives Office, J. Swainson
- Crop Protection Institute, J. Shaw
- Canadian Fertilizer Institute, T. Bruulsema

13:00 Breakout Group Session "B" - Stakeholder Perspectives on AEIs.

14:30 Reports from Breakout Group Session "B"
Synthesis & Discussion
Closing Remarks

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ATTACHMENT 3: LIST OF POSTERS PRESENTED.

- Université Laval, Eco-recherche agricole. (Sylvio Tessier).

- Ministére de l'agriculture, des Pêcheries et de l'Alimentation Evaluation de la qualité du sol et de l'eau. (Aubert Michaud)

- Agriculture and Agri-Food Canada

  - Ecological Stratification Framework for Canada (Scott Smith)
  - Using Indicators to Assess the Health & Management of Agroecosystems (Scott Smith)
  - Agricultural Greenhouse Gas Balances (Philippe Rochette)
  - Nutrient Balances in the Fraser Valley (Dave Moon)
  - Black Brook Watershed Soil & Water Quality Indicators (Herb Rees)
  - Soil Benchmark Monitoring (Herb Rees)
  - Environmental Impacts of Agricultural Policies (Bruce Junkins)
  - EcoRegions of Saskatchewan Map (Bill Barron)
  - Groundwater Quality (P. Milburn)

- Prince Edward Island Department of Agriculture, Residue Cover & Management with Potato Production (Ron DeHaan)

- Environment Canada, Canadian Environmental Quality Guidelinens to Sustain Agmecosystems (Connie Gaudet & Pierre-Yves Caux)

- Alberta Agriculture, Key Conservation Indicators Monitoring (Rhonda Wehrhan)

ATTACHMENT 4: INDICATOR PAPERS DISCUSSED IN BREAKOUT GROUP SESSION "A"

The papers below were prepared by AAFC researchers involved with developing AEIs to guide discussions in Breakout Group Session "A". Participants were asked to focus on the questions listed at the end of each paper.

The order of presentation for each of the papers is as follows:

No paper was prepared for the indicator "Irrigation System Efficiency".

Summary of Crop Yield & Variability Indicator

Indicator Description

The indicator reports the long-term trend in yield, and in variability of yield, for selected major agricultural crops. The measurable parameters include actual crop yield and weather-adjusted crop yield (kg/ha) and variability of yield from historical trends, i.e standard deviation (kg/ha) and/or coefficient of variation (%).

Indicator Rationale

Crop yield is the result of interactions among soil, weather and management inputs. The variability of yields and the risks of crop production appear to be increasing in some regions possibly due to increased weather variability, particularly increased frequency of droughts, and climate change. At the same time, intensive, high input crop production practices are resulting in soil degradation in some areas, thereby decreasing yields and increasing yield variability and adversely affecting the uncertainties of production and economic returns. Knowing the causes of yield decreases or added variability is necessary for developing proper ameliorative measures and to formulate policy initiatives to avoid and/or overcome the yield losses.

Strategy for Developing the Indicator

Trends of crop yield and crop yield variability will be developed from long-term yield records, as collected by crop insurance programs. Weather- and/or management adjusted crop yields will also be calculated using crop growth models, calibrated for the most important agro-environments in Canada.

Challenges and Obstacles

Provincial crop insurance records vary considerably in both spatial and temporal coverage. For example, in Manitoba, approximately 80% of the agricultural area of the province will be covered if a period of 10 years is considered. However, only 40% of the same area is covered if the period of record is 20 years. Similar findings are expected in other provinces and obviously a 'trade-off between spatial and temporal coverage will have to be made.

Separating the effects of weather and various management practices (e.g. N fertilization, rotations, tillage practices, etc.) upon crop yield requires the use of carefully validated crop growth/management simulation models. Long-term experimental data could be used to validate such model, but a protocol for valid regional assessments has not been established.

Different crops are grown in different regions of Canada. Since the indicator is crop specific, different indicators will be developed for different regions of the country. The development of a 'universal' (i.e. Canada wide) indicator based on measured crop yield and variability is presently not under consideration.

Progress Achieved to Date

Records obtained from the Manitoba Crop Insurance Corporation (MCIC) were used to evaluate long-term trends in yield and yield variability for 4 selected Agroecological Resource Areas (ARA's) in Manitoba. Since the objective of the study was to evaluate yield trends beyond the ability of the farmer to control, records were selected from the database according to the following criteria: i) the crop had to be spring wheat; ii) yields had to come from fields not summerfallowed the previous year, with nitrogen applications in excess of 45 kg N ha^{-1}; and iii) only years with 10 or more observations meeting the first 2 criteria were included.

The patterns of mean annual yield for the 4 ARA's in which the predominant soil texture is sand, loam, clay loam and clay is shown in Fig. 1. The yields continue to trend upwards (positive slopes differ significantly from zero at $P<0.05$) in the clay loam and clay soils, but not in the sandy and loam soils. Conversely, the slopes of the coefficient of variability of annual yields (Fig. 2) are significantly different from zero for sandy and loam soils, but not for the clay loam and clay soils. This suggests that crop yields have stabilized in sandy and loam soils, but more importantly, the risks of crop production on these soils is increasing significantly.

Next Steps

Long term trends of wheat yield and wheat yield variability will be calculated for the Prairie region, using data collected by the provincial crop insurance corporations. (performance indicator (PI) description of wheat yield and wheat yield variability over time in the prairies).

Crop growth/management models for selected crops in the prairie provinces will be tested and validated (P.I. comparison of modelled and observed crop yields).

Weather data and crop growth models will be used to remove weather trends from observed crop yield and crop yield variability for selected ARA's in Manitoba (P.I. ARA climate database; weather trends removed from crop yield data).

Crop insurance data from the other provinces and, if necessary, crop yield data from Statistics Canada, will be collated, as will long-term experimental data. (P.I. archived crop yield database). Required weather data will be prepared on an ARA basis.

Questions/Points for Discussion

1. The development of the indicator is presently focussed on spring wheat grown in the Prairies. Which crop(s) and/or geographic regions should be considered next? Are there sufficient data to validate crop growth/management models for crops other than wheat? How accurate should we be able to simulate annual crop yields?

2. The recording of crop insurance yield records started in earnest during the early seventies. What is a minimum period of records (20, 15 or 10 years)? How do we balance temporal and spatial coverage? Can we use additional sources of long-term data?

3. What opportunities for collaboration (eg. data exchange, etc) exist for developing this indicator?

R. de Jong
AAFC, 25 January 1995

Summary of Input Use Efficiency Indicator

Indicator Description

This indicator provides a measure of the use efficiency of chemical inputs of fertilizers, pesticides and energy (farm fuel and electricity) used in Canadian agriculture over time. The trends in this measure can also provide an indirect perspective on the potential direction of environmental impacts. This indicator is in fact the reciprocal of the partial productivity of inputs.

Quantities of fertilizer, pesticide and energy inputs are obtained on an annual basis for each input item. Physical quantity data and implicit quantity data (derived from expenditure data in constant prices) are used. These quantities are then aggregated and indexed, linked to a base year being 100, using corresponding price and share weights for fertilizers, pesticides and energy respectively. Annual indexes for aggregate output were also developed in the same manner for crop and total output respectively.

The aggregate input index (numerator) is then divided by aggregate **crop** output index (denominator) to arrive at the indicator of input use efficiency for fertilizers and pesticides as these are, by and large, applied to crop production. For the input use efficiency indicator for energy, the aggregate input use index for energy is divided by the **total** output index (i.e. crop and livestock output) since energy is used for both crops and livestock. The reverse of this process gives the partial productivity index for the respective inputs.

The indicator can be calculated at various levels: national, eastern Canada, western Canada, prairie Canada and non-prairie Canada. The dividing line for the eastern and western regions of the country is the Ontario/Manitoba border. On a temporal scale, the indexes are available for the 1961 to 1992 period. The analysis will be confined to the 1980 baseline year and beyond because of a) the 1960's and 1970's being the innovation, adoption and adjustment phases for capital and technical inputs, and b) the transition in the agro-economic situation in the 1980's and the 1990's due to agriculture policy reform in Canada, and c) the global trade liberalization making this period relevant to current policy analysis.

Data are obtained from the AAFC data accounts which include annual quantities, expenditures, prices and price indexes for most of the input and output commodities by provinces and regions. These data accounts were established for constructing input, output and multi-factor productivity indexes for Canadian agriculture. The primary source for the data sets is mainly Statistics Canada and in some cases input industry associations.

Indicator Rationale

The indicator provides some idea of the efficiency of agriculture sector regarding the use of environmentally sensitive farm inputs such as fertilizers, pesticides and energy. Efficiency of input use can provide some idea of the relative potential for environmental impacts from input use, thus the direction of change will be used to interpret environmental significance. This indicator is easy to understand as the efficiency is expressed in terms of quantity of input used to produce one unit of crop output both measured in consistent constant dollar values. The trends over time in this indicator are likewise easy to interpret as the increasing trend in efficiency reflecting the use of relatively less inputs per unit of output implies that the relative potential environmental impacts can decrease concomitantly. This provides an important signal to policy makers.

The input efficiency indicator is not, however, an unambiguous measure of the relationship between agriculture production and environmental impacts. Rather this indicator provides only indirect information on the potential direction of environmental impacts with no direct explanation of the causes for change in efficiency trends. Linkages with other indicators and qualitative interpretation are necessary to explain the causes of change.

Progress to Date

Aggregate Input Efficiency Indicators for pesticides, fertilizer and energy inputs have been constructed for Canada, eastern Canada, western Canada, Prairies and Canada without Prairies by AAFC. A discussion paper based on the analysis of these indicators is in progress. At the Fredericton workshop, indicators for fertilizer and pesticide input will be presented .

Next Steps

Immediate plans are to incorporate comments from workshop discussions and finalize the discussion paper for circulation and peer review.

Questions / Points for Discussion

1. Do the trends in input efficiency indicators measured from economic information as described above provide a relevant signal to the industry and policy makers regarding the efficiency of input use and potential environmental impacts? What are the shortcomings and how might these be addressed?

2. Do you have any comments on the efficiency use indicators for fertilizers, pesticides and energy as described in this handout, with regard to:

    - Use of implicit quantity data as a proxy for actual quantities used
    - Inclusion of only chemical fertilizers
    - Not dis-aggregating pesticides by active ingredients based on environmental risks
    - The possible use of threshold values for comparison etc.? How important are these? Is the direction of change sufficient to provide a broad interpretation for the indicator?

3. Should additional research focus on developing input use efficiency indicators to measure the physical quantity of inputs required per unit volume of output for a limited number of major products (eg. wheat, corn, milk, etc)? Do relevant time series data exist for quantity of chemical inputs used by crop? If not, how might such data be obtained?

4. How might the input use efficiency indicator be linked with related indicators, such as nutrient balance?

S. Narayanan
AAFC, 25 January 1995

Considerations for Developing the Nutrient Balance Indicator

Introduction

The concept of a nutrient balance implies a balance between at least two things; in simplistic terms this would be nutrient additions and losses. Although many workers propose a simple ratio of additions to losses as a useful indicator, unfortunately a simple ratio may not be consistently interpretable. For example, if additions exceed losses, the soil may be improving and/or pollution occurring. If losses exceed additions, the soil may degrading or, conversely, a new and more productive equilibrium being established.

The reality will be governed by the balance of biological, chemical, and physical processes rather than a simple I/O ratio. It will be reflected in things like nutrient use efficiency, changes in forms and availabilities of resident nutrients, and changes in the balance of soil processes involving the nutrient. In addition, nutrient use efficiency and nutrient availabilities are strongly influenced by type and timing of management activities (e.g., banding, side-dressing, cultivation, etc.).

The appropriate balance will not necessarily be a 1:1 ratio. It is probable that the appropriate ratio will vary by climatic region, soil type, and management system. Underlying factors such as recovery efficiency, transformations (including volatilization, mineralization, denitrification, and immobilization) and leaching losses will influence the optimal ratio. Environmental sensitivity, conditioned in part by proximity and nature of surface and ground water bodies, will also be regional and will influence acceptable balances. Finally, long term fertilizer use may change the biochemical dynamics of the soil system. In addition, economic and environmental optima may not coincide.

Relationship to Other Indicators

It is clear that a nutrient balance indicator links in concept, data requirements, data acquisition, predictive techniques, application, and interpretation with other indicator initiatives being supported by Agriculture and AgriFood Canada (AAFC). Such linkages are particularly strong with the following indicators which are under development:

1. Soil Degradation Risk
   - Including organic matter depletion (nitrogen, and to a lesser extent phosphorus, are intimately related to organic carbon processes) and erosion,
2. Input Management,
3. Input Use Efficiency, and
4. Water Contamination Risk.

Potential exists for duplication of effort regarding data collection and analysis, and potentially conflicting interpretations. There are, conversely, opportunities for shared data acquisition and integration, analysis and interpretation, and the preparation of an integrated composite indicator in addition to the individual indicators being sponsored.

International Work

International literature reflects a dual role for nutrient balance work. Nutrient balances are being used to both evaluate potential pollution issues and to address the problem of soil mining. The emphasis tends to be regional with Africa, the Indian sub-continent, and areas of south east Asia emphasizing nutrient supply to crops and Europe and North America emphasizing pollution issues. Australian work seems to split fairly evenly. The OECD recently endorsed national-scale nutrient balances as priority indicators for development in its agri-environmental indicator initiative.

If the indicators program is to be used in international trade negotiations to encourage sustainable and nonpolluting production systems then the Canadian program should be consistent with and comparable to work in other countries and regions.

Major Soil Processes

There are four general soil processes which influence nutrient availability and losses. These are additions to the system which will increase the nutrient capital, transformation (changes in the compounds containing the nutrient) which will influence the nutrients availability and susceptibility to loss, translocation (movement from one location in the soil to another) which will influence its availability to plants at different growth stages, and losses from the system which will decrease the nutrient capital. All of these issues will be influenced by the type and timing of management procedures.

Indicator Model Selection

The calculation of a nutrient balance indicator will require the use of one or more models to predict the balance of additions, transformations, translocation, and losses. The choice of model or models should be based on the balance between:

1. the required levels of reliability and precision, and
2. the costs of data acquisition and model execution necessary to meet this level or reliability and precision.

This will require determination of the required levels of reliability and precision and then evaluation of available models and available data to determine which best meets the program needs or alternatively, simply doing the best possible within available resources.

Tentative Approach

The approach will probably have to consider strong regional differences; for example, from the Fraser Valley of British Columbia (where leaching is common and ground water contamination is the critical issue) to areas of the Prairies (where leaching is sporadic and nutrient depletion may be the issue). The interpretation of a simple I/O balance in isolation from management systems and climatic and soil variation will provide, at best, crude indications of extreme over or under fertilization. Some combination of I/O analysis in combination with prevalent regional management systems and regional climate may be a useful approach.

Questions / Points for Discussion

1. While nutrients are required for crop production, under-fertilization can lead to soil depletion while over-fertilization can lead to deterioration of surface and ground water quality. Thus, two nutrient balance related issues are apparent. The first is agricultural resource sustainability and the second is the environmental impact of agricultural activities. This raises the question of whether the nutrient balance indicator is to provide a measure of environmental health related to agricultural activities, to provide a measure of agricultural health in isolation of environmental impacts, or both?

2. If gross measures of over or under fertilization (e.g., extremely high, extremely low, unknown) are the best we can get from available data, are they worth producing?

3. If a more sophisticated and useful indicator requires knowledge of management practices, use efficiency, etc., what sources of information may be available. For example, are there possible collaborations with producer groups, feed and fertilizer sales reps, etc.?

4. There will be a high degree of overlap in the required data and concepts used in a nutrient balance indicator and the other indicator projects currently underway. In addition, interpretations attached to the indicators should be similar. For example, water contamination risk, input use efficiency, inputs management, soil degradation (erosion, organic matter), soil cover and management. Is a nutrient balance indicator even required. Could it not be derived or inferred from work being done by other projects?

5. It is clear that issues related to nutrient balance will vary regionally. Is it feasible or desirable to attempt national coverage by region or should the indicator concentrate on selected regions?

D. Moon
AAFC

Summary of Pesticide Risk Indicator

Indicator Description

The pesticide risk indicator will involve tracking the trends in use of various classes of actives categorized according to their specific environmental risk potentials. The indicator will attempt to measure our progress toward the use of products which are more environmentally acceptable.

The measurable parameters may be the sales and use of agricultural pesticides, as well as the relative environmental risk of the product active ingredients. The units of expression are still to be determined; however, they could involve trends in use(expressed either as $ sold or tonnes of active ingredients) of pesticide active ingredient based upon the sales/use disaggregated, or weighted, by each risk class.

In order to determine the "risk class" value for each pesticide, a pesticide risk classification system will need to be developed. It is essential to note that a pesticide risk indicator based solely on pesticides as a single group is not valid since this approach does not account for the differences in the level of risk associated with various pesticides and can, therefore, be mis-leading. Hence, the pesticide risk indicator will need to account for the differences among pesticides which determine environmental risk. For example a "scoring system" could be developed which would be the basis of the risk classification system and would also outline the extensive differences in the acute aquatic toxicity, chronic aquatic toxicity, bird/mammalian toxicity, toxicity to other non-target organisms, persistence in soil/sediment and or surface/ground water, soil/aquatic half-life, bioaccumulation potential, partition co-efficient and the mobility/leaching potential, etc. Once values have been assigned for the various products it will be possible to analyze the trends in the use of the different products and the subsequent "risk". It will then be possible to look at the general trends of the movement toward the use of agricultural products that are more environmentally friendly.

Indicator Rationale

There are basically three major links of the importance of the pesticide risk indicator to policy:

1. Agri-food Policy Review 1989
2. Pesticide Registration Review(PRR)
3. OECD/International Efforts for Risk Reduction.

The **Agri-food Policy Review of 1989** identified environmental sustainability as a key policy goal for the agri-food sector. Following from this, a federal-provincial committee prepared a report which contained a series of recommendations on how agriculture might pursue environmental sustainability. This report was adopted by the federal and provincial ministers of agriculture and is an important component of the federal government's policy on environmentally sustainable agriculture.

The **Pesticide Registration Review Final Report, December 1990** also recognized the principles of sustainability, as well as the need to revise the federal pest management regulatory system. The major objective of this effort is to "protect human health, safety and the environment by minimizing risks associated with pesticides, while enabling access to pest management tools, namely pest control products and other pest management strategies." A "criteria for registration" of products was emphasized, and was extracted from section 9(2) of the *Pest Control Products Regulations.* It was suggested that these criteria be used as a "starting point in the development of a comprehensive list of criteria that will assist the regulator in determining the regulatory status of all pest control products". The following are criteria relevant to risk reduction and apply to control products for which "the applicant shall provide the Minister with the results of scientific investigations respecting":

i) the safety of the control product to the host plant, animal or article in relation to which it is to be used,
ii) the effects of the control product on representative species of **non-target organisms** relative to the intended use of the control product,
iii) the degree of **persistence, retention and movement** of the control product and its residues.
iv) the effects of the control product or its residue when administered for test animals for the purposes of assessing any risk to humans or animals.

The **OECD, and its Risk Reduction** efforts in the international realm is the third major link of this indicator to policy. The OECD is developing its own set of agri-environmental indicators, and at the OECD Meeting of Experts on Agri-Environmental Indicators in Paris, on Dec. 8-9, 1994, Canada discussed its pesticide risk indicator and suggested a similar route for the OECD. Hence, it was concluded at the meeting that the OECD would adopt a similar approach as Canada, stressing the importance of the "risk classification" system, and looking at products based on their potential environmental risk. The second major link on risk reduction also with the OECD was emphasized at the OECD Meeting of the Pesticide Forum in Paris on Nov. 15, 1994. The Pesticide Forum has a definite Risk Reduction mandate, and Canada recently participated in a joint OECD/FAO survey questionnaire on existing risk reduction activities. The survey will be discussed at a Workshop in Sweden in September of 1995 and Canada is to attend. Canada is also in the beginning stages of forming an Interdepartmental Working Group on Risk Reduction, and AAFC is a participating member. Hence, it is evident that Risk Reduction has gained a high priority in 1995, and that pesticide risk is vitally important in an international perspective.

Progress to Date:

AAFC will be looking at pesticide risk, rather than simply looking at volumes and pesticide use. Canada has also been successful in influencing the OECD to use the risk classification approach rather than volume and is taking a lead in this area. At AAFC, consultation has commenced with the Pest Management Alternatives Office, the Crop Protection Institute, as well as with the Policy Branch of AAFC. Various models of pesticide risk classification systems have been obtained and analyzed. The database at AAFC has been used to look at the historic trends of product use.

Next Steps:

The next major step will be to get a contract started to develop the risk classification system. Data will need to be obtained on pesticide use, and will be combined with the risk classification system to complete the final product of the indicator.

Questions/Point for Discussion

1. What are some of the key factors that you see as an important part of the "risk classification system"? Keep in mind that the factors must be:
   a) readily available
   b) quantifiable

2. What is the role of stewardship practices in the development of the indicator?

3. At what spatial scale(s) might the indicator be developed (eg. national, regional, both)?

4. What pesticide use data exist that are updated on a consistent basis that could be used to support development of the indicator?

5. What opportunities exist for collaboration in developing the Pesticide Risk indicator?

D. Pelka/R. Taylor, AAFC,
23 January 1995

Summary of Indicator of Risk of Water Contamination (IROWC)

Indicator Description:

Water quality is affected by both natural and anthropogenic processes. Water contamination implies some change which impairs the chemical, physical or biological quality of the water. In this context, contamination can refer to any change in:

- natural chemical and biological constituents (e.g., nutrients and bacteria) or sediment
- agronomic chemicals (e.g., fertilizers, pesticides or growth stimulants)
- anthropogenic materials (e.g., heavy metals, industrial organic toxics).

The approach used for this agri-environmental indicator is to assess **risk** of water contamination **from primary agriculture.** Risk of water contamination is a function of contaminant properties, environmental conditions, and specific land use and management practices. It is proposed that the indicator be developed using a partial budgeting approach which will estimate the concentration of potential contaminants as a result of agricultural activities in comparison to tolerable concentrations as defined by various water quality standards (i.e. a ratio of potential contaminant concentration to the allowable concentration).

Another approach is to establish monitoring programs which regularly sample and test water for various contaminants. This approach is used at numerous locations throughout Canada, is an important component of managing water quality, and provides validation for the IROWC for those areas where data are available.

The risk of contamination generally differs between surface water and ground water because of dissimilar processes of contamination. The basic processes include:

1. risk of surface water contamination by
   (a) solution (runoff, tile flow, base flow)
   (b) sediment transport
2. risk of ground water contamination by
   (a) leaching below the root zone (shallow ground water) and beyond tile depth
   (b) deep percolation (deep ground water).

Indicator Rationale:

This indicator will address several policy needs, such as identifying areas (regions) at higher relative risk, providing early warning, helping target programs and tracking progress in reducing water contamination risks. The development of a comprehensive IROWC is being guided by the following requirements:

1. Identification and characterization of spatial hierarchal levels (e.g., national, regional, local, plot) which are relevant for determining IROWC
2. Establishment of IROWC based on physical, chemical and biological factors which determine water quality independent of specific water quality standards (societal goals and values)
3. Establishment of clear boundary conditions for IROWC related to the agricultural sector
4. Selection of appropriate geographic scales at which IROWC procedures might be applied and presented.
5. Definition of the level, scale and factors which are to be combined into a general, integrated indicator of risk of water contamination

Challenges and Obstacles

- Integration of data as many aspects of the indicator of risk of water contamination rely on information developed by other indicators (e.g., nutrient balance, pesticide risk, crop yields).
- The indicator is complex and requires good characterization of the hydrological cycle.
- Comprehensive detailed data sets are required to provide information on the kinds of potential contaminants and also their probable pathways (surface, tile or groundwater). These data sets are not consistently available.

Strategy for Developing the Indicator

A team in Agriculture and AgriFood Canada has been tasked with developing a water quality indicator. This team is composed of specialists from the Research Branch and Policy Branch, and has agreed on the following points:

- A risk-based approach should be used for a water quality indicator
- Further definition of the proposed "water contamination risk" indicator was required. This should be done through the development of a concept paper.
- Following definition of the concept, development of a methodology for calculating the indicator.
- Establishment of a small team of specialists to carry out both of the above tasks.
- Testing of the methodology through a number of regional pilot projects which build on related initiatives already in progress.
- Refinement of the methodology and calculation of the indicator for targeted regions.

Progress Achieved to Date

A team of specialists from AAFC's Research Branch has been assembled to pursue work on the indicator. The work of this Team is being lead by Dr. K.B. MacDonald of the Centre for Land and Biological Resources, Research Branch.

The concept paper outlining the indicator of risk of water contamination is in final draft form and a draft methodology paper has been reviewed by the technical and project teams and is currently being revised. A list of possible pilot study areas is in preparation along with a compendium of associated research in progress across Canada by various agencies.

Next Steps

- Refine and finalize methodology paper over the next month to six weeks.
- Compile a complete listing of potential pilot sites.
- Complete the compendium of associated research activities.
- Identify potential partners for collaboration.

Questions / Points for Discussion

1. Need to clarify the opportunities and limitations of the various levels (national, provincial, ecozone, watershed, plot). At what scale(s) should IROWC be developed and reported for policy needs?
2. Do we need separate indicators for surface water, tile flow and groundwater?
3. Do we need separate indicators for pesticides and nutrients? Or even more detail?
4. Do we need an indicator of mass loading in addition to concentration?

5. What are the appropriate standards for comparison? (e.g., drinking water, suitability for aquatic life, etc.)
6. What opportunities exist for collaboration in developing IROWC?

K.B. MacDonald, AAFC,
23 January 1995

Summary of Indicator of Soil Degradation Risk

Indicator Description

This indicator is made up of 5 components - water erosion risk, wind erosion risk, soil salinization risk, soil organic matter degradation risk and soil quality (susceptibility to change).

The wind and water erosion risk indicators can be expressed in absolute terms (tonnes/ha), classes of severity (low to severe or tolerable to excessive), or as a trend (% change) over time. The indicators are developed from land use and management data coupled with the corresponding soil and slope information. The soil salinity risk indicator is expressed as a salinity risk index taking into account land use, soil chemistry, landscape position and climate parameters. The index can be used to assess the impact of changing land use and climatic variability and the long term trends in soil salinity. Soil quality indicators of agricultural land may be assessed at the national, regional and local level using a composite soil quality index based on four elements that include soil available porosity, nutrient retention and physical and chemical rooting conditions.

Indicator Rationale

Soil degradation has been recognized as a national problem that impacts both agricultural productivity and water quality concerns. Erosion issues have been addressed by several national and provincial programs in recent years (National Soil Conservation Program, Green Plan agreements) that were designed to move agricultural producers to more sustainable production systems.

The development of indicators for each of the degradation processes will allow the monitoring of our soil resources to analyze impacts of changing land use, management and government policies. The soil quality indicator provides an integration of inherent susceptibility of change with land management activities.

Challenges and Obstacles

Obtaining past and current land use data for natural land units is required for each of the components of this indicator. Also needed are correlated soil data from across the nation at a number of different scales to facilitate national, provincial and regional analysis. There is a need to increase the number of sites monitoring soil carbon and to develop techniques for extrapolating process-based models form sites to wider regional and national coverages. The ability to express the results of previous work in a geographic sense varies with each component. Similarly, there is a need to adapt existing landscape-process simulation models to the study of the processes affecting and controlling soil salinity.

Strategy for Developing the Indicator

A team of scientists within the Centre for Land and Biological Resources (CLBRR) of the Research Branch with expertise in each of the components are collaborating to produce indicators on each of the individual components. The Soil Quality component will, to some extent, provide an integration of all of the work but will not replace the results of the analyses of each of the four degradation process (wind erosion, water erosion, organic matter degradation and soil salinity).

- a risk based approach will be used for wind erosion and water erosion;
- an index will be produced to evaluate changes in soil salinity rather than measurements expressed in absolute terms;

- evaluations of soil organic matter will concentrate on the active carbon fractions and total biomass carbon rather than the total carbon present in the soil;

- soil quality will be measured in terms of the inherent soil quality and the susceptibility of a soil to change due to management interactions.

Progress Achieved to Date

A report on Soil Quality Evaluation Project (SQEP) to be published in the spring of 1995 includes chapters on each of the degradation components included within this indicator.

Wind and water erosion data are available in map coverage at a variety of map scales from local to national. Soil organic matter studies are still confined to less than 20 sites largely in central Canada. Soil salinity index methodology is being extended to allow coverage throughout the prairie region of western Canada. Soil quality susceptibility to change analyses have been completed for the prairie region and are presently being extended to central and eastern Canada. Some specific achievements:

- methods developed for calculating national wind and water erosion rates with available information;
- current (1991) wind (prairies) and water erosion rates calculated for each province;
- wind (prairies) and water erosion trends calculated for each province from 1991 to 1991;
- wind and water erosion rates calculated for soil landscape (scale 1:1M) polygons to illustrate on maps the regional distribution of erosion rates in the prairies and Ontario;
- inherent soil quality and soil susceptibility to change calculated and results illustrated on maps for soil landscape polygons of prairie provinces and Ontario.

Next steps

- Work planning meetings are to be held in March with participation of scientists to develop tasks, data requirements and deliverables for 1995 FY.

- Extend the analyses to areas previously not covered by some indicator components and continue to test process models (EPIC, Century, salinity).

- Utilize updated land use data generated from the land use and management indicator.

- Develop links where appropriate to the CLBRR network of benchmark monitoring sites to help extend the geographic coverage of organic matter research.

- Identify potential partners for future funding and collaboration.

Questions / Points for Discussion

1. Is it possible or even necessary to combine factors of degradation risk into a single index?

2. How might we enhance the concept of a soil quality indicators?

3. How does the development of this indicator link to research efforts with other indicators?

4. What opportunities exist for collaboration in developing soil degradation risk indicators with other on-going related research initiatives?

5. How might industry utilize the results of the soil degradation risk indicator, and would there be opportunity to work collaboratively with the private sector on this indicator?

S. Smith, AAFC.

Summary of Agro-Ecosystems Biodiversity Indicator

Indicator Description

This indicator will be designed to provide a signal of the impact of agriculture on native biodiversity at the species and community level. Components of the indicator will measure changes in species abundance (population levels) and taxonomic richness (composition) of groups (guilds and communities) of non-domesticated biota inhabiting agro-ecosystems, measured against baseline or expected values. It will focus on target groups selected to represent providers of key ecological services essential for sustainable agriculture (eg. pollinators, agents of nutrient recycling, natural enemies of pests), indicators of the integrity of soil and freshwater ecosystems affected by agricultural practices (eg. representatives of various trophic levels in food chains) and wildlife shared with other ecosystems in agricultural landscapes.

Indicator Rationale

This indicator will provide a set of standard protocols for assessing and monitoring biota in response to concerns that certain agricultural policies and practices are contributing to declines in biodiversity that threaten the sustainability of ecosystems. These concerns and the need for well documented information to guide policy development in this area were summarized in "Growing Together" and the "Report on the Consultation Workshop on Agri-environmental Indicators", as well as by reports prepared by the OECD. Recently, the sector has confirmed its continuing commitment to assess and conserve biodiversity in agricultural landscapes by endorsing the Canadian Biodiversity Strategy as a full partner. Indicators of biodiversity change provide appropriate and practical measures of "impact" to close the conceptual loop in the stress-response model for assessing and mitigating environmental disturbance.

Challenges and Obstacles

The main challenge will be to assemble the human and financial resources needed to analyze and assess the adequacy of available scientific information and conduct research aimed at filling conceptual gaps. There is a substantial body of literature and expert opinion on the subject of bioindicators, but little of this knowledge has been applied to assess and monitor biodiversity in Canadian agro-ecosystems.

Strategy for Development

Staff at the Centre for Land and Biological Resources Research are attempting to assemble the network of expertise needed to develop and test protocols and methods for this indicator and to promote reporting linkages with indicators being developed to track relevant environmental stressors (eg. Soil Degradation Risk, Water Contamination Risk, Habitat Availability). We are encouraging participation by partners in other labs of both federal and provincial departments of agriculture, other sectoral agencies with complementary interests, universities and the private sector. We intend to prepare a position paper based on a review of available information, leading to the development of protocols and sampling methods and a testing program in appropriate field settings. Selection of target groups will take into account current and future availability of expert knowledge and support services from member organizations of the Federal Biosystematics Committee (CLBRR, Canadian Forest Service, Canadian Museum of Nature).

Progress Achieved to Date

A core team has been assembled at CLBRR to lead in developing and implementing a comprehensive action plan. We are intensifying our ongoing efforts to develop databases and identification aids for target groups of insects, mites, fungi and plants. We have initiated consultations with scientists and programme staff in other AAFC establishments and with interested parties in other federal departments to identify potential long term study sites for testing and improving protocols. We will be participating in a workshop in the near future to develop protocols for a biodiversity indicator study of the Suffield Short-Grass Prairie site in southern Alberta, a planned node in the Environmental Assessment and Monitoring Network of Environment Canada. We have achieved consensus on the need to coordinate development of indicators for a number of aspects of biodiversity change of common interest with representatives of several agencies, including the Canadian Forest Service, the Canadian Wildlife Service, State of the Environment Reporting and the Canadian Museum of Nature, and are helping to establish a federal working group to pursue this objective.

Next Steps

We will be consulting further with potential partners to attempt to secure funding for a postdoctoral position that can be dedicated to the literature review required for development of this indicator. We will request modest "A"-base support so that CLBRR staff can continue these consultations and related initiatives during 1995-96.

Points for Discussion

1. Identification of additional potential partners among non-governmental stakeholders, especially to assess the level of interest in participating in the testing and monitoring phases of the project.

2. Establishment of an operational network to provide timely measurements and reports at the regional level, hopefully involving both scientific personnel and landowners.

I. Smith
AAFC
23 January 1995

Description and Development Plan for the Indicator of Agroecosystem Habitat Availability	
DESCRIPTION:	Indicator measures changes in the availability, and possibly also the fragmentation, of selected wildlife habitats such as grasslands, wetlands, woodlands in agricultural landscapes. The indicator will provide a signal of by measuring agriculture's impact on wildlife habitat at the ecosystem level.
MEASURABLE PARAMETER(S)	Habitat availability and change for specific habitats such as wetlands, woodlands, grasslands, and possibly some types of crop cover (e.g. forage) amenable to wildlife species. Possible subset indicator could give a picture of fragmentation.
NUMERICAL UNIT(S) OF EXPRESSION	Area (hectares) of specific habitat types within Land Resource Areas.
ANTICIPATED SPATIAL COVERAGE	Agricultural landscapes in major agricultural regions of Canada.
ANTICIPATED TEMPORAL COVERAGE	Not yet determined but potentially on a 5-year cycle to coincide with the Census of Agriculture.
TARGETS & THRESHOLD VALUES	Direction of change and proportion to other land uses will be used to assess progress towards environmental sustainability.
PRINCIPAL DATA SOURCES	Initially Statistics Canada Census of Agriculture, and potentially data from Canadian Centre for Remote Sensing, Environment Canada - Canadian Wildlife Service, Conservation NGOs, and provincial agencies.
MAIN DATA CONSTRAINTS & HOW THEY HAVE BEEN / WILL BE RESOLVED	Data availability at a broad geographic scale; also the proposed initial methodology has some limitations in quantifying habitat within a particular landscape unit. Strategy is to work with key partners to assess feasibility of developing the habitat indicator and to resolve other constraints such as lack of fragmentation data.
DEVELOPMENT ACTIVITIES UNDERWAY	Identification of possible partners and data sources and selection of methodology to develop a habitat indicator initially for the prairie region.
DEVELOPMENT ACTIVITIES PLANNED	Evaluate methodology and apply to the Prairie Ecozone. Implement pilot indicator project to be completed by March 1996. Apply the approach and methodology to other agroecosystems of Canada.
LEAD AAFC UNIT	Prairie Farm Rehabilitation Administration.
PRINCIPAL INVESTIGATOR(S)	Mr. T. Weins (phone (306) 780-7379) (fax: (306) 780-8229)

Questions / Points for Discussion

1. The Prairie Farm Rehabilitation Administration is a branch of Agriculture and AgriFood Canada (AAFC) with 27 regional and district offices throughout the Prairies. PFRA has been assigned the lead within AAFC to develop a habitat-related indicator. The attached table represents our current plan to develop an initial wildlife habitat indicator for the agricultural area of Prairie Canada. We arc seeking your advice and guidance on its development.

   - Can you identify any strengths or shortcomings in the current plan? How might **any shortcomings** be overcome?

   - What key habitat types **within agroecosystems** should the indicator be designed to track? Should the habitat indicator focus on crop cover habitats only (eg. native pasture, forage, improved pasture), or non-crop habitats (eg. wetlands) only, or both?

   - What key data are available which would support the development of this indicator for Canadian agroecosystems?

   - Would the weighting of various land cover types (Crops, forage, native pasture, improved pasture), based on their relative value as habitat, add value to a habitat indicator?

2. What role, if any, do you envisage for your agency in the further development of a Wildlife Habitat Indicator?

3. Given the interest of various agencies in pursuing development work on environmental indicators (eg. Environment Canada's work on Biodiversity Indicators, Agriculture and Agri-food Canada's development of Agri-environmental Indicators, Provincial strategies to develop indicators, etc), what opportunities and mechanisms exist to enhance collaboration and integration of effort on this particular indicator?

4. At a recent Environment Canada Biodiversity Indicators Workshop a number of possible framework questions were posed:

   - **What do we (society) want (what are the habitat / biodiversity objectives)?**
   - **What do we have now (what is the state of habitat / biodiversity)?**
   - **What are the agents of change (both natural and human)?**
   - **What are some possible indicators of change?**
   - **Does anything need to be done (If so, what is the response)?**

How would the development of a habitat availability indicator fit into an overall framework for biodiversity indicators (and help define potential societal response to biodiversity/habitat loss)?

T. Weins, AAFC,
24 January 1995

Summary of Soil Cover and Land Management Indicator

Indicator Description

Soil Cover and Land Management Indicators address agricultural land use issues as they relate to degradation of environmental quality in general and soil erosion in particular. Soil cover relates primarily to the stabilization of topsoil and thus has implications for soil quality as well as contamination of water with solids, nutrients and chemicals. Land management factors relate to the manner in which farmers use land and soil and are concerned with farm structure, tillage practices, input levels, crop rotations and soil amendments.

Initial studies concerning soil cover will attempt to determine current status and trends in a suite of characteristics such as:

- the proportion of cropland under annual and perennial crops,
- the ratio of high and low cover crops,
- the proportion of area in summerfallow and
- the amount of vegetative and residue cover on cropland (soil cover index).

Land management studies will involve determination of:

- the proportion of farmers using conservation practices,
- the area of cropland under conservation and no-till systems and
- farm types as determined by cropping systems and enterprises.

Over the longer term, a wide variety of economic and social conditions related to land management will be involved in assessing soil and environmental quality.

Indicator Rationale

Determination of soil cover and land management indicators is necessary in order to identify the risk of environmental damage and to evaluate progress toward economically and environmentally sound agricultural practices.

The Federal Government has an expressed policy of encouraging sustainable production, and in order to identify needs, targets and progress, a series of performance indicators is required. Management practices, and those affecting the amount of soil cover in particular, are the mechanisms through which market and policy forces affect soil and water quality. In order to respond to national and international standards and commitments with respect to environmental sustainability, while at the same time enhancing economic conditions, it is particularly critical to identify the status and monitor trends in land use activities. The databases, information and results of soil cover and land management indicator work are also of critical importance to other agri-environmental indicators, such as degradation and water contamination risk. In addition, effective use of sustainability and extension program resources requires a method of targeting areas and practices of concern and of evaluating impacts.

Development Strategy

A primary data source that offers national coverage is the Census of Agriculture, which provides a summary of structural, crop and socioeconomic data for every farm in the country at 5-year intervals. Of particular relevance is the 'conservation module' of 1991 and subsequent years, an addition which addresses issues such as the amount of cropland under conservation and no-till systems and the use of rotations, cover crops, contour tillage, windbreaks and grassed waterways. Current plans for development of this indicator are to conduct national assessments of crop distributions, land management practices and soil cover estimates and to use those to identify target regions for more detailed study. Aerial photography and satellite imagery will be used as a complement in detailed studies of high intensity or high risk areas, and benchmark sites, expert systems and site specific management will provide information for validation and extrapolation. The entire study of soil cover and land management indicators will be based on the spatial stratification provided by Soil Landscapes of Canada, Land Resource Areas, Ecodistricts and Ecozones.

Future Considerations

The overview presented above focuses on crop and tillage conditions as the most direct manifestations of the status and trends in land use, but there are a variety of other, more complex issues involved in assessing land management and its relationship to environmental quality. A variety of variables have been suggested as relating to economic or environmental sustainability, and a number of them may be useful as indicators. These variables can be grouped into those dealing with:

1) the spatial structure of the farm community (farm area as a % of regional area, area owned as a % of farm area, competing land uses, etc.),

2) the flexibility of agricultural production (soil capability, number of crops & livestock types, amount of forest products sold, diversity of markets, etc.),

3) economic viability (net margins, support payments as a % of income, economic efficiency, etc.),

4) social conditions (rural/urban population ratio, population/cropland ratio, level of farm services, reliance on off-farm work, etc.),

5) conservation structures (terraces, windbreaks, grassed waterways, manure storage, etc.),

6) input levels (labour, manure, chemicals, fuel, etc.).

Although it is recognized that all have a connection with sustainability, their value as agri-environmental indicators is not clear.

Progress

Work has been completed on reorganizing the 1981 and 1991 Censuses of Agriculture to a biophysical (SLC) base for use in indicator development and analysis of broad trends is underway. Reports in progress involve small-scale national assessments of long-term trends in farming and cropping practices and selected large-scale regional evaluations of status and 1981-1991 trends in cropland distribution, conservation practices and soil cover. Reports will include an explanation of the issues and the significance of trends and will be supplemented with maps, tables and photographs. A general bulletin dealing with the national picture and focussing on several significant areas and characteristics is in preparation for the "National Environmental Indicator Series" of Environment Canada's State of the Environment Reporting Program.

Future efforts will involve developing a "minimum data set" of variables to be monitored and a spatial stratification to identify critical areas and conditions. Reports and papers will involve more detailed research on specific areas and issues using regional databases and satellite imagery.

Questions and Points for Discussion

1. What is your response to the strategy for developing and reporting soil cover and land management indicators as outlined above (i.e. national assessment of trends in general characteristics, followed by more detailed evaluations in 'target' regions)?

2. What are the most useful and informative variables for characterizing soil cover and land management trends? Should the variables listed on page 1 be expanded to include other aspects, such as those presented in the 'Future Considerations' section above? Which of these are the most important and useful? Do they have pertinence at some scales and not at others?

3. Is the time frame defined by the 1981 and 1991 (and presumably 1996) censuses sufficient to identify land management trends, or should resources be expended in acquiring and organizing the datasets from 1986, 1976, 1971, 1966 etc.? (estimate a cost of $20,000 per year of data)?

4. Are there 'on-farm', local or corporate needs and uses for these indicators, and if so, can you identify potential collaborators?

T. Huffman, AAFC,
30 January, 1995.

Summary of Input Management Indicators

Indicator Description

The indicator will track use/adoption of selected best management practices (BMPs) for pesticide, manufactured fertilizer and manure inputs, which are defined as farming practices which have been proven, in research and through field-level testing, to give optimum production potential, input efficiency, and environmental protection.

Measurable parameters for the indicator have not yet been determined. These will depend on the management practices selected. The indicator could report the percent of targeted producers using desirable inputs management practices and/or the area of land receiving the desirable treatment(s).

Indicator Rationale

There is a strong link between pesticide and fertilizer use and public concerns about the environmental effects of agriculture. hen improperly used, agricultural inputs can affect the environment. Environmental concerns with pesticides, fertilizers and manure often relate to the management practices associated with their use.

Increasing adoption of BMP's could indicate a reduction in environmental risks from pesticide and fertilize] use. BMP's help track the agri-food sector's progress toward environmentally-sustainable agriculture. BMP's can also indicate how agriculture is responding to environmental and resource stewardship concerns. BMP's are practical and fact driven. They are being researched, tested, implemented and evaluated.

The environmental problems and/or management practices being addressed with BMP's are:

- leaching of pesticides and fertilizer to groundwater
- manure runoff
- pesticide runoff
- soil mining (depletes carbon and some nutrients)
- over-application of some nutrients

Challenges and Obstacles

Availability of sector-wide or commodity-group specific data, and obtaining access to existing data, on use/adoption of BMPs for inputs are the key obstacles.

Strategy for the Feasibility Study of the Indicators

1. Identify key BMPs to track as indicators for pesticides, nutrients, manure and possibly other farm inputs.

2. Develop Selection Criteria

3. Evaluate the BMP's against the Criteria

4. Prepare and circulate a Discussion Paper for input

Progress Achieved to Date

The following 7 input management practices have been identified as possible indicators for input management:

- Pesticide Certification Course (number / % of producers certified)
- Environmental Farm Plans (number / % of farms that have developed a plan)
- IPM or specific IPM practices (to be determined)
- Pesticide Sprayer calibration
- Use of soil fertility tests
- Timing of fertilizer, pesticide and manure application
- Manure handling - Whether or not adequate run-off containment is in place

The Selection Criteria include:

1. scientific validity
2. regionally responsive (within region and broadly)
3. unambiguously interpretable
4. simple quantification- (can required data be collected from farmers or others through surveys?)
5. stability (ie. won't change fast)
6. environmental impact (ie. size of the problem)
7. available method
8. anticipatory (does the BMP have the desired future impact)
9. cost-effectiveness
10. data availability

Next Steps

- Participants at Fredericton Seminar asked to consider/prioritize the specific input indicators (i.e. management practices) and the selection criteria which should be used.
- Finalize the evaluation of the BMP's against the selection criteria,
- Further consideration of indicator design and statistical aspects, data evaluation, etc.
- Feasibility paper to be circulated for review.
- Identification of relevant data.
- Select the BMP's for development.
- Develop the indicators over the medium term
- Identify and use existing data where feasible and explore options for collecting new data. The principal potential data sources are the Census of Agriculture, Statistics Canada surveys, input industries and government program administrative data.
- Monitoring of core indicator (i.e. through surveys).
- Report indicators
- Reevaluation over time.

Questions/Points for Discussion

1. Prioritize the 7 proposed management practices identified above based on the selection criteria.

2. Identify additional management practices that should be tracked through an input management indicator.

3. Potential sources of information for the indicators
- what data are currently available
- what alternatives are there for collecting the data.

3. What opportunities exist for collaborating to develop inputs management indicators for Canadian agriculture?

M. Spearin
January 25, 1995

Summary of the Agricultural Greenhouse Gas Balance Indicator

Background to the Framework Convention on Climate Change

Atmospheric concentrations of many radiatively active gases are increasing rapidly and general circulation models are predicting that global air temperature will be 2 to 5°C warmer by the year 2050. In response to public and scientific concerns about the impacts of climate change, the United Nations negotiated the Framework Convention on Climate Change (UNFCC), which came into force on March 21, 1994. Canada ratified this convention in December 1992. The ultimate objective of this convention is to "achieve...stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system".

The Convention includes a requirement to report, to the Conference of the Parties, a national inventory of emissions by sources and removal by sinks of greenhouse gases resulting from all human activities, including agriculture.

Agriculture and Climate Change

Carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) are the most important greenhouse gases (GHG) emitted by agricultural sources. Agricultural soils can act both as a source or a sink of carbon (C). The C content in agricultural soils is a function of the original C content, time elapsed since cultivation began, and crop and soil management. In order to estimate the net gain or loss of soil C in agroecosystems in Canada, it is necessary to determine: i) which agricultural soils have reached an equilibrium in C content (assuming negligible losses by erosion), and ii) the rate of change for those that are not in equilibrium.

Nitrous oxide is produced in soils as a by-product of nitrification and denitrification processes. A fraction of this N_2O is released at the soil surface and contributes to the increase in atmospheric N_2O concentration. The total amount of N_2O emitted from soils is the summation of a background component (resulting from the natural cycling of N), a manure component (for soils receiving manure) and a nitrogen fertilizer component (for soils receiving N fertilizers). Manure also generates N_2O during storage in quantities that depend on the type of storage practices and duration of the storage period. Other agricultural sources of N_2O are from combustion of fossil fuels and biomass burning.

The sources of methane from agroecosystems are ruminants, animal wastes, wet areas (within agricultural land) and consumption of fossil fuel.

Indicator Description

The Greenhouse Gas Balance (GHB) indicator will estimate (as accurately as current scientific knowledge permits) and report the **net** exchange of greenhouse gases between agroecosystems and the atmosphere in Canada. The indicator relates directly to a larger national effort to respond to the requirements of the Climate Change convention and report periodically on national sources and sinks of greenhouse gases.

Strategy for Developing the Indicator

The sources and sinks of GHG in agroecosystems are reasonably well known but the magnitude of the various fluxes is more uncertain. The aggregation of the individual sources and sinks also poses a challenge. Emissions of GHG vary greatly depending on various factors related to soil, climate and management practices, which are characterized by a high spatial variability. Significant research efforts are therefore underway to reduce this uncertainty. Typical combinations of factors which determine GHG fluxes in agroecosystems will be used to represent conditions in Canada.

Current activities to develop the indicator include:

- Use of the Century model, which provides estimates for the impact of climate and soil management on soil carbon evolution, to estimate the rate of change in soil C content.

- Quantification of other sources and sinks of CO_2 , N_2O and CH_4 , based on current knowledge of the contribution of agricultural activities to GHG exchange between agroecosystems and the atmosphere.

- Collection and analysis of information on farm animal populations and distribution, animal waste management (storage conditions and duration), acreage occupied by various crops/soil types/land uses/climate types, utilizations of manure (acreage, dose), fertilizer uses (dose, type) and fossil fuel consumption in Canada.

- Selection of typical "soil type-climate-soil management" combinations which are representative of conditions in Canada, following a statistical design that will allow for the determination of the impact of the scaling-up procedure on the estimation of error.

Questions / Points for Discussion

1. How can more accurate and comprehensive data be obtained on:

    - Fertilizer production and usage per region, per fertilizer type and (preferably) per crop in Canada.

    - History of the usage of conservation tillage in Canada (# ha per region per year).

    - Crop rotations per region in Canada.

    - Various manure storage systems (stock-piled, composted, liquid) used in Canada?

2. Any suggestions to improve the accuracy of the estimates of the greenhouse gas balance in agroecosystems in Canada.

P. Rochette, AAFC,
24 January 1995

ATTACHMENT 5: DISCUSSION POINTS FOR BREAKOUT GROUP SESSION "B"

Following a recommendation of the Federal-Provincial Agriculture Committee on Environmental Sustainability (which reported in 1990), and in relation to recommendations and requests from other groups (eg. Office of the Auditor General of Canada, Organization for Economic Cooperation & Development, Green Plan, Canadian AgriFood Research Council, etc), AAFC initiated work to develop environmental indicators for Canadian agriculture, following the first consultation workshop on agri-environmental indicators held in December 1993.

1. As documented in the draft Description and Implementation Plan for the agri-environmental indicator project, substantive work to develop the conceptual basis for the project has been accomplished within Agriculture and AgriFood Canada (AAFC). In addition, specific agri-environmental indicators have been identified. For some indicators, development work is underway and several will be publicly reported in the coming months. In light of plans to report comprehensively on the results of the project following the 1996 Census of Agriculture, and given the need to develop indicators that will be relevant over an even longer term, it is important at this stage to ensure that the overall approach is broadly acceptable to stakeholder groups.

    - ***Do you feel that the conceptual approach to developing agri-environmental indicators is acceptable as proposed?***
    - ***If needed, what changes would you suggest (drop/add indicators, refine existing indicators, further integration of indicators, etc.).***

2. Development work to date on the twelve agri-environmental indicators has been largely confined to the federal scene. However, the indicators will have implications throughout the agrifood sector. AAFC is interested fostering a broader sense of "ownership" of the agri-environmental indicator initiative and in working collaboratively with others as much as possible.

    - ***What level of involvement is your agency or stakeholder group prepared to assume in contributing toward the development of agri-environmental indicators? Involvement can proceed at several levels. For example:***
        - ***provide advice as work proceeds;***
        - ***contribute data and information for specific indicators of interest;***
        - ***play an active role in developing indicators of interest.***
    - ***What mechanisms might be used to foster such collaboration?***
    - ***In what manner should future consultations occur? For example, through another workshop, distribution of progress reports, a newsletter, etc.?***

3. A range of uses and applications exists for the environmental information to be developed and reported by agri-environmental indicators. For example, AAFC must analyze the environmental impacts of its policies and programs, contribute to national state of the environment reports and provide information to international agencies and the public. Provincial governments also have specific needs for environmental information on agriculture, as do non-governmental agencies.

    - ***What are the priority uses and applications of agri-environmental indicators for your group?***
    - ***What level of spatial detail/aggregation is required to meet your priority uses and applications?***