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Climate Change Funding Initiative in Agriculture (CCFIA)

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Climate Change Funding Initiative in Agriculture (CCFIA)

Introduction

As part of the Government of Canada's commitment to the Kyoto Protocol on reducing greenhouse gas (GHG) emissions, the National Climate Change Secretariat established 16 *Issue Tables* to examine options for reducing Canada's GHG emissions. The Agriculture and Agri-Food Climate Change Table published its options report, *Reducing Greenhouse Gas Emissions from Canadian Agriculture*, in January 2000.

The options report notes that approximately 9.5% of Canadian GHG emissions are attributed to agricultural production activities, not including the use of fossil fuels or the indirect GHG emissions from fertilizer production. Emissions from agriculture are primarily nitrous oxide associated with fertilizer and animal manure use, and methane associated with cattle and livestock manure.

However, the complex biological nature of processes involved in producing the dominant GHGs in the agricultural sector makes emissions highly variable and sporadic. The Table found there are still many knowledge gaps in the measurement and understanding of agricultural GHG emissions and the search for GHG-reducing technologies identified only a few that with certainty could significantly reduce GHG emissions from agriculture at a low cost. The AAF Table identified the need for public resources to support basic research activities for net GHG reduction particularly in the areas of crop nutrient management, livestock nutrient management, manure management, carbon sequestration and biofuels, and a need for refinement of national inventory, measurement and verification systems for net GHG emissions and to reflect improvements in technology.

In February 2000 the federal Minister of Agriculture and Agri-Food Canada announced funding of $4 million over 4 years from the Canadian Adaptation and Rural Development II (CARD II) program for a *Climate Change Funding Initiative in Agriculture* (CCFIA). The Canadian Agri-Food Research Council (CARC) is responsible for delivering the CCFIA for the AAFC Environment Bureau, with the following four goals:

1. Increased Canadian human resource research capacity and expertise in climate change issues in agriculture.
2. Research on knowledge gaps in agricultural greenhouse gas emissions.
3. Development of industry best practices and technology to reduce agricultural greenhouse gas emissions and increase carbon sequestration potential of agricultural soils.
4. Enhanced awareness and improved communication on climate change.

This report documents the first steps taken towards meeting each of these goals.

L.E. Haley, Ph.D., Chair
CARC CCFIA Committee
February, 2001

A Word About CARC

The Canadian Agri-Food Research Council (CARC) provides leadership in coordination and networking of research and technology transfer and is a catalyst for building consensus on research prioritization in Canada. It is in this spirit that research and technology transfer are directed to assist the agriculture and food industry to be globally competitive, environmentally sustainable and socially responsible.

CARC is a not-for-profit organization established in 1974. CARC's national and provincial committee structure has more than 1100 participants from across the country who identify issues and opportunities to be addressed through agri-food research and development. Provincial agricultural coordinating committees represent regional research and development interests and interact with CARC's Canada committees to resolve issues of interest.

CARC also maintains a comprehensive national database for agriculture and food research in Canada. The Inventory of Canadian Agri-Food Research (ICAR) contains detailed information on current research projects in agriculture, food, human nutrition, aquaculture, biotechnology and other related areas. ICAR can be accessed through the CARC website: www.crac-carc.ca.

The Agriculture and Agri-Food Climate Change Table Options Report, *Reducing Greenhouse Gas Emissions from Canadian Agriculture*, and other detailed information on Canada's national climate change process can be found at the Climate Change Secretariat website: www.nccp.ca.

Acronyms and scientific symbols used in this report:

AAFC	Agriculture and Agri-Food Canada
GHG	Greenhouse Gas
C	carbon
CO_2	carbon dioxide
CH_4	methane
K	potassium
N	nitrogen
N_20	nitrous oxide
NH_3	ammonia
P	phosphorous

Table of Contents

CCFIA Component 1

Developing Canadian Human Resources

The Agriculture and Agri-Food Climate Change Table options report noted there are still many knowledge gaps in the measurement and understanding of agricultural GHG emissions. Further, it was recognized that Canadian research capability in agricultural climate change issues requires enhancement. The goal of Component 1 of the CCFIA is to facilitate the development of human resources and research expertise while addressing Canada's priorities in meeting greenhouse gas reductions in the agricultural sector.

The CCFIA is providing matching funding of $100,000 over three years (2000 - 2003) to each of the eight Canadian agricultural universities and colleges to support development of knowledge activities in climate change related to agriculture.

The funds are being used by the universities and colleges in several ways, including the establishment of new Chairs in Climate Change Research, and hiring and training of post-doctoral fellows and graduate students in climate change related research projects.

The universities and colleges funded are:

The University of British Columbia, Faculty of Agricultural Sciences
Graduate students will work with researchers to study ways by which GHG emissions can be reduced while maintaining and improving sustainable dairy production systems.

University of Alberta, Department of Agriculture, Forestry and Home Economics
Post-graduate students will work with researchers in development of scientifically defensible estimates of N_20 emissions from agricultural ecosystems in Canada, including field techniques in greenhouse gas flux measurement.

University of Saskatchewan, College of Agriculture
Graduate and post-doctoral students will participate in research related to one or more of the issues identified in the Agriculture and Agri-Food Climate Change Table options report; and assist in a communications and collaboration initiative on GHG research within the university.

University of Manitoba, Faculty of Agricultural and Food Sciences
Graduate students will work with researchers on projects related to conserved pasture grazing; greenhouse gas emissions and grassland farming; and measurement of GHG emissions from agriculture.

University of Guelph, Department of Land Resource Science

Graduate students will be trained in all aspects related to greenhouse gas emissions and mitigation in the agricultural sector related to crop nutrient management and carbon sequestration.

Laval University, Faculty of Agricultural Sciences and Food

Graduate students will assist researchers in work on GHG emissions originating from the management of treated and untreated manure and liquid manure.

McGill University, Faculty of Agricultural and Environmental Sciences

The university is establishing a new Chair in Climate Change Research specifically related to agriculture and micrometeorology.

Nova Scotia Agricultural College, Environmental Management Research Centre

The college is appointing a post doctoral fellow in climate change agricultural research initiatives and an Environmental Management Outreach and Research Coordinator to manage climate change adaptive research, outreach and extension activities for the Atlantic Canada agri-food industry.

CCFIA Component 2
Science Networks for Climate Change in Agriculture

CCFIA Component 3
Industry Matching for Climate Change in Agriculture

The goal of Components 2 and 3 of the CCFIA, *Science Networks for Climate Change in Agriculture* and *Industry Matching for Climate Change in Agriculture*, is to provide support to consortia of experts from universities, industry, and federal and provincial organizations, to address the fundamental agricultural climate change knowledge gaps identified by the AAF Table. Specifically, research is needed in the areas of crop nutrient management, livestock nutrient management, manure management, carbon sequestration and biofuels, and in the refinement of national inventory, measurement and verification systems for net GHG emissions and to reflect improvements in technology. It is expected that work funded under Components 2 and 3 will also contribute to the development of Canadian research expertise.

Experts in Canadian universities, industry and government were invited to submit research proposals addressing the knowledge gaps, with emphasis placed on a team approach of diverse expertise and affiliation. A Committee comprised of representatives from the AAF Table, CARC, AAFC Research Branch, Environment Canada and industry (see Appendix A), was established by CARC and approved by the AAFC Minister to evaluate and determine funding for research project proposals. The Committee was augmented by individual GHG experts who assisted in the scientific peer review process.

The CCFIA is providing funding totaling $2,762,245 under Components 2 and 3 of the program for 15 research projects across Canada for up to three years, ending in the fall of 2003. The executive summaries and objectives for each project, as submitted by the lead investigator(s) and approved by the CCFIA Committee, are contained in the following pages. The amount of the grant awarded by the CCFIA Committee is included with each project. All projects are also financially supported by matching funding from non-government sources, a requirement of the CARD program.

Projects are listed alphabetically by lead investigator.

Individual project information and annual updates will also be available on ICAR (Inventory of Canadian Agri-Food Research) at www.carc-crac.ca.

CCFIA Components 2 & 3 — Project 1

Part 1: Reduction of GHG Emissions in Swine by Diet Manipulation
Part 2: Measurement of GHG Emissions and Odour from Swine Manure Derived from Standard and Modified Diets

CCFIA Grant $250,000

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Executive Summary, Part 1

The proposed experiments address the nutritional intervention strategies most promising to reduce greenhouse gas emissions by pigs. These studies concentrate on pregnant sows and finisher pigs, which produce two-thirds of the greenhouse gas emissions by pigs in Canada. The emphasis is on improving the efficiency of retention of dietary carbon by increasing protein and energy efficiency. This will be achieved by using low protein diets supplemented with amino acids and by dietary supplementation of enzymes that improve efficiency of dietary protein and energy retention.

The requirements for the first two limiting amino acids for pregnant sows will be determined to optimize the formulation of low protein diets for sows. The effectiveness of low protein diets will be quantified in sows and grower/finisher pigs by comparing the carbon and nitrogen balance during feeding of normal and low protein diets. The effect of these low protein diets on greenhouse gas emissions from pig slurry will be assessed in collaboration with Drs. Leonard and Feddes (Part 2 of this proposal).

Program Objectives

Hypothesis 1: Low protein diets, achieved by appropriate amino acid supplementation, will reduce greenhouse gas emissions by swine.

- Determine the requirement for the first and second limiting amino acids for pregnant sows to enable accurate formulation of low protein diets.
- Quantify the effectiveness of improved low protein diets on the emission of greenhouse gases by both pregnant sows and finisher pigs.
- Assess the economic impact of the above measures.

Collaborator

Sönke Möhn, Ph.D., Department of Agriculture, Food and Nutritional Science, University of Alberta

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Executive Summary, Part 2

There is no doubt that greenhouse gases are generated in swine manure, and some quantitative data on this are already available, particularly with respect to methane (CH_4). However, there is a general need for more data, particularly with respect to nitrous oxide (N_20) and the influence of manure management methods on GHG emissions. In addition there is a complete lack of data on the influence of diet on GHG emissions from swine manure. The proposed two-year project is aimed at addressing these data needs. Emissions will be measured from a barn with a manure collection pit and outdoor open storage. In the first year the manure will be derived from grower/finisher pigs fed a standard diet. The influence of manure management will be investigated by measuring emissions from undisturbed and disturbed storage, from slurry with solids removed, and from slurry composted with straw. In the second year the manure will be derived from pigs fed a modified diet determined on the basis of parallel investigation by Dr. Ron Ball (Part 1 of this proposal). Again emissions will be measured from the barn and storage. Emissions from 'control' manure, similar to that used in the first year, will also be measured during the storage phases.

Program Objectives

The principal objectives of the proposed project are:

- Comparison of GHG emissions from hog manure resulting from conventional modified diets.
- Quantification of emissions of N_20 and CH_4 from hog manure storages under prairie conditions.
- Evaluation of the influence of manure/storage management on these emissions.

In addition to the above, the project will also seek to:

- Obtain additional data on odour emissions from storages.
- Compare GHG emissions from conventional liquid manure storages with emissions from composted hog manure.

Collaborator

John Feddes, Ph.D., Department of Agricultural, Food and Nutritional Science, University of Alberta

Nutrient Best Management Practices for the Reduction of Greenhouse Gas Emissions

CCFIA Grant $200,000

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Executive Summary

This proposal addresses Recommendation 5 of the Agriculture and Agri-Food Climate Change Table by evaluating greenhouse gas emissions from emerging best management practices (BMPs) for nitrogen management in selected cropping systems in two regions of the country. By identifying agronomically viable BMPs, this project will provide a rapid and practical means of reducing greenhouse gas (GHG) emissions.

Commercial nitrogen fertilizer and animal manure are the major sources of human-induced N_2O emissions. Nitrogen fertilizers have been instrumental in realizing the increased crop yield. The Canadian agricultural sector has set as its goal to expand to 4% of the global market by 2005, while at the same time reducing total GHG production by 6% of the 1990 emission level. Developing nitrogen delivery strategies that support increased productivity while reducing N_2O emissions must be a key objective in national economic and environmental goals for the Canadian agricultural sector.

The project proposes to add a GHG monitoring component to a series of studies examining nitrogen best management practices for potato production and for wheat production. The study capitalizes on the resources being applied to these agronomic studies, extending the existing focus of these projects to include a GHG component. The collaborators also represent geographical areas that have been under-represented in previous greenhouse gas monitoring efforts. The monitoring of GHG emissions from these cropping systems will result in increased local awareness of the issue, the training of regional cropping systems specialists in GHG measurement technologies, and providing regional estimates of GHG emissions for the national database.

Program Objectives

The primary objective of this program is to extend research developing soil nitrogen best management practices to include the assessment of GHG emissions. In the course of achieving this primary objective the additional objectives of:

- Training highly qualified personnel in the methods of GHG research.
- Providing GHG emission factors derived under Canadian conditions.
- Providing emission estimates from previously under-represented cropping systems and areas of the country.
- Improving our understanding of the fundamental processes of GHG production will also be achieved.

Collaborators

Don Flaten, Ph.D., Department of Soil Science, University of Manitoba
Cynthia Grant, Ph.D., Karl Volkmar, Ph.D., AAFC Brandon Research Centre
John MacLeod, Ph.D., AAFC Crops and Livestock Research Centre, Charlottetown
Bernie Zebarth, Ph.D., AAFC Potato Research Centre, Fredericton

Quantifying N_2O Fluxes Associated with Agricultural Practices in Non-Level Prairie Landscapes

CCFIA Grant $177,000

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Executive Summary

As few attempts have been made to directly compare N_2O fluxes from different land usages, this project will estimate N_2O fluxes associated with agricultural practices common to the Canadian Prairies. Agricultural practices that will be examined include: conventional cropping, reduced-tillage, and forage legume production. An unfertilized wheat/fallow rotation also will be included. A distinctive feature of this research is that it will focus on improving estimates of N_2O fluxes from the hummocky (i.e., non-level) landscapes characteristic of the prairie provinces. A second unique feature of this research is that it will compare N_2O flux estimates associated with the land application of hog manure to those associated with the use of conventional (i.e., chemical) fertilizers. This research builds on the existing efforts of scientists at the University of Saskatchewan to understand soil processes at the landscape-scale and model N_2O fluxes associated with manure applications. The proposed research will provide critical data for both the evaluation of agricultural practices on N_2O emissions and the development of an emission factor for hog manure that is pertinent to western Canadian agriculture. In addition, this research will produce the calibration data required to test the applicability for the major N_2O emission models to Prairie agriculture and, in doing so, expand our knowledge of the role N_2O fluxes play in global cycles.

Program Objectives

The proposed study builds on previous and existing research by combining a manipulative, landscape-scale, treatment based design that has been used successfully during the past five years for variable rate fertilization research in non-level landscapes with a standardized chamber-based, gas-flux measurement system currently being used in a small-plot study to assess the effects of fertilizer placement on N_2O emissions.

The program objectives are to:

- Assess N_2O emissions from major agricultural uses (i.e., conventional cropping, no-till, forage, and pasture) using both conventional N-fertilization and swine manure as a nutrient source on a hummocky surface.
- Measure critical soil parameters at the site to assess the usefulness of the major N_2O flux models (e.g., DeNitrification and DeComposition (DNDC) model; EXPERT-N).
- Calculate a N_2O emission factor for swine manure.

Collaborators

Diane Knight, Ph.D., Daniel Pennock, Ph.D., Bing Cheng Si, Ph.D., Department of Soil Science, University of Saskatchewan

Environmental Performance of Alternative Dairy Production Systems

CCFIA Grant $116,440

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Executive Summary

The trend of confining dairy cattle year-round is resulting in increased separation of dairying from a land-base and reducing direct impact of the cow on the environment. These changes also result in increasing dependence on fuel and off-farm sources of N. Consideration of this change on a broad range of impacts in the context of environmental and economic sustainability is needed. Management intensive grazing is being promoted as a way to reduce reliance on purchased external inputs and lower costs for the large number of dairy farms where a physical land-animal connection still exists. There is evidence that well-managed grazing can improve sustainability of dairy production in regions where grazing is feasible, particularly Eastern Canada (Fredeen et al., 1999). We (Martin et al., 1999) have postulated the benefits of forages, particularly when grazed, regarding greenhouse gas emissions from agriculture. However, effects of grazing on GHG emission are largely unknown. The potential exists for lower global N_2O emissions in a grazing system which may use no N fertilizer and less imported feed N because of its use of white clover. However, urine patches on pasture are likely sources of N_2O and NH_3. Methane production of grazing cattle has been observed previously to be higher relative to those receiving grain as a significant portion of their diet (Harper et al., 1999). Higher forage quality seen with management intensive grazing, however, may result in a lower methane generation than that normally seen with high forage intake. Given the high degradability of nitrogenous substances in grazed and ensiled forages, composition of the supplement is likely to have a large impact on the excretion of N in urine (which can be predicted by the Cornell-Penn-Miner model). Since excreted urinary N produces ammonia and N_2O, effect of degradability of N and carbohydrate in the supplement on GHG emission and N loss from the system is likely critically important.

The hypothesis is that global greenhouse gas emission will be lower in a low input intensively managed pasture system in which cows are supplemented appropriately, compared with

silage-feeding under high input confinement management with use of a supplement that does not encourage high N capture in the rumen.

The objectives are to evaluate relative environmental and economic impacts of dairy production under grazing versus confinement feeding strategies, as well as to evaluate impact of grazing strategies and dietary supplementation. In addition, the performance of various systems under climatic change will be modelled. Although previous research has focussed on one or more aspects of environmental impact, this study is novel in its approach to identifying strategies for reduction of GHG emission in the context of effects on N and energy flows, and partial costs.

The research will be conducted using 40 paired dairy cows in mid-lactation. Thirty-two will be split among four balanced groups of eight grazing separate but similar paddocks on the same pasture. The remainder will be a single group in confinement. Four supplements differing in N and carbohydrate degradabilities will be fed over the six month grazing season. An additional measurement will be made in February. GHG emissions will be measured using trace gas analysis. N flows and GHG emissions in both systems will be determined during the last week of each 30 day period. Effects of the systems on energy and economic costs will be modelled.

Program Objectives

- Compare environmental and economic performance of pasture based and confinement systems.
- Evaluate the sustainability and GHG emission of pasture-based dairy production.
- Evaluate the impact of diet on GHG emission and other environmental factors.
- Suggest GHG reduction strategies within a more global context of economics and environment.
- Predict the impact of climatic change on economic and environmental performance of alternate systems.

Collaborators

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Ralph Martin, Ph.D., Department of Agricultural Sciences, Nova Scotia Agricultural College
Chaouki Benchaar, Ph.D., Agriculture and Agri-Food Canada and Nova Scotia Agricultural College
Gary Patterson, Ph.D., Agriculture and Agri-Food Canada, Crops and Livestock Research Centre, Charlottetown

Greenhouse Gas Emissions from Constructed and Natural Wetland Systems

CCFIA Grant $135,000

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Executive Summary

Natural and constructed wetlands represent a major portion of our agricultural landscape. Although they have traditionally been viewed as major carbon sinks due to their dense vegetation, there is considerable debate regarding their role in relation to other greenhouse gases such as nitrous oxide (N_2O) and methane (CH_4). This is even more important when it is considered that the relative infrared absorptive characteristics of CH_4 and N_2O are 7.6 and 290 times that of CO_2 respectively.

The objective of this proposed study is to utilize a micro-meteorological approach using a tunable diode laser trace gas analyzer to evaluate GHG emissions under a range of meteorological and physical conditions from both on-farm constructed wetland treatment systems and natural wetland areas.

This project will allow for a more detailed understanding of the benefits and impacts of natural and constructed wetland systems and provide information on the GHG source/sink relationships within these systems. Additionally, recommendations on wetland management can be developed with respect to climate change impacts including the role that wetlands (including riparian zones) play in relation to GHG mitigation and the potential for establishing wetlands from unproductive agricultural land.

Program Objectives

To evaluate greenhouse gas emissions (N_2O and CH_4) under a range of meteorological and physical conditions from (i) on-farm constructed wetland treatment systems and (ii) natural wetland areas, to identify their source/sink status relative to GHGs.

Collaborators

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Ralph Martin, Ph.D., Department of Agricultural Sciences, Nova Scotia Agricultural College
Peter Havard, P.Eng., Ali Madani, Ph.D., Department of Agricultural Engineering, Nova Scotia Agricultural College
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Development of Scientifically Defensible Estimates of N_2O Emissions from Agricultural Ecosystems in Canada

CCFIA Grant $225,000

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Executive Summary

N_2O fluxes will be measured using flux chambers in field plots at several agricultural sites in Alberta in order to establish the effects of N management practices (band vs. broadcast application, fall vs. spring application, slow vs. fast release products, low vs. high rates of application) on N_2O emissions from agricultural ecosystems. N_2O fluxes will also be measured using a tunable diode laser over entire fields at an agricultural site near Ottawa to evaluate the use of new technology for measuring the effects of N management practices (low vs. high rates of application) on N_2O emissions at a field scale.

All these measurements will be used to test predictions of N_2O emissions from a mathematical model of agricultural ecosystems in order to establish how well we understand the processes by which N_2O emissions are controlled. Model development and testing during this project will establish confidence in the model as a method for making scientifically defensible estimates of land management effects on N_2O emissions from agricultural ecosystems.

Program Objectives

- To measure the sensitivity of N_2O emissions from agricultural ecosystems to different fertilizer products, rates, placements and timing.
- To develop and test a scientifically defensible technique (in the form of a mathematical model) for estimating N_2O emissions from agricultural soil under any combination of climate, soil type and land management (fertilizer, irrigation, rotation, tillage, harvesting).
- To use this technique in later studies for estimating regional N_2O emissions as affected by postulated changes in climate and land management as a way to predict the impacts of climate and land management policy on these emissions.

Collaborators

Noorallah Juma, Ph.D., Natalie Cooper, graduate student, Department of Renewable Resources, University of Alberta
Tom Goddard, M.Sc., Conservation and Development, Alberta Agriculture, Food and Rural Development
Leonard Kryzanowski, Ph.D., Elston Solberg, M.Sc., Mingchu Zhang, Ph.D., Agronomy Division, Alberta Agriculture, Food and Rural Development
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Site-Specific Application of Fertilizer N for Reducing Greenhouse Gas Emissions

CCFIA Grant $225,000

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Executive Summary

Current estimates indicate nitrous oxide (N_2O) accounts for over 50% of greenhouse gas emissions from agriculture. However, factors controlling N_2O emissions from soil are poorly understood. Application of fertilizer N to agriculture soils, at rates in excess of crop requirements, increases the risk of N_2O emission. Thus, developing methods to accurately predict and apply crop fertilizer N requirements are high priorities for research. It is well known crop requirements for N fertilizer vary significantly within agriculture fields. However, a majority of fields have a constant rate of fertilizer N applied to them. Recently, methods of varying the rate of fertilizer N within a field (i.e., site-specific or precision application) have been developed using satellite global positioning systems (GPS), digital fertilizer requirement maps, and computer controlled variable rate fertilizer applicators. Field sites have been established across Canada to study site-specific fertilizer application. This study measures greenhouse gas emissions (N_2O, CO_2) at existing site-specific study sites in Québec, Ontario, and Alberta, where significant information on within-field-variability of soil properties exists. The gas emission measurements will be combined with the other soil and crop information to establish a database for verification of greenhouse gas flux models. The influence of site-specific application of N fertilizer on reducing N_2O emissions will be assessed.

Program Objectives

The objectives of this project are to:

- Quantify greenhouse gas (N_2O, CO_2) emissions from existing site-specific fertilizer application research sites, across a range of soil and climates in Canada. The measurements of emissions will be combined with existing and on-going measurements of

soil and crop measurements at the sites, into a common database for model testing.
- Evaluate the potential of site-specific fertilizer N application to reduce N_2O emissions, across a range of soils/climates in Canada.
- Develop and test stochastic spatial scaling theory for estimating field scale greenhouse gas (N_2O, CO_2) flux.

Collaborators

Régis Simard, Ph.D., AAFC Soils and Crops Research and Development Centre, Ste-Foy
Ivan O'Halloran, Ph.D., Department of Land Resource Science, University of Guelph
Colin McKenzie, Ph.D., Alberta Agriculture, Food and Rural Development, Brooks
Dennis Rolston, Ph.D., Department of Land Air Water Resources, University of California, Davis

Documenting Impact of a Reduction in Tillage on the Amount of C Sequestered, the Stability of Sequestered C and Emissions of N_2O under Corn/Cereal/Soybean Rotations in Ontario

CCFIA Grant $350,000

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Executive Summary

The research that is proposed will document the extent of carbon (C) sequestration that has occurred on long-term no-till sites, the ease with which this C is lost to the atmosphere if tillage is reintroduced, and the amount of N_2O that is emitted from a fine textured soil under no-till (in relation to conventional till). In addition, the Century model will be refined for simulating C and N dynamics. The focus of the field and modeling components of the study will be on southern Ontario and on cropping systems involving corn, soybeans and wheat. The project will enable researchers at the University of Guelph and three Agriculture and Agri-Food Canada research stations to integrate their research activities on a focused project that will lead to a better understanding of the influence of tillage on C and N dynamics and on GHG emissions.

The Ontario Field Crops Research Coalition will fill an advisory role throughout the project and will assist the research team with communicating the results of this project to user communities (farmers, advisory personnel and government policy agencies).

Program Objectives

The objectives of this study will be to:

- Document the extent of C sequestration when no-till has been practiced for at least 8-10 years on different soils under corn/cereal/soybean cropping systems.
- Determine the reversibility of the C sequestration process subsequent to the reversion to conventional tillage for a single year.
- Compare the annual losses of N_2O from soils under conventional till with losses from soils under no-till for at least 8-10 years.

- Refine the Century model to improve accuracy of predictions of carbon and nitrogen dynamics when cropping systems utilizing different tillage practices, cover crops and N management practices are carried out on different soils/landscapes in Ontario.

Collaborators

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Craig Drury, Ph.D., AAFC Greenhouse & Processing Crops Research Centre, Harrow
Ronald Beyaert, Ph.D., AAFC Research Farm, Delhi
Ed Gregorich, Ph.D., AAFC Eastern Cereal and Oilseed Research Centre, Ottawa

Greenhouse Gas Emissions from Swine Operations in Québec and Saskatchewan: Benchmark Assessments and Selective Mitigation Processes

CCFIA Grant $150,000

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Executive Summary

Agriculture as a whole could account for 9.5% of the total Canadian greenhouse gas emissions, with N_2O and CH_4 contributing 61% and 38% respectively. It is also estimated that 42% of the agricultural GHG emissions originate from livestock operations and one third of these are associated with manure management. There exists a need to better determine the relative contributions of the different stages of livestock production and manure management to the GHG emissions caused by this agricultural sector. Another important emission issue for livestock operations, particularly in swine production, is odours. There is a need to better assess the effects of the different components of livestock operations (animal housing, manure management) on their global emissions.

The general objective of the proposed research is to evaluate GHG (CH_4, CO_2 and N_2O) and odours emissions for swine operations in two provinces (Québec and Saskatchewan) under liquid manure management. More specifically, the study will be targeted at:

- Determining the GHG and odour emissions from different types of swine production buildings and building floor designs during a two year period.
- Determining the GHG and odour emissions from different types of manure storage facilities (covered and uncovered) over a two year period.
- Determining the GHG and odour emissions associated with the agitation and emptying of those facilities.

All GHG emission data will be expressed in terms of mass of gas emitted per animal mass unit per time unit. This will allow for the evaluation of the relative contribution of the animal housing and manure storage components of swine production systems to the total GHG emissions, thus facilitating the identification of the sub-systems where potential mitigation measures for the reduction of GHG emissions should be implemented. In addition, it will be possible to more precisely assess the relative importance of the Canadian swine production industry to the total GHG emissions of the country, thus determining if this industry should be a priority target for GHG emissions reductions in the future.

Program Objectives

The general objective of the proposed research is to evaluate GHG (CH_4, CO_2 and N_2O) and odour emissions for swine operations in two provinces (Québec and Saskatchewan) under liquid manure management. More specifically, the study will be targeted at:

- Determining the GHG and odour emissions from different types of swine production buildings (gestation, farrowing, nursery and finishing barns or sections of barns) and two different types of floor designs (fully and partially slatted floors);
- Determining the GHG and odour emissions from different types of manure storage facilities (earthen manure storage, concrete tanks, use of covers (temporary or permanent)), and
- Determining the GHG and odour emissions associated with the agitation and emptying of swine manure storage facilities.

Collaborators

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Robert Lagacé, ing., agr., Ph.D., Département des sols et de génie agroalimentaire, Université Laval
Stéphane Lemay, P.Eng., Ph.D., Prairie Swine Centre Inc.
Roch Joncas, ing., agr., M.Sc., Institute de recherche et développement en agroenvironnement du Québec

Examination of Environmentally and Economically Sustainable Management Practices in Forage-Based Beef Production Systems

CCFIA Grant $61,445

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Executive Summary

The National Climate Change Secretariat has identified the need for accurate collection of data to quantify greenhouse gas emissions in the agricultural sector and validation of existing models utilized to predict greenhouse gas production (Recommendations 6 and 7). Further, they have also identified the need to work with the agricultural sector to establish and promote management practices whose implementation will lead to a reduction in greenhouse gas emissions (Recommendations 1 and 9). In accordance with these recommendations, it is necessary to examine methane production by the cattle industry as this is a sector which currently contributes more than $20 billion annually to the Canadian economy and has experienced considerable growth in recent years. This expansion is particularly apparent in Western Canada where forage-based production systems have begun to predominate. The increased utilization of forage in the prairie region, where the vast majority of beef production occurs, has made it necessary to identify cost-effective production practices, as well as to examine the environmental impact associated with implementation of such practices. As such, this project will examine overwintering rates of gain in backgrounded cattle and identify the management system which will realize the greatest economic return when subsequently grazed in either a tame or native grazing system. Further, methane emissions associated with each system will be measured and compared thus providing the necessary data to identify the best management/production practices to the beef sector. Changes in species biodiversity which occur when cattle are grazed in tame and native pastures systems will also be examined.

The proposed project provides a unique opportunity to bring together the production, extension, conservation and research sectors of the beef industry to identify economically and environmentally sound management practices appropriate for forage-based beef production in

Western Canada, as outlined in Recommendations 1, 6, 7 and 9 of the Agriculture and Agri-Food Climate Change Table Options Report.

Program Objectives

- To measure and publish methane emissions associated with the consumption of forage of different qualities in the drylot, as well as in rotationally-grazed tame and native pasture systems.
- To monitor live weight gain, feed intake, and feed efficiency of cattle when fed at four rates of gain during a 90-day backgrounding phase and a 120-day pasture phase on rotationally grazed native or tame pastures.
- To determine the effect of rotational grazing on species composition of tall grass, native, as well as tame pasture systems.
- To disseminate the information generated from this project to the scientific, extension and producer sectors of the beef industry.

Collaborators

Adrien Grenier, Stuartburn-Piney Agricultural Development Corporation
Fraser Stewart, Forage Specialist, Manitoba Agriculture and Food
Wally Happychuk, Agricultural Representative, Manitoba Agriculture and Food
Janet Moore, Critical Habitat Wildlife Program

CCFIA Components 2 & 3 Project 11

Multi-scale Estimation on N_2O Flux from Agroecosystems

CCFIA Grant $200,000

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Executive Summary

Measurement, verification, and refinements of the national N_2O emissions inventory from agriculture have been identified by the Agriculture and Agri-Food Climate Change Table (AACCT) as a key part of a national strategy to reduce greenhouse gas emissions. It is widely recognized that measurement and verification must proceed at several scales - from the individual farmer's field to regional scale assessments. The problem to date is that models of nitrous oxide emissions for large areas have been difficult to validate because the "scale" of collaborating measurements have been very local - normally, a small chamber. However, recent developments in aircraft monitoring techniques of nitrous oxide emissions make it possible to validate these model results for much larger areas. The proposed project, which is intended to build on past research and development, focuses on providing integrated N_2O flux measurements from the major agroecosystems in Saskatchewan and in Ontario using a combination of chamber-based point measurements and aircraft-based flux measurements.

The proposed project has two major stages. In the first, sampling strategies for large area estimates of N_2O emissions will be developed and applied in Ontario for the aircraft methods and in Saskatchewan for the chamber-based methods during 2001. These measurements will provide separate estimates for N_2O emissions for these regions. In 2002 both methods will be used to measure the emissions from major agroecosystems in Saskatchewan during the snow melt period. Hence, both the methods for regional estimates and the estimates themselves will be considerably advanced by this project.

Program Objectives

- To develop techniques for large area measurements of N_2O emissions using chamber and aircraft-based methods.

- To measure N_2O emissions during spring melt from major agricultural landscapes in Ontario using tower and aircraft methods and in Saskatchewan using chamber and aircraft methods.
- To test and improve the usefulness of the main N_2O models for predicting N_2O fluxes at large area scales as well as reflecting the improvements in technology.
- To refine the estimates from the agricultural sector in the national inventory.

Collaborators

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Ray Desjardins, Ph.D., AAFC Research Branch, Ottawa
John MacPherson, M.Sc., National Research Council, Ottawa
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Reduction of GHG Emissions from Dairy Production Systems and Poultry Manure and its Impact on Agricultural Sustainability

CCFIA Grant $250,000

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Executive Summary

This project proposes to develop methods to reduce GHG emissions throughout the dairy production system from barn, to cow, to bedding, to wastes, to the feedcrops, and back to the cow, and assess the impacts of these methods on the sustainability of the system. The University of British Columbia can provide this approach through a multi-disciplinary team of experts.

The impact of feed additives on cow methane (CH_4) production and effective nitrogen (N) fertilization rates of crops to reduce N excretion from the cow will be determined. Optimum management/behaviour of livestock can improve health and milk production efficiency reducing waste, a primary source of GHG. The aim is to provide a scientific base to recommendations for bedding types and free-stall designs that optimize cow stall usage patterns and comfort.

Improved bovine and poultry manure management to minimize GHG emissions will be investigated. Greenhouse gas emissions from different types of composting facilities and composted manure will be quantified and monitored. Laboratory- and pilot-scale experiments will also be conducted. Ammonia and nitrous oxide (N_2O) from each component of the system will be monitored as well as carbon dioxide (CO_2) and CH_4 from manured pasture areas. The annual carbon (C) sequestration or net ecosystem production (NEP) of the pasture areas and the economic value of the carbon sequestered will be estimated.

Use of manure reduces GHG production when it replaces inorganic N produced using fossil fuels. A practical, low-cost system for producing crops without adding mineral N will be developed and evaluated and an economic analysis of its benefits will be prepared. The new dairy barn, milking parlour and manure handling system built at the UBC Dairy Education and

Research Centre, Agassiz, BC and expertise at PARC will allow this research to be conducted efficiently.

Program Objectives

Dairy Cow Nutrition

- To determine the effects of feed enzymes, surfactants and ionophores on cow production, ration digestion and value of resultant manure as a fertilizer.
- To determine the effects of rate of N fertilization of forage grass species on milk production yield and form of N produced.
- To use these data to formulate more effective dairy cattle diets using the Cornell Net Carbohydrate and Protein Model.
- To test these diets in production and digestibility trials with dairy cows to determine efficiency of N use.
- To develop methodology for rapid determination of manure characteristics through the use of NIR.

Composting

- To characterize dairy and poultry manure for total and volatile solids content, and C and N content.
- To quantify GHG emissions from composting facilities.
- To quantify GHG emissions from land application of composted manure.

Manure Application

- To develop new low-cost technology of manure application that will enable Canadian farmers to comply with tightening environmental regulations, especially reducing GHG emissions, with no cost or inconvenience.
- To develop a sustainable system for application of manure on land to completely replace all fertilizer which does not lead to accumulation of other nutrients such as phosphorus (P) and potassium (K) while minimizing the ratio of GHG gases production to crop yield.
- To assess the on-farm costs and benefits associated with the use of manure.

GHG Emissions

- To determine the impact of GHG (CH_4 and N_2O) and NH_3 emissions from dairy cattle barns, stored manure, and forage crop production under different manure management options by considering the effect of:
  - site of sampling (cow, floor, solid/liquid separation, manure storage and spreading);
  - bedding type (sand, sawdust, etc.);
  - cow diet.

Pasture/Soil GHG Emissions and Carbon Sequestration

- To compare the emissions of CO_2 and CH_4 from the soil in tall fescue pasture plots with 50 kg NH_4^+-N and 100 kg NH_4^+-N manure applications 4 times a year with a control with no manure application.

- To determine the relationships between the CO_2 and CH_4 emissions and environmental variables, in particular soil temperature, soil water content and water table height.
- To compare the annual carbon sequestration or net ecosystem productivity of the treatments and the control with particular attention to growing season gains vs. losses during the winter months.
- To evaluate the reliability of scaling up chamber fluxes to those from fields by comparing chamber fluxes with eddy covariance CO_2 flux measurements.
- To parameterize the C sub-model in the Meteorological Service of Canada's soil-vegetation-atmosphere-transfer model, Canadian Land Surface Scheme (CLASS), for application to Lower Fraser Valley pastures.
- To measure seasonal and annual exchange of CO_2 between the atmosphere and pastures in the Lower Fraser Valley.
- To measure the components of the annual C balance of the soil in these pastures.
- To estimate the market value of increases in pasture-based C sequestration in the context of tradeable carbon permits.

Collaborators

Dan Weary, Ph.D., Andy Black, Ph.D., Faculty of Agricultural Sciences, University of British Columbia
Anthony Lau, Ph.D., P.Eng., Faculty of Applied Science, University of British Columbia
Shabtai Bittman, Ph.D., Laurens van Vliet, M.Sc., AAFC Pacific Agri-Food Research Centre, Agassiz

Network on Crop Production Practices to Reduce Agricultural Greenhouse Gas Emissions in Eastern Canada

CCFIA Grant $175,0000

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Executive Summary

Canada has made a commitment to reduce its greenhouse gas production over the next decade. Canadian crop production offers three means to do this: 1) reduction in the production of N_2O associated with crop production, 2) adoption of production methods that sequester more carbon into soils, 3) production of biomass suitable for biofuels. This research will examine the effects of N fertility rates and tillage systems (conventional and no-till) on N_2O production and carbon sequestration into soils by a set of perennial and annual crops in eastern Canada. It will examine the use of nitrogen fertility levels and tillage system as mechanisms to alter the partitioning of N_2:N_2O during denitrification in agricultural soils. The soils work will measure both accumulated carbon in the soil and the emission of CO_2 from the soil surface. The crops produced will be evaluated for yield and for the production of biomass that could be used in biofuel production or as some other form of industrial material. The research team will also evaluate the ability of a new technology, shown to enhance crop biomass production. This work will be accompanied by modeling of soil carbon levels. A longer-term outcome of the work will be the establishment of a group with expertise in this area in eastern Canada; the current group involves three university, four government and one industry researchers and will train two Ph.D. students and a postdoctoral fellow in research activities related to crop production and climate change.

Program Objectives

General Objective

To determine net GHG production associated with various crop production methods under the cool-humid conditions of eastern Canada.

Specific Objectives

- Information on fertility management to minimize N_2O production.
- Better understanding of how cropping systems can maximize sequestration of carbon into soil organic matter.
- Development of methods to enhance crop uptake of CO_2.
- Estimates of biomass production suitable for biofuel manufacture under various cropping systems and with a range of annual and perennial crops.
- Establishment of an eastern Canadian knowledge base and expertise network for future work in this area.

Collaborators

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Chandra Madramootoo, Ph.D., Department of Agricultural and Biosystems Engineering, McGill University
Ed Gregorich, Ph.D., Baoluo Ma, Ph.D., AAFC Eastern Cereal and Oilseed Research Centre, Ottawa
Denis Angers, Ph.D., Philippe Rochette, Ph.D., AAFC Soils and Crop Research and Development Centre, Ste-Foy

Improved Greenhouse Gas Emission Estimates from Manure Storage Systems

CCFIA Grant $200,000

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Executive Summary

Estimates of greenhouse gas emissions from Canadian agriculture point to animal waste as an important source of greenhouse gases. However, these estimates of GHG emissions from animal manure are based on emission factors that may not be appropriate for Canadian conditions. The large uncertainty in emission estimates makes the identification of GHG reduction measures for the agricultural sector very difficult.

This knowledge gap will be addressed by conducting year-round *in situ* measurements GHG emissions (CH_4 and N_2O) from several typical manure storage systems used by Canadian farmers. Emphasis will be placed on swine and dairy cattle manure, due to their importance in GHG emissions. Use of a micrometeorological mass balance method combined with tunable diode laser trace gas analyzers will enable quasi-continuous flux measurements. In addition a verification system based on an agricultural pollutant dispersion model will be developed to assess source strength of confinement facilities.

In addition, on-farm cost estimates (which were established in 1999) will be updated and GHG emission estimates obtained with our measurement campaigns will be incorporated to the newest version of 'Manure and Nutrient Management Suite 2000'. This will result in a management tool to assess not only GHG emissions from various manure storage systems, but also the cost effectiveness of various options.

The proposed research directly addresses "the need for more accurate raw data, and the refinement of analytical models that can be used to manage and to assess the effectiveness of GHG-reduction policies" as identified in Recommendation 6 of the AAF Table Options Report.

Program Objectives

- To quantify N_2O and CH_4 emissions from manure storage systems *in situ.*
- To develop a verification system to assess source strength of confinement facilities.
- To incorporate findings into the decision support system MCLONE (Manure - cost, labour, odour, nutrient and environment), providing an analytical tool for evaluating the most cost effective solutions associated with greenhouse gas reductions.

Collaborators

Grant Edwards, Ph.D., School of Engineering, University of Guelph
Peter Stonehouse, Ph.D., Department of Agriculture Economics & Business, University of Guelph
Ron Fleming, M.Sc., Ridgetown College, University of Guelph

Feedlot Greenhouse Gas Emissions: Effect of Diet and Manure Storage System

CCFIA Grant $47,360

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Executive Summary

The National Climate Change Secretariat has identified the need for accurate collection of data to quantify greenhouse gas emissions in the agriculture sector and validation of existing models utilized to predict greenhouse gas production (Recommendations 6 and 7). Further, they have also identified a need to work with the agriculture sector to establish and promote management practices whose implementation will lead to reduced greenhouse gas emissions (Recommendations 1 and 9). The Agriculture and Agri-Food Climate Change Table identified general areas of agriculture production that had the most potential for mitigation options. In attempting to assess mitigation options for Western Canada's feedlot industry, the Table noted a complete lack of information about emission rates using current feeding and management practices. Without this initial data base, estimates for potential greenhouse gas reduction potential within the industry can not be assessed.

Livestock production, unlike crop production, has the opportunity for major expansion within Canada because current production levels are well below resource constraints and current world demand for animal product is high. At the same time a number of provinces have engaged in manure management policies, with little understanding of impact on greenhouse gas emission. Therefore, it is timely that a study be designed to measure actual greenhouse gas emissions for feedlot cattle using commercially relevant feeding practices and manure storage options.

This proposal involves expertise at the University of Manitoba and Agriculture and Agri-Food Canada (Brandon and Lethbridge Research Centres). The proposed project is unique in that a number of disciplines (animal nutrition, soil science and manure handling and storage expertise)

will be brought together to study all aspects of greenhouse gas emissions during one feedlot cycle.

Program Objectives

- To measure methane emissions (% GEI (Gross Energy Intake), and g kg^{-1}gain) associated with the feeding of feedlots rations differing in the ratio of forage to concentrate.
- To measure methane emissions (% GEI, and g kg^{-1}gain) associated with feeding feedlot rations that are isocaloric, with and without unsaturated fats.
- To compare manure pack characteristics and greenhouse gas emissions for feedlot cattle receiving diets with different forage to concentrate ratios.
- To compare greenhouse gas emissions of stock-piled manure from cattle receiving diets with different forage to concentrate ratios.
- To compare greenhouse gas emissions of composted manure from cattle receiving diets with different forage to concentrate ratios.
- To disseminate the information generated from this project to the scientific, extension and producer sectors of the beef industry.

Collaborators

David Burton, Ph.D., Department of Soil Science, University of Manitoba
Julie Small, Ph.D., Shannon Scott, Ph.D., Katherine Buckley, Ph.D., AAFC Brandon Research Centre
Tim McAllister, Ph.D., AAFC Lethbridge Research Centre

Component 4

Workshop on Climate Change and Communications

Communications and dissemination of information and project results will be critical to the success of the CCFIA. In early 2002, CARC will host a workshop to bring together all those funded under Components 1, 2 and 3 of the CCFIA. Researchers will report on the progress of their respective projects, followed by interactive discussions. The workshop will provide an opportunity for assessment of the program and allow modifications if required. Funding for the workshop totals $60,000.

In addition, CARC has begun work towards developing a strategy for communications and continuity in climate change research in Canada. CARC will host a workshop on April 28-29, 2001 for members of its Canada Committees and Expert Committees. The two key committees are the CARC Canada Committee on Natural Resources and its Expert Committee on Manure Management and Expert Committee on Greenhouse Gases and Carbon Sequestration. These committees include representatives from industry, universities and federal and provincial governments. The objectives of the workshop are to:

- Discuss international, federal and provincial protocols, policies and funding programs to reduce greenhouse gas emissions.
- Discuss agricultural climate change research in Canada and identify needs and emerging issues.
- Establish an ongoing process within the CARC committee system to ensure continuity to climate change research.

Participation is limited to 125 persons with priority being given to CARC Canada and Expert Committee members, in order to ensure focused discussions and clear identification of emerging climate change research needs in Canada and mechanisms for ensuring ongoing activities of climate change coordination and networking.

Appendix A

Climate Change Funding Initiative in Agriculture (CCFIA) Committee

Chair

L.E. Haley, Ph.D., Co-Chair, Agriculture and Agri-Food Climate Change Table[1]
Truro, Nova Scotia

Members

Derek Anderson, Ph.D., Chairperson, CARC Canada Committee on Animals
Professor and Head, Department of Animal Science, Nova Scotia Agricultural College
Truro, Nova Scotia

Marie Boehm, Ph.D., advisor to Agriculture and Agri-Food Climate Change Table
and Member, Sinks Table[2]
Research Scientist, Agriculture and Agri-Food Canada
Saskatoon, Saskatchewan

David Burton, Ph.D., Member, Agriculture and Agri-Food Climate Change Table
Associate Professor, Department of Soil Science, University of Manitoba
Winnipeg, Manitoba

Gordon Dorrell, Ph.D., Director General, Western Region, Agriculture and Agri-Food Canada
Ottawa, Ontario

Ken Edie, producer
Member, CARC Board of Directors and Council member
representing Canadian Federation of Agriculture
Dugald, Manitoba

Michael Goss, Ph.D., Chairperson, CARC Canada Committee on Natural Resources
Director, Agri-Food Resources & Environment Program, Office of Research,
University of Guelph
Guelph, Ontario

John Harapiak, Member, Agriculture and Agri-Food Climate Change Table
Canadian Fertilizer Institute
Calgary, Alberta

Norris Hoag, Chairperson, Canadian Agri-Food Research Council
Executive Lead, Scientific Projects, Ontario Ministry of Agriculture, Food and Rural Affairs
Guelph, Ontario

Art Jaques, Co-Chair, Sinks Table
Head, Greenhouse Gases, Pollution Data Branch, Environment Canada
Hull, Quebec

Keith MacLeod (non-voting), Environmental Analyst, Environment Bureau, Agriculture and Agri-Food Canada
Ottawa, Ontario

Gilles Rousselle, Ph.D., Director, Soils and Crops Research and Development Centre, Agriculture and Agri-Food Canada
Sainte-Foy, Quebec

Chang Liang, Ph.D., (alternate for A. Jaques), Project Officer, Pollution Data Branch, Environment Canada
Hull, Quebec

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[1] The Agriculture and Agri-Food Climate Change Table completed its work with the publication of the options report, *Reducing Greenhouse Gas Emissions from Canadian Agriculture*, in January 2000.

[2] The Sinks Table completed its work with the publication of an *Options Report* in September 1999.

Both Table reports can be found on the website of the Climate Change Secretariat: www.nccp.ca.