



**BIOCAP-Funded Research Projects
2002 – 2006**
Final Summary

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BIOCAP Canada Foundation

156 Barrie Street,
Queen's University,
Kingston, Ontario. K7L 3N6

Tel: 613 542 0025

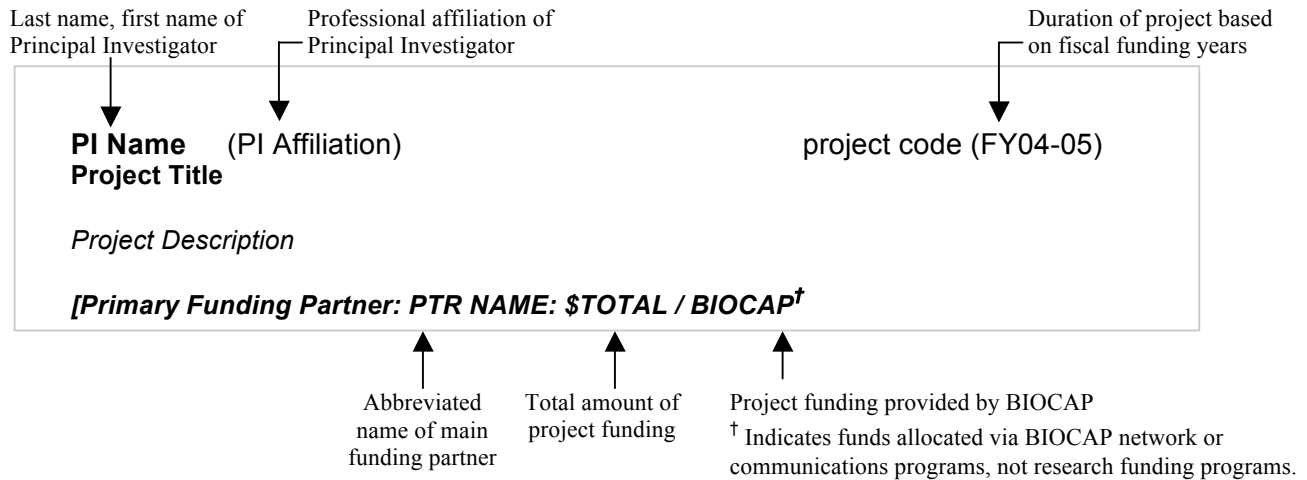
Fax: 613 542 0045

Email: info@biocap.ca

Web Site: www.biocap.ca

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How to Read Project Summaries:



Introduction & Background

Since 2002, BIOCAP-affiliated networks and grants have been providing research funding support to projects exploring biosphere-based solutions to the problems of climate change and clean energy. BIOCAP funding occurs under four main research areas: Forestry and Natural Ecosystems, Agriculture, Bioenergy and Policy Development. In many cases, these research areas overlap and cross cut, creating important linkages among research sectors which are the basis of BIOCAP's 'network of networks'.

This comprehensive report summarizes the Foundation's 125+ research investments and highlights BIOCAP's contribution to the creation of a sustainable bioeconomy. Within the research area of forestry and natural ecosystems BIOCAP funding support focusses on advancing an understanding of how climate and disturbance affect the carbon (C) and nitrogen (N) cycles in Canada's forests and lakes as well as the socioeconomic implications of managing forests and their watersheds for enhancing carbon sequestration or bioenergy production. BIOCAP's support of research in agriculture is developing insights and technologies that will reduce agriculture's environmental footprint and help secure a sustainable supply of biomass for producing energy, chemicals and materials. BIOCAP-funded research is also developing the insights and technologies to inform policy and investment decisions related to the harvesting, transportation, conversion and use of biomass as a source of bioenergy and bioproducts. Finally, BIOCAP supports research synthesis and integration to help identify bioeconomy solutions that are economically and environmentally feasible, and relevant to industry and government ventures.

BIOCAP Research & Development Goals

The BIOCAP Canada Foundation is guided by four overall goals which are critical to the transformation to a sustainable bioeconomy. Every BIOCAP-funded research project contributes to at least one or more of these goals. This promotes the development of multidisciplinary and multisector collaborations that can yield realistic, economic, and environmentally sustainable solutions to the problems of climate change and clean energy. The four goals are:

- **Quantify to Predict:** Quantify, understand and predict biological sources and sinks of greenhouse gases associated with human activities;
- **Improve Environmental Footprint:** Identify management strategies, develop new technologies and assess socio-economic impacts of efforts to reduce biological GHG emissions, enhance C sinks or provide other environmental services (e.g. clean air and water);
- **Produce Biomass Sustainably:** Develop new crops or trees or identify optimal management strategies for sustainable biomass production to provide energy, chemicals and materials, or to enhance biological carbon stocks as a GHG offset; and
- **Use Biomass Sustainably:** Develop the tools, technologies, and implementation strategies for accessing & processing biomass into a sustainable supply of the energy, chemicals and materials that will complement and extend fossil carbon resources.

BIOCAP-Funded Research Projects

For the purposes of this summary, projects have been grouped into established or emerging network theme areas, as summarized on page 2 in the Table of Contents. Project groupings will be revisited once stakeholders align to the scope of emerging network theme areas and consultations take place with individual researchers.

Forestry and Natural Ecosystems

1. Fluxnet Canada Research Network / Canadian Carbon Program

Fluxnet-Canada was a national research network that brought together university and government scientists to study the influence of climate and disturbance on carbon cycling in Canadian forest and peatland ecosystems. The network had 22 research locations conducting continuous measurements of carbon dioxide, water, and energy exchanges between ecosystems and the atmosphere using the eddy covariance flux measurement technique. The network maintained a publicly-accessible database, containing flux and associated ecological data, which was updated on a regular basis. The work and assets of this research program were transitioned to the Canadian Carbon Program (CCP) in early 2007.

Margolis, Hank (Professor, Laval Univ.) FY02/03-06/07

Fluxnet Canada Research Network (Co applicants: plus many others).

[Primary Funding Partner: NSERC, CFCAS: \$13,631,731/1,000,000]

[Central Admin Funding: \$2,720,665/199,583]

Barr, Alan (Univ. of Saskatchewan) FY 02/03-06/07

Boreal Ecosystem Research and Monitoring Sites (BERMS) (Coapplicants: Amiro, McCaughey, Van Rees, Bhatti, Black)

The BERMS site in central Saskatchewan was undertaken co-operatively by government and university collaborators in 1993 as part of the BOREAS research project and has continued as BERMS since 1997. It has three research sites located in mature aspen, black spruce, and jack pine forests, which represent common, ecologically important forest types of the western boreal forest of Canada. Measurements from BERMS are the basis for continued monitoring of the effects of climate variability on carbon exchange, and the mature forest research sites provide a baseline for a satellite network of flux towers in younger forests.

[Primary Funding Partner: NSERC, CFCAS: \$2,416,573/177,276]

Black, Andrew (Professor, Dept. of Soil Science, Univ. of British Columbia) FY 02/03-06/07

British Columbia Flux Station (Co applicants: Whiticar, Stull, Prescott, Livingston, Guy, Trofymow, Novak)

The British Columbia Flux Station is located in a Douglas fir forest near Campbell River, BC. The mild winters and dry summers of coastal BC are dramatically different than the climates of other Fluxnet stations and result in very different seasonal patterns of C exchange. Consequently, the data obtained at the BC Flux Station is critical for testing the robustness of Fluxnet's climate and ecosystem process models.

[Primary Funding Partner: NSERC, CFCAS: \$1,299,766/95,349]

Bourque, Charles (Professor, Forestry & Environmental Mgmt, Univ. of New Brunswick) FY 02/03-06/07

New Brunswick Flux Station (Co applicants: Lavigne, Arp, Meng)

The New Brunswick Flux Station measures long-term carbon fluxes at a mature balsam fir forest and uses a roving tower to measure fluxes from disturbed forest sites. The Station also applies a model of net photosynthesis to quantify net carbon exchange from single trees to entire stands. The unique climatic and ecological characteristics of the New Brunswick Flux Station make it a critical maritime component of the national Fluxnet Network.

[Primary Funding Partner: NSERC, CFCAS: \$920,012/67,490]

Flanagan, Larry (Professor, Dept. of Biological Sciences, Univ. of Lethbridge)
Cross Transect Stable Isotope (Co applicant: Whiticar)

FY 02/03-06/07

The study of stable isotope fractionation and carbon cycling provides a useful way to link ecological processes with atmospheric measurements. Stable isotope measurements are made at all Fluxnet flux stations and provide three kinds of information: 1. Integrated information on how the environment affects CO₂ and water vapor fluxes and how these vary across Canada; 2. An estimate of how net ecosystem CO₂ exchange is separated into its major component processes (i.e. photosynthesis and respiration); and 3. Classification of ecosystem productivity, which will inform large-scale studies that separate the net sequestration of anthropogenic CO₂ emissions between the ocean and terrestrial ecosystems.

[Primary Funding Partner: NSERC, CFCAS: \$1,009,694/74,069]

Flanagan, Larry (Professor, Dept. of Biological Sciences, Univ. of Lethbridge)
Western Peatland Flux Station

FY 02/03-06/07

The Western Peatland Flux Station is located in a treed fen near the Labiche River in Northern Alberta and provides a western complement to the Eastern Peatland Flux Station. This station is examining how climate can affect peatland processes and the influence of peatland structure and function on ecosystem productivity.

[Primary Funding Partner: NSERC, CFCAS: \$804,264/58,999]

Grant, Robert (Professor, Forestry and Home Economics, Univ. of Alberta)
Integrated Modelling and Scaling (Co applicants: Price, Arain, Chen, Wang)

FY 02/03-06/07

The modelling and scaling component of Fluxnet applies the insights gained at individual flux stations to the full spatial and temporal diversity of environmental conditions occurring within a region. Modelling activities occur in two different categories: 1. An integrated modelling component that conducts cross-transect model tests and provides scaling to regional and national levels; and 2. Modelling conducted by researchers working at the individual flux stations.

[Primary Funding Partner: NSERC, CFCAS: \$1,034,618/75,898]

Lafleur, Peter (Professor, Dept. of Geography, Trent Univ.)
Eastern Peatland Flux Station (Co applicants: Roulet, Richard, Moore)

FY 02/03-06/07

Activity at the Eastern Peatland Flux Station is concentrated in three areas: 1. Continuing long-term carbon flux measurements in order to develop a more accurate assessment of the contemporary carbon balance of the bog and its relationship with climate; 2. Extending the measurement program to other peatland types to obtain model parameters for a peatland simulator model; 3. Improving understanding and predictions of the future of carbon cycling in Canada's peatlands under a changing climate.

[Primary Funding Partner: NSERC, CFCAS: \$959,486/70,386]

Margolis, Hank (Professor, Faculty of Forestry and Geomatics, Univ. Laval)
Quebec Flux Station

FY 02/03-06/07

The Quebec Flux station is situated in a black spruce forest, providing a comparison to black spruce research sites in Saskatchewan and Manitoba. Forests surrounding this station frequently undergo changes due to silvicultural management practices; this station will make long-term measurements of carbon exchange in a mature stand and a site recently disturbed by silvicultural management. Measurements of ecosystem components will allow the effects of harvest and climate to be better understood.

[Primary Funding Partner: NSERC, CFCAS: \$1,095,258/80,346]

McCaughey, Harry (Professor, Dept. of Geography, Queen's Univ.)
Ontario Flux Station (Co applicants: Treitz, McLaughlin, Morrison, Chen, Beall, Payne, Peng, McRae, Dumas)

FY 02/03-06/07

The Ontario Flux Station is located in the boreal mixedwood forest of northeastern Ontario, which is a mixture of five main species: trembling aspen, white birch, white spruce, black spruce, and balsam fir. These species make up the majority of the central boreal forest, and occupy over 50% of the total forest land base in northern Ontario. This station will provide valuable information on the role of climate variability and forest management practices on carbon exchange for this type of forest.

[Primary Funding Partner: NSERC, CFCAS: \$1,371,396/100,603]

Moore, Tim (Professor, Dept. of Geography, McGill Univ.)
Dissolved Organic Carbon and Carbon Cycling in Canadian Forests

FY 03/04-05/06

*This project will help reduce the uncertainty regarding the contribution of Dissolved Organic Carbon (DOC) to the carbon cycle of Canadian forests by determining DOC fluxes into, through, and out of the Fluxnet Canada forested sites (both natural and disturbed) in BC, SK, ON, QC, and NB. This information will be used to validate and calibrate several carbon cycle models. **[Primary Funding Partner: NSERC: \$261,270/130,635]***

Moore, Tim (Professor, Dept of Geography, McGill Univ.)

FY04/05-07/08

Atmospheric Exchange of Methane and Nitrous Oxide in Canadian Forest Soils

Not directly linked to Fluxnet nor to CCP, this project is examining the exchange of the greenhouse gases methane (CH₄) and nitrous oxide (N₂O) between the atmosphere and the soil at forested sites in Canada. The environmental and biological factors controlling this gas exchange will be identified and modelled spatially across Canadian forests to assess the impact of climate change on the CH₄ and N₂O balances.

[Primary Funding Partner: CFCAS: \$345,000/45,000]

Amiro, Brian (Dept. Soil Science, Univ. of Manitoba)

FY 05/06-06/07

Climate and Hydrology Drivers of the Carbon Balance in Northern Black Spruce Forests (Co applicant: Black).

This project is affiliated with Fluxnet and is exploring the importance of hydrology and climate in controlling the carbon balance of a Northern Old Black Spruce forest ecosystem near Thompson, Manitoba. The linkage of environmental factors such as hydrology and climate to carbon sequestration has large implications for the potential ability of forests to store carbon under future climate scenarios.

[Primary Funding Partner: CFCAS: \$328,397/39,640]

Margolis, Hank (Professor, Laval Univ.)

FY06/07-08/09

Canadian Carbon Program Research Network (Co applicants: plus many others).

The Canadian Carbon Program (CCP) is building on the accomplishments of the Fluxnet Canada Research Network to help develop a predictive capability for analyzing the effects of different climate change scenarios on future C stocks and wood supply. The major deliverable of the CCP will be the development of a scientific framework for estimating the carbon budget of Canada and North America at monthly to multi-annual time scales through a coordinated program of high quality ecosystem and atmospheric measurements and modelling.

[Primary Funding Partner: CFCAS: [\$4,500,000/100,000]

2. Sustainable Forest Management NCE (BIOCAP Component)

The BIOCAP/SFMN Joint Venture was launched to integrate studies of forest carbon management into the SFMN program. Studies funded under this joint venture provide valuable insights to inform investment and policy decisions regarding how forest C management can provide GHG emission reduction credits.

Fyles, Jim (BIOCAP/SFMN joint venture Program Leader, Univ. of Alberta)

FY 02/03-06/07

Sustainable Forest Management NCE - C Mgmt Aspect (Co applicants: plus many others).

[Primary Funding Partner: SFM NCE: \$1,588,690/536,100]

[Central Admin Funding: SFM NCE: \$25,000/12,500]

Adamowicz, Vic (Professor, Univ. of Alberta)

FY 02/03-05/06

A Bioregional Assessment of Sustainable Forest Management for the Boreal Plains (Co applicants: Hauer, Bunnell, Kurz, Schmiegelow, Butterworth, Armstrong, Boutin).

This project used a scenario modelling approach to study integrated resource management policies in the Boreal Plains ecozone of western Canada. The modeling framework included dynamic representations of human behavior, the ecological system, and the socioeconomic system, and examined the effects of: setting ecological and /or economic objectives at different forest management scales; alternative land tenure arrangements; alternative biodiversity conservation strategies; and alternative incentive structures for carbon sequestration and land use rights on ecological and economic sustainability.

[Primary Funding Partner: SFM: \$262,800/75,000]

MacLean, David (Assistant Professor, Univ. of New Brunswick)

FY 02/03-05/06

Influence of Forest Management, Silviculture, and Pest Management on Carbon Sequestration (Co applicants: Meng, Bhatti, Arp, Quiring).

The two key objectives of this project were: 1. to integrate carbon budget and sequestration objectives into strategic forest management plans, using study areas in New Brunswick and Newfoundland; and 2. to quantify the effects of integrated pest management of several major insect pests on forest defoliation, plant growth rate, and carbon sequestration.

[Primary Funding Partner: SFM: \$276,200/138,100]

Armstrong, Glen (Assistant Professor, Univ. of Alberta)

FY 03/04-05/06

Carbon credit trading: the law, firm behaviour, economics and landscape impacts (Co applicants: Thomassin, Elgie, Adamowicz).

If forests are to contribute to Canada's Kyoto commitments without compromising other forest values, policy and implementation options must be fully understood and carefully chosen. This research provided insights into effective forest policy options using a combination of legal analysis, experimental economics, and landscape level modelling. This analysis will be linked with Canadian Forest Service carbon models in order to inform aboriginal, industrial and government decision makers about the implications of carbon management schemes.

[Primary Funding Partner: SFM: \$330,201/123,377]

Duinker, Peter (Professor, Resource & Environmental Studies, Dalhousie Univ.)

FY 03/04-05/06

Old-Growth forests in Eastern Canada: exploring tradeoffs among timber, biodiversity, carbon, and public preferences (Co applicants: Bull, Wang, Crowe, Messier, Chen).

The goal of this project was to develop knowledge that will assist forest managers to conserve old-growth forests (OGF) and their associated values through both set-asides and active silvicultural intervention. Using three study forests in Nova Scotia, Quebec and Ontario, this project undertook to: a) assess the degree to which OGFs fulfill ecological functions associated with biodiversity and carbon cycling; b) determine how various citizen constituencies perceive and value OGFs; c) assess the implications of alternative OGF management approaches on forest values associated with timber production, biodiversity and carbon uptake/storage in the study forests; and d) develop detailed OGF management strategies for consideration by forest managers.

[Primary Funding Partner: SFM: \$85,270/38,033]

Lantz, Van (Professor, Forestry and Environmental Mgmt, Univ. of New Brunswick)

FY 03/04-05/06

Role of pest management in sequestering carbon in the 2008-12 Kyoto Commitment Period: integration with CBM-CFS3 and economic analysis (Co applicants: Cooke, MacLean).

This project addressed the potential for insect management to contribute to measurable carbon stock changes during the 2008-12 Kyoto Commitment Period. The specific objectives included: a) evaluating the impact of insect outbreaks on forest carbon dynamics from 2008-12 and determining the influence of pest management on forest carbon dynamics; b) assessing the cost-effectiveness of investing in pest management activities for forest carbon sequestration; and c) exploring long-term costs and benefits of an institutional arrangement whereby carbon credits are purchased by companies and the revenues used for pest management activities.

[Primary Funding Partner: SFM: \$164,500/63,590]

Malcolm, Jay (Assistant Professor, Faculty of Forestry, Univ. of Toronto)

FY 04/05-06/07

Dynamics of woody debris in eastern boreal forests: implications for C and wildlife management

The woody debris of a forest, including downed logs and standing dead trees, is a valuable resource from several perspectives, providing wildlife habitat, a pool of carbon and nutrients, and a potential source of renewable biofuel. The purpose of this research was to examine tradeoffs among these values, in particular, the implications for biological communities, carbon supplies, and ecosystem productivity of harvest-induced changes in the supply of woody debris.

[Primary Funding Partner: SFM: \$444,720/85,500]

3. Other – Sustainable Forest Management

These projects are helping to understand the potential impact of climate change on forest productivity and the potential for enhancing forest carbon stocks through forest genetic resources management and forest fertilization. The impact of management and climate change related disturbances on peatland carbon dynamics is also considered.

Aitken, Sally (Associate Professor, Dept. of Forest Sciences, Univ. British Columbia)

FY 02/03-05/06

Adapting Forest Genetic Resource Management to Climate Change (Co applicant: Yanchuk).

This research explored opportunities for mitigating the effects of climate change and enhancing forest C stocks by mixing seed from genetically selected individuals from different populations for reforestation. It also evaluated the ability of natural populations to adapt to new climatic and elevated CO₂ conditions in the absence of intentional intervention. The results can be used in the development of new forest policies addressing seed use and climate change and new strategies for optimizing use of selected genotypes for uncertain future climates.

[Primary Funding Partner: NSERC: \$460,052/230,026]

Grayston, Sue (Associate Professor, Dept. of Forest Sciences, Univ. British Columbia) FY 04/05-07/08
Forest fertilization and identification of microbial indicators to enhance C sequestration and reduce GHG emissions. (Co applicants: Bull, Mohn, Prescott, Weetman).

This project is helping to determine the impact of fertilization on carbon sequestration in Canada's boreal forests, and hence the potential for carbon credits. Nitrogen availability is a critical factor in forest productivity, and therefore addition of nitrogen fertilizer may lead to increases in overall stand productivity. Of significant importance in this research is the balance of greenhouse gases methane (CH₄), nitrous oxide (N₂O), and carbon dioxide (CO₂) under a variety of fertilization scenarios.

[Primary Funding Partner: NSERC: \$435,639/75,000]

Chen, H (Assistant Professor, Faculty of Forestry & the Forest Environment, Lakehead Univ.) FY 05/06-07/08
Can mixedwood management increase carbon sequestration in the eastern-central boreal shield? (Co applicants: Bergeron, Pare).

This project is examining the role that boreal mixwood forests play in carbon sequestration by comparing the carbon uptake ability of aspen/spruce mixtures to single species forest stands. The two forest types will be compared based on their ecosystem biomass, total carbon pool, primary productivity, soil respiration and their response to forest fire. The results of this project will help improve forest management practices and provide more accurate carbon accounting for mixed boreal forests.

[Primary Funding Partner: NSERC: \$405,000/36,000]

Black, Andrew (Professor, Dept. of Soil Science, Univ. British Columbia) FY 06/07-08/09
Impact of nitrogen fertilization of coastal Douglas-fir stands in British Columbia on forest productivity, carbon sequestration and greenhouse gas emissions (Co applicants: Grayston, Guy, Novak, Stull, Spittlehouse, Trofymow)

There is a great deal of uncertainty regarding the effect of N fertilization on soil C stocks and N₂O emissions. This study will use eddy covariance, chamber and ecophysiological measurements to (1) better understand C and N dynamics in fertilized Douglas fir stands and (2) to calculate the net GHG global warming potential and economic benefits of forest fertilization in terms of wood volume production.

[Primary Funding Partner: NSERC: \$225,280/20,000]

Coops, Nicholas (Professor, Forest Resources Management, Univ. British Columbia) FY 06/07-08/09
Predicting forest growth potential and climate change impacts using a MODIS satellite-constrained physiological model (Co applicants: Waring, Hamann, Aitken)

The sustainable management of forests in Canada's Pacific Northwest region would greatly benefit from estimates of growth that take into account regional warming trends. This research will involve the application of a physiological growth model and remote sensing imagery to generate the best available predictions of actual and maximum potential growth for a suite of widely distributed species in the PNW under past and present climate variability. These predictions will allow investigation of landscape scale plant-climate relationships, genetic variation among tree populations and present and future capacity of coastal mountain environments to grow forests and sustain biodiversity.

[Primary Funding Partner: NSERC: \$335,472/20,000]

4. Aquatic Systems and Climate Change Research Network

The primary objective of this network is to advance understanding of the role of aquatic systems in global C and N cycles and the potential of lakes to be both sources and sinks for greenhouse gases. The network will contribute to this outcome by generating data and models that increase scientific understanding of the processes, environmental factors and human activities that directly or indirectly affect GHG sources and sinks in aquatic systems.

Lucotte, Marc (Director, Center for Res in Geochem. & Geodynamics, UQAM) FY 05/06-07/08
A process-based model for assessing the impacts of reservoirs and forest harvesting on the carbon budget of aquatic ecosystems (Co applicants: Peng, Gélinas, Duchemin).

The focus of this project is to create a new biogeochemical model called the Integrated Carbon Cycle (ICC) model. The ICC model will link terrestrial and aquatic systems in order to determine the interrelationship and impacts of forest harvesting and reservoir impoundment on greenhouse gas emissions at the watershed scale. The modelling knowledge provided by this research will improve understanding of the long-term effects of human disturbance on the greenhouse gas dynamics of aquatic systems.

[Primary Funding Partner: NSERC: \$507,734/72,534]

Dillon, Peter (Professor, Environment and Resource Studies, Trent Univ.)

FY 06/07-08/09

Catchment scale modelling of carbon fluxes in the Great Lakes Basin (Co applicants: Molot, Schiff, Aherne)

The breakdown of DOC in aquatic systems can lead to the production of significant quantities of greenhouse gases. This project will develop a catchment-scale carbon model for the Great Lakes Basin that can be used to predict dissolved organic carbon (DOC) fluxes from the terrestrial environment via rivers and inland lakes into the Great Lakes. The results of this research will improve significantly our knowledge of the carbon budget of the Great Lakes, our ability to quantify the effect of human activities on carbon budgets and improve our ability to predict the effect of environmental stressors such as climate change.

[Primary Funding Partner: NSERC: \$394,572/24,667]

Dillon, Peter (Professor, Environment and Resource Studies, Trent Univ.)

FY 06/07-08/09

Dissolved Organic Matter in Aquatic Systems: Factors Affecting its Role in Greenhouse Gas Formation

When dissolved organic matter (DOM) is transported through aquatic systems it is transformed by photochemical and microbial processes. This alters the chemical structure and fate of DOM. Some of the DOM is transformed into particulate matter and ends up in lake sediments and some ends up as CO₂ and emitted to the atmosphere. This project will quantify the relative importance and magnitude of direct and indirect anthropogenic factors affecting the partitioning of DOM between the sediment and the atmosphere.

[Primary Funding Partner: NSERC: \$464,308/29,000]

Schiff, Sherry (Professor, Dept. of Earth Sciences, Univ. of Waterloo)

FY 06/07-08/09

N₂O and N cycling in Canadian rivers: New isotopic tools for river science and management (Co applicants: Taylor, Aravena)

Aquatic systems that are impacted by high nutrient loading from agriculture and wastewater treatment plants have elevated levels of NO₃ and NH₄ which are harmful to aquatic organisms and threaten water supplies. Aquatic systems impacted by high nutrient loading are also large sources of N₂O to the atmosphere. This project will determine the importance of different nitrogen sources and processes leading to elevated NO₃ and NH₄ levels in rivers and determine the magnitude and source of N₂O flux to the atmosphere from rivers. The Grand River watershed will be studied as an example of a large watershed heavily impacted by agriculture and wastewater treatment plants where a variety of agencies and regulators require information to aid in science-based watershed management.

[Primary Funding Partner: NSERC: \$380,519/28,000]

5. Tools for Quantifying GHG Sources and Sinks

The ability to accurately quantify sources and sinks of GHGs is critical for developing predictive models that are reliable and can be used with a known degree of confidence. The three projects below focus on the development of better tools that will increase Canada's capacity to model and predict GHG sources and sinks.

Tulip, John (Professor, Dept. of Electrical Engineering, Univ. of Alberta)

FY 02/03-05/06

Laser Atmospheric Sensing (Co applicant: Jaeger).

This project developed a compact, lightweight instrument that can be used for unattended open path remote monitoring and will improve the economic feasibility and accuracy of Canada's ability to monitor atmospheric GHG emissions (in particular nitrous oxide). This innovative laser technology will allow for economical measurement of GHGs with up to 1000 times the sensitivity of current detectors. The heightened sensitivity will allow researchers to determine the relative importance of various sources and sinks of GHGs to enable well-informed policy and investment decisions.

[Primary Funding Partner: NSERC: \$407,000/203,500]

St. Onge, Benoit (Associate Professor, Department of Geography, UQAM)

FY 03/04-05/06

Analysis of Forest Biomass and Carbon Stocks Using Lidar and Photogrammetry in Support of the National Forest Inventory (Co applicants: Gillis, Kurz, Treitz, Wulder).

This project aimed at providing accurate and cost-effective methods to derive major forest attributes that help in assessing the forest carbon, using a combination of recent advanced technologies like light detection and ranging (LIDAR) and digital stereo-photogrammetry. This study increased the capacity to estimate local, regional, and national carbon stocks, which will enhance the knowledge base and inform Canada's position on eventual claims to carbon credits relating to afforestation.

[Primary Funding Partner: NSERC: \$402,550/201,275]

Predoi-Cross, Adriana (Assistant Professor, Dept of Physics, Univ. of Lethbridge)

FY 05/06-07/08

Spectroscopic studies and instrumentation to enable accurate, simultaneous measurements of sources and sinks of methane, carbon dioxide and nitrous oxide (Co applicant: Tolton).

This project will improve the measurement accuracy of greenhouse gas release and uptake by using the visible radiation spectra of methane, carbon dioxide (CO₂) and nitrous oxide (N₂O) to standardize and calibrate equipment. In cooperation with Synodon Inc., this data will enable the development of a new field instrument to measure CO₂. [Primary Funding Partner: NSERC: \$182,000/26,000]

Agriculture

1. Environmental Goods and Services Research Network

The Environmental Goods and Services Network is an amalgamation of two BIOCAP emerging networks: the Landscape-scale Cropping Systems Research Network and the Animal Production and Manure Management Research Network. The focus is on the development and implementation of BMPs that not only provide value to agricultural producers but also environmental benefits such as GHG reductions, enhanced soil health, biodiversity, and water quality.

Layzell, David (BIOCAP Canada Foundation & Dept of Biology, Queen's Univ.)

FY 02/03

Understanding and quantifying linkages between the carbon, nitrogen and oxygen cycles.

When soil microorganisms convert nitrogen among its various forms, there is a production or consumption of reducing power that should impact the metabolism of carbon and oxygen in the soil (and potentially lead to the production of greenhouse gases). To test this hypothesis, and develop a non-invasive assay for nitrification and denitrification processes in soils, this project built a prototype of an instrument (US Patent #6,220,076, April 24 2001) that could simultaneously monitor CO₂ and O₂ exchanges in soils undergoing known rates of soil nitrogen transformation. The results supported the hypothesis and the prototype instrument built here formed the basis for a commercial instrument that is now being built and sold by a Canadian company (Qubit Systems Inc, Kingston).

[Primary Funding Partner: Queen's U: \$50,000/50,000]

Thomsen Corporation

FY 02/03-03/04

Beneficial Management Practices to Reduce Greenhouse Gas Emissions and Increase Carbon Sinks in Canadian Agriculture

This paper identifies, on a regional and temporal basis, the most promising Best Management Practices (BMPs) by providing a thorough assessment of recognized costs and co-benefits of these BMPs and how these impacts relate to the major agricultural regions of Canada. This paper also addresses the practical aspects of implementing these BMPs both now and in the future, especially the infrastructure that will be required to document and verify net emissions reductions and potential economic, social or policy barriers to adoption by agriculture producers.

[Primary Funding Partner: CARC, AAFC: \$48,000/16,000]

Livingston, Nigel (Professor, Forest Biology, Univ. of Victoria)

FY 02/03-05/06

The Development of Methanotrophic Biofilters and Bioreactors to Reduce Point Source Methane Emissions, Sequester Carbon and Increase Soil Fertility (Co applicants: Hintz, McLean, Roy, Turpin, Whitaric).

Several species of methanotrophic bacteria found in soils are known to have the ability to simultaneously convert atmospheric nitrogen into a chemical form useable by plants for their growth function (nitrogen fixation). By taking soils from a variety of sources this project aimed to identify, isolate, and culture populations of methane oxidizing, nitrogen fixing bacteria that have an enhanced capacity to assimilate methane and increase soil fertility. These bacteria can be inoculated back into soils, which can lead to substantial GHG emission uptake in soils by converting the carbon in methane to soil carbon, which is in turn utilized by growing crops. This could serve as a biofilter technology to capture methane at landfill sites, or released from housed farm animals and manure storage.

[Primary Funding Partner: NSERC: \$466,000/233,000]

Lobb, David (Assistant Professor, Dept of Soil Science, Univ. of Manitoba)

FY 03/04

Integrated Catchment Monitoring of GHG Emissions in the Prairie Pothole Region – Manitoba Site

This project assessed the carbon storage and nitrous oxide emission potentials of typical wetlands across agricultural landscapes in Manitoba. The specific objectives were to determine the carbon storage ability and N₂O emissions for prairie wetlands and the wetland-field transition, to assess the relationship between carbon storage and N₂O emission potentials and terrain attributes, and to apply the major models of N₂O and carbon dynamics to the project's agricultural landscapes.

[Primary Funding Partner: Ducks Unlimited: \$46,667/16,667]

Pennock, Dan (Professor, Dept of Soil Science, Univ. of Saskatchewan) FY 03/04

Integrated Catchment Monitoring of GHG Emissions in the Prairie Pothole Region - Saskatchewan Site

(Co applicants: Farrell, McDougal, Si).

This project assessed the carbon storage and nitrous oxide emission potentials of typical wetlands across agricultural landscapes in Saskatchewan. The specific objectives were to determine the carbon storage ability and N₂O emissions for prairie wetlands and the wetland-field transition, to assess the relationship between carbon storage and N₂O emission potentials and terrain attributes, and to apply the major models of N₂O and carbon dynamics to the project's agricultural landscapes.

[Primary Funding Partner: Ducks Unlimited: \$46,666/16,666]

Wagner-Riddle, Claudia (Assoc Prof, Dept of Land Resource Science, Univ. of Guelph) FY 03/04

Long-term Greenhouse Gas Flux Monitoring Site at Elora, Ontario (Co applicant: Warland).

The goal of this project was to better understand the ability of agricultural best management practices (BMPs) to reduce greenhouse gas emissions from agricultural fields. This project was based on existing, long-term greenhouse gas measurements from the agricultural research station at Elora, Ontario. It was found that the use of best management practices, particularly soil nitrogen testing and the employment of cover crops, reduced the nitrous oxide emissions by over 40% from fields grown with a rotation of soy, corn and winter wheat.

[Primary Funding Partner: OSCIA: \$46,667/16,667]

Pennock, Dan (Professor, Dept. of Soil Science, Univ. of Saskatchewan) FY 03/04-05/06

Landscape-Scale Measurement and Upscaling of Process-Level Nitrous Oxide Measurements (Co applicants:

Burton, Farrell, Lemke, Lobb, Murkin, Papakyriakou, Si, Siciliano, Tenuta).

This research focussed on establishing the linkage between upland management practices and wetland greenhouse gas dynamics at two research sites in hummocky, till landscapes located in Manitoba and Saskatchewan. Researchers produced whole-landscape estimates of emissions and assessed the contribution of individual controllers on these emissions. Documentation of the landscape-scale benefits of different management options will be critical if agricultural producers are to access carbon offset funding.

[Primary Funding Partner: NSERC: \$750,483/307,742]

Pennock, Dan (Professor, Dept. of Soil Science, Univ. of Saskatchewan) FY 04/05-05/06

Landscape-Scale Cropping Systems Network

The LSCS network focuses on understanding and quantifying the effects of various crop and landscape management practices on greenhouse gas emissions (particularly N₂O) and soil carbon stock changes in agricultural systems. The insights gained from this work will support the National Inventory of GHGs, and offer a critical analysis of those beneficial management practices being put forward to improve the efficiency and sustainability of landscape-scale farm operations.

[Primary Funding Partner: N/A: \$25,000/25,000]

France, James and Claudia Wagner-Riddle (Univ. of Guelph) FY 04/05-05/06

Animal Production and Manure Management Network

The mandate of the Animal Production and Manure Management Network is to understand and quantify the sources and sinks of GHGs associated with beef, dairy, and pork production. This understanding will be used to identify 'best management practices' and new technologies that can mitigate GHGs, while providing additional value to the agricultural producer. Reliable estimates of GHG reductions will also be achieved through these practices. This research will provide results and insights to inform policy and investment decisions among producers, the agricultural industry, and government.

[Primary Funding Partner: N/A: \$45,000/45,000]

Wagner Riddle, Claudia (Assoc Prof, Dept of Land Resource Science, Univ. of Guelph) FY 04/05-07/08

Temporal dynamics of greenhouse gas fluxes linked to soil biophysical processes and management practices (Co applicants: Drury, Dunfield, Janzen, Kay, Lobb, Papakyriakou, Tenuta, Voroney, Warland).

This project is comparing the impact of no-tillage and conventional tillage agricultural soil management techniques on seasonal greenhouse gas (both carbon and nitrogen) cycles. By using a variety of soil chemical, physical and microbial measurements, the research will help identify strategies for net greenhouse gas reduction from agriculture under differing soil and climatic conditions.

[Primary Funding Partner: NSERC: \$602,843/120,000]

Jamieson, Rob (Professor, Process Eng & Applied Sciences, Dalhousie Univ.) FY 05/06-07/08
Isotopic and Modelling Tools for Predicting Air and Water Quality Impacts of Nitrogen Management Strategies (Co applicants: Schiff, Burton, English, Gordon, Petrone).

This project is studying the nitrogen balances of agricultural basins in Ontario and Nova Scotia to improve the management of nitrogen-based fertilizers (a major source of nitrous oxide greenhouse gas) on agricultural soils. The nitrogen and water mass balances will be measured at the two field sites and modeled to predict the long-term nitrogen export from agricultural systems.

[Primary Funding Partner: NSERC: \$635,900/60,000]

Trevors, J (Professor, Dept. of Environmental Biology, Univ. of Guelph) FY 05/06-07/08
Environmental regulation of denitrifying activity in soil producing nitrous oxide and the expression of denitrifier genes in the soil bacteria (Co applicants: Burton, Gordon, Filion, Patten).

In this project, soil microorganisms known as denitrifiers are being examined for their role in nitrous oxide (N₂O) production from agriculture soil. N₂O emissions, soil denitrifier communities and the expression of denitrifying genes will be measured across an agricultural landscape following events such as soil thawing, rainfall, and fertilizer application. The results of this research will improve the accuracy of N₂O modelling and aid in the development mitigation strategies for N₂O emissions.

[Primary Funding Partner: NSERC: \$449,320/50,000]

Cahill, James (Associate Professor, Biology, Univ. of Alberta) FY 06/07-08/09
Understanding and mitigating the impacts of altered temperature and precipitation regimes on the function and biodiversity of rangeland communities (Co applicants: Wilson, Bork, Proctor, Chang)

Canada has 22,000,000 ha of land dedicated to range and forage production and less than 50% is in healthy condition. The interaction of management practices and climate change could have significant consequences for rangeland ecosystems and associated industries. This research will increase our understanding of how climate change and management practices impact the ecological dynamics of rangeland systems. The identification of key linkages between grazing, climate change, carbon storage and primary production will be used to identify new management strategies for mitigating the impacts of climate change.

[Primary Funding Partner: NSERC: \$722,380/38,000]

France, James (Professor, Animal and Poultry Science, Univ. of Guelph) FY 06/07-08/09
Modelling the hydrogen economy of the rumen ecosystem (to determine feeding management strategies for mitigating methane production from dairy cows)

The rumen of animals is the largest biogenic source of methane (CH₄) which is a potent GHG. The goals of this project are to (1) model the hydrogen economy of rumen ecosystems in order to develop feeding management strategies for mitigating emissions from intensive dairy operations, and (2) provide more accurate estimates of emission factors for dairy cows for use in constructing national greenhouse gas inventories.

[Primary Funding Partner: NSERC: \$159,989/10,000]

2. Green Crop Research Network

The Green Crop Network is focused on developing or selecting crops and their associated micro flora that will improve the sustainability and reduce the environmental footprint associated with crop production. The research objectives of the network are to develop crops that: produce fewer N₂O emissions, enhance soil C stocks, flourish in an elevated CO₂ atmosphere, and provide materials for bio-based products.

Smith, Don (Professor, McGill Univ.) FY 05/06-10/11
Green Crop Network Secretariat (Co applicants: plus many others).

[Primary Funding Partner: NSERC Network Grant: \$6,621,550/100,000]

[Central Admin Funding: \$621,300/12,961]

Altosaar, Illimar (Professor, Univ. of Ottawa)

FY 05/06-09/10

Identification of regulatory genes to reduce N₂O production

This project is bioengineering crop plants to reduce nitrous oxide (N₂O) emissions from soil using two different approaches: 1) by engineering the crops to secrete an enzyme that converts N₂O into inert nitrogen gas (N₂), thereby lowering N₂O emissions from the soil surrounding the plant; 2) by engineering plants to produce more enzymes that increase the ability of the plant to use nitrogen, which would allow the amount of nitrogen fertilizer applied to crop soils to be decreased.

[Primary Funding Partner: NSERC: \$379,000/6,670]

Ellis, Brian (Professor, Faculty of Agricultural Sciences, Univ. of British Columbia)

FY 05/06-09/10

Manipulating lignin deposition (Co applicants: Douglas, Mansfield, Samuels, Abrams).

This project is analyzing the genetic structure of lignin, a binding material that gives plants their strength and rigidity. The critical genes that are identified will then be modified for use in crop development to create stronger crops via increased lignin deposition in their cell walls.

[Primary Funding Partner: NSERC: \$527,750/9,315]

Grodzinski, Bernard (Professor, Dept of Plant Agriculture, Univ. of Guelph)

FY 05/06-09/10

Identification and characterization of plant variants exhibiting enhanced photosynthesis & biomass production under elevated CO₂, high temperature & drought (Co applicants: Huner, Savitch, Robert, Singh, Mullen, Sarhan).

Conditions associated with climate change include high temperatures, increased drought and elevated levels of carbon dioxide (CO₂) in the atmosphere. This project is identifying and analyzing genetic variations of plants, including biomass feedstock crops, that are best able to sequester CO₂ and maintain or increase their growth under the stress conditions expected by climate change.

[Primary Funding Partner: NSERC: \$499,000/8,804]

Kronzucker, Herbert (Professor, Dept of Life Sciences, Univ. of Toronto)

FY 05/06-09/10

Regulation of N-assimilation and biomass production

This project is studying and modifying the genetic structure of wheat and rice to increase the production of enzymes that control the ability of plants to uptake carbon and nitrogen. The goal of this research is to understand and increase carbon sequestration (via increased plant biomass) in two of the world's most important crop species.

[Primary Funding Partner: NSERC: \$196,500/3,424]

Kunst, Ljerka (Professor, Dept of Botany, Univ. of British Columbia)

FY 05/06-09/10

Investigation of the contribution of oil biosynthetic enzymes to seed oil content in Brassica napus & Arabidopsis thaliana (Co applicants: Haughn, Taylor).

This project is working to reassemble specific genes in Arabidopsis plants to create new plants with varied oil content and composition. The project is also examining enzymes related to oil production in Brassica and Arabidopsis plants (both related to the mustard family) to determine how changes to these enzymes can be used to vary the seed-oil content of plants.

[Primary Funding Partner: NSERC: \$772,000/12,806]

Layzell, David (Professor, Dept of Biology, Queen's Univ.)

FY 05/06-09/10

Nitrogen fixation, hydrogen production and N₂O emissions (Co applicants: Dong, Wood).

This project is assessing the relationship between hydrogen (H₂) and nitrous oxide (N₂O) production by legume crops and will use this assessment to test the accuracy of the International Panel on Climate Change (IPCC) equations for nitrous oxide (N₂O) emissions. The link between H₂ oxidation and carbon dioxide (CO₂) fixation will be investigated to understand how legume crops can influence carbon sequestration in soils. H₂ treatment, soil microorganisms and chemicals will also be investigated for their role in enhancing soil fertility and plant growth.

[Primary Funding Partner: NSERC: \$314,000/5,514]

Plaxton, William (Professor, Dept of Biology, Biochemistry, Queen's Univ.)

FY 05/06-09/10

Reverse engineering plant variants for direct carbon sink mgt: Respiratory metabolism of natural plant variants with beneficial growth responses to prolonged elevated CO₂ levels (Co applicants: Ko, Vanlerberghe).

At the physiological, biochemical and anatomical levels, this project is measuring the metabolization of carbon in genetic varieties of plants relative to expected conditions under climate change, such as elevated CO₂, high temperatures and drought. The metabolic structures and activities of the plants will then be mapped to identify critical processes leading to enhanced carbon sequestration. Genes that control the metabolism of carbon will be identified and engineered to increase the ability of the plants to store carbon.

[Primary Funding Partner: NSERC: \$399,000/0]

Rothstein, Steven (Professor, Molecular & Cellular Biology, Univ. of Guelph)	FY 05/06-09/10
Identification of regulatory genes to improve nitrogen use efficiency (Co applicant: Shelp).	
<p><i>This project is studying the plant Arabidopsis (a relative of mustard) to identify and better understand the genes that control the metabolism of nitrogen in plants. Arabidopsis is a 'model plant' in terms of its genetic structure and has a fully documented genome; the knowledge gained by studying its nitrogen-regulating genes will be transferred to agricultural crop species such as corn and canola in order to improve understanding of the use of nitrogen in plants.</i></p>	
<p>[Primary Funding Partner: NSERC: \$374,000/6,581]</p>	
Scarth, Rachael (Professor, Dept of Plant Science, Univ. of Manitoba)	FY 05/06-09/10
Identification of Brassica genotypes and molecular markers for increased seed-oil content (Co applicants: Li, Rakow).	
<p><i>This project is examining individual species of the genus Brassica (related to the mustard family), with a specific focus on Brassica napus (rapeseed), a plant commonly used as a feedstock for biofuel production. The study will identify the genotypes of Brassica that express a tendency for increased oil content in their seeds. A new type of Brassica napus will be created based on these findings and will be analyzed to identify the specific genetic markers that are associated with high seed-oil content.</i></p>	
<p>[Primary Funding Partner: NSERC: \$621,000/5,602]</p>	
Siciliano, Steven (Asst Professor, Dept of Soil Science, Univ. of Saskatchewan)	FY 05/06-09/10
Nitrous oxide emission from the rhizosphere: microbial coordination of sources and mitigation (Co applicants: Tenuta, Vessey, Walley).	
<p><i>This project is examining soil microbe communities to determine the sources and signals that cause nitrous oxide (N₂O) emissions from the rhizosphere of soils. A key goal of the project is to identify a potential target area for biotechnology development to reduce N₂O emissions from agricultural ecosystems.</i></p>	
<p>[Primary Funding Partner: NSERC: \$217,000/3,201]</p>	
Smith, Donald (Professor, Dept. of Natural Resource Science, McGill Univ.)	FY 05/06-09/10
Microbial control of plant responses to climate change related stress (Co applicants: Seguin, Beaulieu, Ma).	
<p><i>This project is studying the signals sent from microbes to plants that can affect a plant's photosynthetic rate, growth rate, and its ability to deal with environmental stress. The goal is to determine the extent to which microbe-to-plant signals will allow a plant to manage the stresses of high temperature and drought that are associated with climate change. Microbes and compounds identified to help plants manage climate change can be used to increase plant growth and improve plant resistance to climate change stress.</i></p>	
<p>[Primary Funding Partner: NSERC: \$282,000/4,802]</p>	
Vessey, Kevin (Professor, St. Mary's Univ.)	FY 05/06-09/10
The bilateral influence of plant and rhizosphere characteristics in Brassica sp. varying in seed oil productivity (Co applicants: Burton, Smith, Bradley).	
<p><i>This project has two objectives: 1) To assess the effects of genetically altering species of Brassica and Arabidopsis for increased seed-oil content on carbon dynamics in the plants, the efficiency with which the plants use nitrogen, and the effect of the altered plants on the rhizosphere environment (zone of soil surrounding the plant roots); 2) To examine the microscopic plant life in the rhizosphere and determine if it can be manipulated to enhance Brassica plants for use as a biodiesel feedstock.</i></p>	
<p>[Primary Funding Partner: NSERC: \$779,000/8,092]</p>	
Walley, Francis (Professor, Dept of Soil Science, Univ. of Saskatchewan)	FY 05/06-09/10
Manipulation of rhizosphere organisms to enhance c-sequestration and reduce N₂O emissions (Co applicants: Germida).	
<p><i>The goal of this project is to understand how organisms that exist in the zone of soil immediately surrounding the roots of plants (termed the rhizosphere) influence carbon and nitrogen cycles in soil. The project will also examine how plant-growth promoting bacteria can be used to enhance carbon sequestration, increase plant biomass production and reduce nitrous oxide emissions from soil.</i></p>	
<p>[Primary Funding Partner: NSERC: \$199,000/3,468]</p>	
Whalen, Joann (Professor, Dept. of Natural Resource Science, McGill Univ.)	FY 05/06-09/10
Transforming plant carbon into soil carbon: process-level controls on carbon sequestration (Co applicants: Gregorich, Angers, Rochette, Janzen, Grayston, Simpson).	
<p><i>Plant carbon (C) is transformed into soil carbon by microorganisms and fauna found in soils. This project is using modelling techniques to determine how the modification of crops can influence the transformation of plant C into soil C by soil organisms. This will improve understanding of the potential for crop modification to influence C sequestration in soil.</i></p>	
<p>[Primary Funding Partner: NSERC: \$441,000/8,759]</p>	

3. Biomass Crops Research Network

The emerging Biomass Crops Research Network is focused on developing innovative genotypes and production technologies to optimize the quality and quantity of biomass and maximize the environmental and economic sustainability of biomass production systems.

Chang, Scott (Asst Professor, Dept. of Renewable Resources, Univ. of Alberta) FY 05/06-07/08
Land use changes, greenhouse gas emissions, and C budgets in hybrid poplar plantations (Co applicants: Bhatti, Grant, Price, Thomas).

This project is examining the afforestation of a Poplar plantation on previously farmed land and its effect on GHG emissions and C sequestration and the effect of N fertilizer application on N₂O emissions. The results of this project will improve understanding of C cycling in poplar plantations and will contribute to the creation of verifiable carbon credits under the Kyoto Protocol.

[Primary Funding Partner: NSERC: \$322,000/60,000]

Pharis, Richard (Professor, Botany, Univ. of Calgary) FY 05/06-07/08
Identification and Selection of Fast-growing Poplar Genotypes for Sequestration of Carbon & Biomass Production (Co applicants: Guy, Mansfield).

This project is identifying genetic variations of poplar trees that are best-suited for enhanced carbon sequestration by relating plant growth hormone levels and carbon content to the rate of Poplar growth. The goal is to develop time- and cost-effective methods of selecting Poplar variants for optimal carbon uptake and biomass production in varied environmental conditions across Canada.

[Primary Funding Partner: NSERC: \$392,000/56,000]

Campbell, Malcolm (Associate Professor, Botany, Univ. of Toronto) FY 06/07-08/09
Biomass Improvements through Genomics in Populus (Co applicants: Mansfield, Regan)

The utility of poplars for carbon sequestration and as a feedstock for bioenergy is directly related to rates of biomass accumulation in plantations. Recent data suggests that poplar biomass accumulation is positively correlated with the functions of the stomata, the dynamic pores on plant leaves that allow the uptake of CO₂ while limiting water loss. This study will explore the link between, carbon sequestration, biomass accumulation and the genes controlling stomata function in natural and engineered poplar trees. Ultimately, the project will develop diagnostics that can be used to select trees for the purposes of improving biomass accumulation.

[Primary Funding Partner: NSERC: \$580,000/25,000]

Plant, Aine (Associate Professor, Plant molecular biology, Simon Fraser Univ.) FY 06/07-08/09
Developing tools to select for robust Populus genotypes capable of adapting to environmental change (Co applicants: Campbell, Mansfield)

Poplars are favoured for plantation forestry due to their capacity for rapid juvenile growth. However, access to plantation sites with sufficient water to support the rapid growth of poplars is problematic in many parts of the country. This research will investigate the genetic and epigenetic response of poplars to drought stress in order to identify molecular and biochemical markers for selecting trees with improved biomass accumulation and drought tolerance.

[Primary Funding Partner: NSERC: \$620,900/30,000]

Van Rees, Ken (Professor, Dept. of Soil Science, Univ. of Saskatchewan) FY 06/07-08/09
Developing a Saskatchewan Model for Short Rotation Willow Biomass Production and GHG Benefits (Co applicants: Belanger, Vujanovic, Farrell, Scoles, Grant)

The environmental impact of converting traditional crops to willow over a large area is still poorly understood. This project will establish high density willow plantations on agricultural land and will carry out field and modelling studies to investigate the impact of willow plantations on (1) biogeochemical cycling at the stand level and (2) carbon stocks at the landscape scale.

[Primary Funding Partner: NSERC: \$755,926/35,000]

Whalen, Joann (Assistant Professor, Dept. of Natural Resources Science, McGill Univ.) FY 06/07-08/09
Environmental and economic benefits of tree-based intercropping (TBI) systems in Canada (Co applicants: Bradley, Gordon, Shipley, Klironomos, Smith)

This project will evaluate the potential of tree-based intercropping systems (TBI), in which agricultural crops are grown in alleys between tree rows, to reduce the environmental impacts of climate change and intensive agriculture and provide economic benefits for Canadians. Ecological and economic models will be used to examine the range of environmental and economic benefits and tradeoffs that could be expected from TBI systems under various scenarios. The knowledge generated will be used to suggest policies and incentive programs that would make TBI systems a feasible option for landowners across Canada.

[Primary Funding Partner: NSERC: \$355,150/27,000]

Biomass Conversion and Utilization

Bioenergy Research Network

Bioenergy is operationally defined as the sustainable production of energy from biologically derived material. Given the immense scope of this research network the research projects are structured around seven focus areas. Of the 7 focus areas, 4 are recognized as being bioenergy production platforms; the remaining 3 are cross-cutting themes that are incorporated into all four production platforms.

a. Waste platform

The processing of waste bio-products includes the use of municipal solid waste (MSW), animal wastes, biosolids, restaurant and industrial wastes. The waste platform also considers the sound integration of energy conversion technologies with issues of waste storage, separation and processing.

Karan, Kunal (Dept. of Chemical Engineering, Queen's Univ.) FY 03/04
Technical and Economic Analysis of Alternative Processes for Agricultural Waste Fueled Solid Oxide Fuel Cell

Biomass from agricultural wastes can be converted to a fuel gas that is usable in a solid oxide fuel cell (SOFC). In this project, detailed technical and cost analyses of a complete process based system for conversion of agricultural waste to fuel gas via anaerobic digestion, and its subsequent conversion to electricity and heat in a SOFC system, will be performed. The objective of this project is to identify the most commercially viable process configuration for an agricultural-waste fueled fuel-cell power systems for a future field demonstration of a 5 kW Fuel Cell Technologies Ltd. SOFC system.

[Primary Funding Partner: NRCan: \$48,000/15,000]

Dube, Marc (Associate Professor, Dept. of Chemical Engineering, Univ. of Ottawa) FY 03/04-05/06
Biodiesel Production from Acid-Catalyzed Transesterification of Waste Oils (Co applicants: Kates, McLean, Ternan, Tremblay).

By providing technological improvements to the production of biodiesel fuel and increasing process profitability, this project is working to fulfill its overall objective to develop an efficient and cost-effective continuous process to manufacture biodiesel from low grade or waste oils.

[Primary Funding Partner: NSERC: \$286,140/143,070]

Cabral, Alexandre (Professor, Dept. of Civil Engineering, Univ. of Sherbrooke) FY 05/06-07/08
Attenuation of Greenhouse Gases Emitted by Landfills Using an Engineered Passive Methane Oxidation Barrier (Co applicants: Greer, Allaire).

Methane barriers are engineered cover systems made of soil and compost that have the ability to trap methane emissions from landfill sites. This project will build and compare three barriers, varying in composition and thickness, to determine the optimal structure for methane capture.

[Primary Funding Partner: NSERC: \$345,827/49,404]

Kennedy, Kevin (Professor, Dept. of Civil Engineering, Univ. of Ottawa) FY 05/06-07/08
Development of Technically and Economically Viable Microwave Pretreatment for Enhanced Biogas Production and Greenhouse Gas Recovery from Municipal Sludge and Agricultural Waste (Co applicants: Drost, Parker).

This research is examining a new method of pre-treating municipal sewage sludge that enhances the creation of energy-rich biogas and reduces greenhouse gas emissions associated with sewage sludge disposal. Microwave pre-treatment (MWPT) exposes the sludge to microwave radiation, which disrupts the cellular structure of the sludge and makes it more biodegradable. The project will address the technical obstacles preventing the adoption of MWPT in Canada, with the ultimate goal of developing an economically viable pretreatment process to transform sludge into a fully stabilized biosolid product.

[Primary Funding Partner: NSERC: \$378,400/40,000]

Liss, Steven (Adjunct Professor, Dept. of Chemistry, Biol. & Chem Eng, Univ. of Toronto) FY 05/06-07/08
Anaerobic Membrane Processes for Energy Recovery from Wastewater (Co applicants: Berube, Hall, Liao, Parker).

This project is investigating anaerobic processes used to treat municipal and industrial wastewaters and sludges. In the absence of oxygen, anaerobic microorganisms convert organic matter into hydrogen and methane. With further research, the use of anaerobic membranes in wastewater treatment plants can ensure the retention of these microorganisms, thereby improving operational control, decreasing reactor size and increasing the ability to recover energy from organic material. This research will address the technical and economic challenges of applying anaerobic membranes by simulating their operational processes, design and performance factors.

[Primary Funding Partner: NSERC: \$450,000/60,000]

b. Sugar platform

Sugars are naturally occurring in biomass and can be derived by breaking down more complex starch and cellulose molecules. Energy from sugar molecules is typically derived by fermentation processes to form ethanol which may be used as a fuel source. Emerging technologies are enabling the production of ethanol from waste substrates including crop stubble and forestry waste.

Saddler, Jack N. (Dean, Faculty of Forestry, Univ. of British Columbia) FY 03/04-05/06
The Development of a Technically and Economically Viable Pretreatment and Enzymatic Process for the Conversion of Softwood Residues to Ethanol.

This project is providing fundamental and applied research to enhance the viability of establishing an overall biomass-to-ethanol process using softwoods as a feedstock. By comparing the established steam explosion pre-treatment process with the organosolv process proposed by Lignol, the two technical bottlenecks of achieving fast, efficient, complete hydrolysis of the cellulose for eventual fermentation to ethanol and finding higher value chemical uses for the co-product lignin will be addressed.

[Primary Funding Partner: NSERC: \$455,500/227,750]

Lessard, Jean (Professor, Chemistry Dept., Univ. of Sherbrooke) FY 04/05-07/08
Biomass-derived high octane synfuels from C5 sugars

This project is exploring the potential for catalytic conversion of C5 sugars, derived from the hemicellulose component of biomass, to oxygenates (oxygen-containing compounds) for addition to gasoline fuel. Challenges exist in C5 sugar fermentation as compared to C6 sugar fermentation into ethanol, which is currently practiced commercially. This research is utilizing alternate methods of conversion in order to utilize all the components of hemicellulose, and hence reduce waste and provide additional products.

[Primary Funding Partner: NSERC: \$199,500/36,000]

Sheppard, John (Associate Professor, Dept of Bioresource Engineering, McGill Univ.) FY 05/06
Control of bacterial contamination in continuous ethanol fermentation processes

This project is investigating two methods to increase the efficiency and reliability of the fermentation of starch (such as that found in wheat or corn) during the production of ethanol: 1) the use of a novel rotating membrane process, called pervaporation, to continuously remove ethanol from the fermenter, 2) the addition of hops extracts to eliminate the need for antibiotic addition to control bacterial contamination. Enhanced fermentation processes will improve the energy balance during ethanol production and reduce the ethanol production cost, creating a more competitive biofuel.

[Primary Funding Partner: NSERC: \$110,255/22,000]

Clarke, Anthony (Professor, Office of Research, Guelph Univ.) FY 06/07-08/09
Biophysical studies on the mechanism of cellulose biodegradation (Co applicants: Dutcher, Roscoe, Lipkowski)

Depolymerization of cellulose to saccharides is an important step in the production of biofuels from lower value biomass. This study will apply novel methods to develop more efficient enzymes for isolation and depolymerization of cellulose to improve the efficiency of biofuel production.

[Primary Funding Partner: NSERC: \$474,000/15,000]

Schlaf, Marcel (Associate Professor, Chemistry and Biochemistry, Guelph Univ.) FY 06/07-08/09
New Ionic Hydrogenation and Hydrogenolysis Catalysts for the Deoxygenation of Renewable Sugar Polyols and Lignins to alpha, omega-Diols and Phenolics as Polymer Components

This research is aimed at the molecular level design and development of new man-made transition metal catalysts. The development of these catalysts is important because they will open up new pathways to the production of high value-added non-food products from locally grown agricultural and forestry commodities - in particular corn, soybeans, canola and wood.

[Primary Funding Partner: NSERC: \$262,750/12,000]

c. Oil platform

The oil platform focuses on the processing of bio-oils produced from fats and oils derived specifically from dedicated energy crops. The production of these items is commonly performed through chemical processing and conversion processes. Biodiesel is an example of a fuel product derived from this platform.

Dalai, Ajay (Professor, Dept. of Chemical Engineering, Univ. of Saskatchewan) FY 03/04-05/06
Production of Biodiesel from Vegetable Oils and Lubricity Additives for Ultra-Low Sulphur Diesel Fuel and of Hydrogen from Byproduct Glycerol (Co applicants: Bakhshi, Boocock, Hertz).

This project is developing a new approach to produce effective fuel lubricity additives, canola as well as soya methyl-ethyl esters (known as biodiesels) from inedible low-grade canola and soya oils and restaurant waste grease. With cooperation of industrial partners, biodiesel from waste oils will be commercialized and introduced into the market.

[Primary Funding Partner: NSERC: \$240,000/120,000]

Thomson, Murray (Associate Professor, Dept Mech & Ind. Eng, Univ. of Toronto) FY 04/05-05/06
Enabling Biodiesel Fuel Use for Sustainable Mobility (Co applicants: Wallace, Sobiesiak, Zheng, Reader, Dalai, Neill).

This project measures the physical, chemical and combustion properties of biodiesel and conducts testing to determine the effects of biodiesel on engine systems. The information gained from this research will reduce the barriers to biodiesel commercialization, which is particularly important as Canada's first commercial biodiesel plant is under construction.

[Primary Funding Partner: Auto21 NCE: \$310,000/30,000]

Thomson, Murray (Professor, Mechanical and Industrial Engineering, Univ. of Toronto) FY06/07-08/09
Development of a bio-oil Stirling Engine for sustainable power (Co applicants: Ashgriz, Wallace)

Small transportable engines that use bio-oil would enable the provision of small amounts of heat and power in remote locations with no net GHG emissions. Bio-oil has poor ignition characteristics which prevents its use in many types of engines. Sterling engines which do not need continuous ignition could potentially be adapted to use bio-oil. This project will develop the technology and scientific understanding of bio-oil combustion to convert an existing sterling engine to run on bio-oil.

[Primary Funding Partner: NSERC: \$297,197/20,000]

d. Thermochemical platform

Thermo-chemical processing of biomass uses heat and chemical reactions to convert biological material into biofuels and bioproducts. Areas of focus for these projects include oil processing, gasification/pyrolysis techniques, Fischer-Tropsch Synthesis, and charcoal (biosteel) production. There is also an emphasis on improved processing efficiency, novel reaction systems, and value-added products that lead to the realization of the biorefinery concept.

Guthrie, Rod (Director, Energy & Environmental Res Lab, McGill Univ.) FY 04/05-07/08
Application of Bioenergy for the GHG Mitigation in the Iron and Steel Industry (Co applicants: Kozinski, Hawari).

Iron and steel production is very energy intensive and releases large amounts of CO₂ through industrial processes. This project is examining the potential greenhouse gas benefits, technical hurdles, and environmental/product impacts of complementing fossil fuels with biomass in iron and steel operations. This could have major implications for Canada's iron and steel industries in contributing to Canada's climate change commitments.

[Primary Funding Partner: NSERC: \$470,850/78,000]

Abatzoglou, Nicolas (Professor, Chemical Engineering, University of Sherbrooke) FY 06/07-08/09
The development of catalysts for Fischer-Tropsch synthesis using biosyngas (Co applicants: Bakhshi, Gitzhofer, Dalai)

Fischer-Tropsch Synthesis (FTS) is an old technology but it can be adapted to be used with biosyngas or biogas for the production of "green" diesel. This project addresses some of the scientific and technological challenges associated with using biogas as feedstock for the FTS reaction. Specifically, the project will prepare and test new nanosized high external surface catalyst formulations in lab and bench scale fixed bed and slurry reactors. This will lead to improvements in the efficiency of the slurry reactor as a reaction system for biogas based FTS reactions.

[Primary Funding Partners: CANMET/NSERC: \$600,420/30,000]

Duff, Sheldon (Professor, Chemical and Biological Engineering, Univ. of British Columbia) FY 06/07-08/09
Processing of pyrolysis oils for co-product development and improved oil characteristics (Co applicants: Smith, Watkinson, Ellis, Kadla)

Bio-oil produced by pyrolysis is a sustainable liquid fuel that can be used to replace fossil fuels to generate power and heat. More research and development is needed so that pyrolysis can become part of commercial biorefineries. This project is aimed at addressing the technological barriers to commercialization of pyrolytic oil and to further developing technologies for the production of a range of valuable products from pyrolytic oil.

[Primary Funding Partners: NRCAN/NSERC: \$355,300/11,000]

Cross-cutting themes:

e. **Systems & feedstock logistics**

The effective movement of biomass and materials across the vast landscape of Canada will require an integrated systems approach. Life cycle analyses (LCAs) of bioenergy strategies provide an effective framework for addressing issues of scale and transportation logistics at regional, provincial and national levels and across sectors. LCAs also provide insights on how to enhance the economic viability and environmental sustainability of bioenergy production systems. This focus area is a cross-cutting theme across all of the aforementioned bioenergy production platforms.

Sokhansanj, Shahab (Research Scientist, Univ. of British Columbia) FY 05/06-07/08
Biomass Feedstock Integration for an Emerging Bio Industry in Canada (Co applicants: Bi, Afzal).

This project is undertaking the development and application of a simulation model to identify innovative, sustainable and cost-effective supply options for biomass in Canada. This model addresses the high cost of the collection and transport of biomass, which is a critical barrier preventing the large-scale use of forestry and agricultural residues in Canada's emerging bio-industry.

[Primary Funding Partner: NSERC: \$349,100/44,000]

f. **Biorefinery systems for integrated bioapplications and commercialization**

The ability to produce the maximum value from bioenergy products will further bolster the emergence of bioenergy as a competitive energy source. This cross-cutting theme area focuses on the emergence of technologies which will enable the production of value-added bioproducts from the waste materials created during the production of bioenergy.

Duff, Sheldon (Professor, Univ. of British Columbia) FY 03/04-05/06
Enhancing Prospects for Higher Value Uses for Bio-Oil (Co applicants: Ellis, Smith, Watkinson).

This project is assisting in bringing the biomass refinery concept to reality by exploring: 1) conversion of levoglucosan to ethanol; 2) thermal degradation of bio-oils in fuel and chemical conversion processes; 3) upgrading of bio-oil to reduce oxygen content, and 4) development of emulsion fuels from bio-oil and biodiesel.

[Primary Funding Partner: NSERC: \$343,500/171,750]

Sain, Mohini (Assoc Prof, Chemical Engineering & Applied Chemistry, Univ. of Toronto) FY 03/04-05/06
Sustainable Biopackaging Materials for Green Technology (Co applicants: Hubbes, Saville).

This project aims to develop an economically integrated process for the production and commercialization of novel biopackaging materials using nano-fibrils from agro-forest and recycled wood resources and biopolymers. The packaging material will be evaluated for its properties, durability and safety. Quantification of carbon sequestration potential of the products will be completed using a lifecycle analysis.

[Primary Funding Partner: NSERC: \$309,479/133,001]

Schlaf, Marcel (Dept. of Chemistry & Biochemistry, Univ. of Guelph) FY 03/04-05/06
Direct Synthesis of 1,3-propane diol from Glycerol Using Transition Metal Based Ionic Hydrogenation Catalysts

This research aims to develop a direct conversion of glycerol (the main waste product of biodiesel production) to 1,3-propane diol, as cost-controlling component of the new terephthalic acid polyesters "Corterra" and "Sorona", which were recently introduced into the market by Shell and DuPont. A second use of glycerol is the hydrogenation of glycerol to propane, which can then be used as a renewable and waste derived fuel with characteristics similar to natural gas. Either of these processes has the potential to turn the anticipated excess of glycerol from biodiesel production into a value-added chemical or fuel, thereby economically benefiting biodiesel production.

[Primary Funding Partner: NRCan: \$125,949/15,000]

Levin, Dave (Associate Professor, Dept. of Biology, Univ. of Victoria) FY 04/05-07/08
Hydrogen Production from Cellulosic Biomass (Co applicants: Cicek, Sparling).

*While hydrogen holds potential as a future energy source, it is currently produced almost entirely from fossil fuels. This project is assessing the mechanisms of hydrogen production from renewable, carbon neutral biomass for the anaerobic bacteria *Clostridium thermocellum*. The goal of this research is to develop a system for enhanced and sustained hydrogen production.*

[Primary Funding Partner: NSERC: \$316,300/54,000]

Saddler, Jack (Dean, Faculty of Forestry, Univ. of British Columbia) FY 04/05-07/08
The development of value-added bioproducts from the bioconversion of lignocellulosics (Co applicant: Kadla).

This project is assessing the production and use of the lignin component of lignocellulosic biomass. While the sugars of biomass can be fermented into bioethanol, lignin currently has few uses. This research will examine whether it is possible to selectively produce lignin with beneficial chemical properties for use in co-products such as adhesives, carbon fibres, and a variety of polymers. An economic and environmental assessment is also a core component of the project.

[Primary Funding Partner: NSERC: \$270,000/45,000]

Kadla, John (Associate Professor, Wood Science, Univ. of British Columbia) FY 06/07-08/09
Self-assembly of ordered microporous materials from wood-based biopolymers

Natural and renewable alternatives to synthetic polymers are receiving increasing attention. This project is focused on improving the properties and potential uses of cellulose, the principle component of wood, through understanding the effect of cellulosic structure on self-assembly and resulting material properties. Specifically, this project explores the potential for regioselective modification of cellulose to form functionalized self-assembled microporous films and gels.

[Primary Funding Partner: NSERC: \$190,000/15,000]

Saddler, Jack (Dean, Faculty of Forestry, Univ. of British Columbia) FY 06/07-08/09
The development of biorefinery technologies for conversion of softwood residues to ethanol and co-products

Large-scale ethanol production from renewable feedstocks for use in the transportation sector will require a diversified feedstock supply. This research is focused on the development of pretreatment technologies and cheaper enzyme systems for the efficient bioconversion of lodgepole pine residues to ethanol.

[Primary Funding Partner: NSERC: \$317,401/25,000]

g. Socio-economic and policy implications

The foundation of a sound set of policies is essential for the sustainable emergence of bioenergy production. The incorporation of socio-economics is beneficial in establishing an overall framework that acknowledges all local, regional and national stakeholders and parties.

The purpose of this project was to investigate the economic feasibility of using biomass to generate H₂S. Anaerobic bioreactors were constructed and fed with SO₂ and elemental sulphur, along with biomass-derived carbon. The rate of H₂S production was optimized by exploring dilution rate, nutrient balance, source of sulphur and sulphur-to-substrate ratio.

[Primary Funding Partner: NRCan: \$220,000/30,000]

See Human Dimensions of GHG Management Network (below) for extensive list of research projects focused on socio-economic questions.

Research Integration and Feasibility Initiatives

Research integration and feasibility initiatives link primary research and technology development with broader social, economic and sustainability issues. These projects are essential in helping to inform policy and investment decisions by government and industry, and in identifying research priorities for BIOCAP. The Projects described below address issues relating to socioeconomic dimensions of managing GHGs, forest carbon dynamics, agricultural GHG mitigation, carbon trading systems and bioenergy.

1. Human Dimensions of GHG Management Network

Greenhouse Gas Management Canada (GHGMC) addressed the socioeconomic dimensions of greenhouse gas management at the local, national and international levels. GHGMC nodes included: Emission Trading Systems, Terrestrial Carbon Economics, Cost Effective Strategies and Technologies, Mitigation Strategies Analysis, Bioproducts Research and Transformative Change.

Thomassin, Paul (Professor, McGill Univ.)

FY 02/03-04/05

Greenhouse Gas Management Canada (Co applicants: plus many others).

[Primary Funding Partner: SSHRC: \$3,340,000/1,740,000]

[Central Admin Funding: SSHRC: \$200,000/0]

Fulton, Murray (Professor, Dept of Agricultural Economics, Univ. of Saskatchewan)

FY 02/03-04/05

Transformative Change in Biosphere Greenhouse Gas Management (Co applicants: Farnese, Weersink, Belcher, Hauer, Furtan, Olfert, Baylis, Gray).

Canadian agricultural and forest sectors have the potential to play a large role in greenhouse gas mitigation; however, to effectively play this role, a variety of new regulatory regimes such as afforestation incentives and carbon credit trading schemes are likely to be introduced. Given the transformative effect that GHG policies will have on the agricultural and forest systems, the purpose of this research was to understand the new systems so that efforts to reduce GHGs take place efficiently and effectively.

[Primary Funding Partner: SSHRC: \$614,030/331,045]

Kulshreshtha, Suren (Professor, Dept. of Agricultural Economics, Univ. of Saskatchewan)

FY 02/03-04/05

Integrated Analysis of Mitigation Strategies for Greenhouse Gas Emissions from Agriculture (Co applicants: Fox, Grimsrud, Gulati, Noble).

This project investigated various agricultural greenhouse gas mitigating measures using a comprehensive assessment framework in order to gain a better understanding of the regional and interregional impacts for all agricultural stakeholders. The research focussed on two key areas: 1) The development of multi-regional and inter-linked models depicting agricultural production and management activities and the related economic and environmental impacts; 2) Evaluation of certain mitigative and policy measures using the selected multi-criteria assessment framework.

[Primary Funding Partner: SSHRC: \$438,590/305,720]

Thomassin, Paul (Professor, Dept of Agricultural Economics, McGill Univ.)

FY 02/03-04/05

Institutional Development of a Domestic Emission Trading System that Includes Carbon Offsets from the Agriculture and Forestry Sectors (Co applicants: Baker, Barichello, Bull, Ellis, Cloutier).

The objective of this research node was to investigate and develop the institutional structures and rules that would be required to provide incentives for producers in the agriculture and forest sectors to produce carbon offsets or reductions, for industrial sectors to purchase these carbon offsets or reductions and to ensure that these are recognized under the Kyoto Protocol.

[Primary Funding Partner: SSHRC: \$541,585/277,455]

Van Kooten, G. Cornelis (Professor, Dept of Economics, Univ. of Victoria) FY 02/03-04/05
The Economics of Terrestrial Carbon Sinks: Land Use, Land Use Change and Forestry (Co applicants: Laaksonen-Craig, Barichello, Hauer, Vercammen, Vertinsky, Clark).

This project studied the environmental and socioeconomic aspects related to carbon flux resulting from land use, land-use change and forestry (LULUCF) activities. This included an estimate of the social costs and benefits of enhanced carbon sequestration through LULUCF activities and an investigation of the mechanisms that will enable carbon offsets from LULUCF activities to be traded in CO₂-emissions markets. The potential role that terrestrial carbon and product sinks will play in future negotiations (beyond Kyoto) to reduce international emissions of CO₂ was also examined.

[Primary Funding Partner: SSHRC: \$388,525/202,730]

Weersink, Alfons (Professor, Dept of Agriculture Economics & Business, Univ. of Guelph) FY 02/03-04/05
Cost-Effective Agricultural Management Strategies and Technologies for Mitigating Greenhouse Gas Emissions (Co applicants: Johnson, Jeffrey, Yang, Belcher, Yiridoe).

The purpose of this research node was to evaluate the economic-environmental tradeoffs stemming from agricultural management strategies and technologies developed under BIOCAP-related research. Alternative and traditional land management systems were evaluated by developing tradeoff curves that illustrated and quantified the impact on the economic viability of producers and on the environmental sustainability of the production systems using such environmental indicators as GHG emission levels, water quality and soil health.

[Primary Funding Partner: SSHRC: \$511,240/275,240]

Klein, Kurt (Professor, Dept of Economics, Univ. of Lethbridge) FY 02/03-04/05
Socioeconomic Research Network on Bioproducts and Bioprocesses (Co applicants: Gervais, Hobbs, Isaac, Kerr, Larue, LeRoy, Marceau, Romain, West).

This project examined the economic, environmental and social impacts of new bio-processing technologies that can provide a renewable and sustainable source of bio-based energy, chemicals and materials. The main research objectives were to: 1) Assess industry trends, opportunities, and government policies and determine factors that affect adoption and acceptance of bio-based products; 2) Estimate the socio-economic and environmental impacts of a major expansion of Canada's bio-based industry; 3) Assess the required changes and costs in supply chains of bio-based products as compared to the current supply chains for agricultural and fossil fuel derived products, 4) Investigate trade issues in adaptation to a bioeconomy.

[Primary Funding Partner: SSHRC: \$646,030/347,810]

2. Forest Carbon Dynamics and Climate Change

Griss, Paul (Consultant) FY 03/04
Forest Carbon Management Pilot Series

The objective of this project was to initiate and coordinate a Forest Carbon Management Pilot series in Canada that ensures consistency in the application of science in the development of tradable carbon credits across eligible forest carbon management activities.

[Primary Funding Partner: Various: \$120,000/20,000]

Hunt, Shelley (Adjunct Professor, Dept of Environmental Biology, Univ. of Guelph) FY 05/06
Threats and impacts of exotic pests under climate change: implications for Canada's forest ecosystems and carbon stocks (Co applicants: Otis, Newman)

This project assessed the threats and possible impacts of exotic forest pests (such as insects and disease) to forest carbon stocks under future climate scenarios in Canada. Current research in this area was linked to create maps of the potential distribution of pests and to develop a conceptual model of the ability of pests to influence carbon storage in forest ecosystems.

[Primary Funding Partner: N/A: \$17,020/17,020]

Johnston, Mark (Senior Research Scientist, Saskatchewan Research Council) FY 05/06
Adapting forest management to the impacts of climate change in Canada (Co applicants: Williamson, Price, Spittlehouse, Wellstead, Gray, Scott, Askew, Webber)

This project examined the impacts, challenges and opportunities of Canadian forest management under the influence of climate change. The capacity of forest management-related human and economic systems to adapt to climate change impacts was assessed with the goal of identifying regions and systems with a high degree of vulnerability..

[Primary Funding Partner: N/A: \$20,000/20,000]

Li, Chao (Research Scientist, Canadian Forest Service)

FY 05/06

Combined forest management effect on landscape carbon stock changes in west-central Canada (Co applicants: Liu, Barclay, Hans)

This project modelled the carbon dynamics of managed and unmanaged forests in western and central Canada. By comparing the influence of different silvicultural practices, it is possible to better understand the influence of forest management on the carbon sequestering ability of Canadian forests.

[Primary Funding Partner: N/A: \$19,000/19,000]

3. Agricultural Greenhouse Gas Mitigation

Fenton, Jim (President, Jim Fenton & Associates)

FY 05/06

Benefits and Costs of Shifts to Biomass Crops – Producer and Public Perspectives (Co applicants: Sokhansanj, Mani).

The purpose of this study was to examine the private and public benefits and costs, including impacts on GHGs, of plausible shifts from traditional cropping systems to biomass cropping systems. The analysis includes an estimation of the potential for such shifts to occur in probable future economic settings and an identification of opportunities for public intervention to influence the nature and level of such shifts. This study focussed on the Peace River region of BC and was based on representative producer cases in each of the broad agro-ecological zones in order to quantify and substantiate anticipated producer responses.

[Primary Funding Partner: N/A: \$27,945/27,945]

Flynn, Peter (Professor, Dept. of Mechanical Engineering, Univ. of Alberta)

FY 05/06

Optimum sizing for anaerobic digestion (Co applicants: Ghafoori, Searcy, Kumar).

This project addressed the issue of finding the optimum size of a processing plant to support the anaerobic digestion of biomass provided from livestock feedlots. By developing a detailed cost model, it was possible to identify the optimum size of an anaerobic digestion facility as a function of animal density per hectare for beef and dairy cattle.

[Primary Funding Partner: PI funds: \$19,400/16,500]

Wall, Greg (Principal Researcher, The Soil Resource Group)

FY 05/06

The potential for agricultural greenhouse gas emission reductions in the temperate region of Canada through nutrient management planning (Co applicants: Huber, King, Duke).

This project focussed on determining the contribution of agricultural practices that manage the nutrient content of soils to reduce greenhouse gases in Canada. Current data was reviewed and integrated to estimate the ability of nutrient management to achieve greenhouse gas reductions for various rates of adoption of these management practices.

[Primary Funding Partner: N/A: \$20,131/20,131]

Swift, Mary Lou (President, Pacific Agri Technologies Ltd.)

FY 05/06

Whole Farm Modelling to Evaluate Economic and Production Implications of BMP's Designed to Reduce GHG Emissions – Case Study of Dairy Production in Coastal British Columbia (Co applicant: Bittman).

This project used a computer model called the Integrated Farm Systems Model (IFSM) to simulate the long-term performance of dairy farms using greenhouse gas reducing techniques. A dairy farm in coastal British Columbia was evaluated as a case study to understand the efficacy and economic return gained by implementing best management practices for feeding, cropping and manure handling. By considering dairy farms as whole, integrated systems, it is possible to understand how changes in management practices can affect all aspects of the farming operation.

[Primary Funding Partner: N/A: \$18,630/18,630]

4. Offset Systems for Carbon Sequestration

Forest and agricultural lands could be managed as short-rotation carbon sinks while longer terms solutions for controlling GHG emissions are developed. Management practices that enhance carbon uptake in forest and agricultural soils could be part of a carbon emissions trading system. The objective of these research integration projects was to explore the institutional structures, rules, and incentives that would encourage agriculture and forest offsets or reductions, motivate industrial sectors to purchase these carbon offsets or reductions and ensure that these are recognized under the Kyoto Protocol.

Wilman, Elizabeth (Professor, Dept. of Economics, Univ. of Calgary) FY 03/04
Property Rights and Contracts for Carbon Sequestration (Co applicants: Lucas, Feng).

This project explored three sources of knowledge needed to define property rights and develop landowner contracts for the services provided by carbon sequestration in forests and soils: 1) Economics - how do we set up property rights and contracts to provide the incentives needed to encourage sequestration in a situation in which the complications of time and uncertainty are present? 2) Law - how do we use existing legal instruments, or develop variations on them, to define property rights and contracts? 3) Soil Science - what is actually going on with respect to soil carbon?

[Primary Funding Partner: AB Gov't: \$88,160/50,000]

Lucas, Alastair (Professor, Faculty of Law, Univ. of Calgary) FY 05/06
Disputes and Dispute Resolution in the Offsets System (Co applicant: Daudu).

This project examined the issue of ownership in Canada's Offset System, which, as currently described, leaves room for disputes and increased transactions costs. The report addresses the legal aspects of potential disputes between the Offset System Program Authority and the offset project proponents, as well as the procedural fairness rights that should be accorded to project proponents affected by registration, certification, and compliance decisions by the Program Authority.

[Primary Funding Partner: N/A: \$9,797/9,797]

Wilman, Elizabeth (Professor, Dept. of Economics, Univ. of Calgary) FY 05/06
Offsets for Carbon Sequestration in Agricultural Soil and Tradable Emissions Permits for Large Final Emitters (Co applicant: Vojtassak).

The purpose of this project was to examine the use of emissions intensity targets, offset credits and the price assurance mechanism, which are intended to assist large final emitters (such as electricity generation, oil and gas and mining and manufacturing sectors) to achieve GHG reductions in a manner that supports the continued competitiveness of industry. The report investigates the benefits and costs of intensity targets relative to absolute targets, either when used alone or in combination with a per tonne emissions cap and/or GHG sequestration offsets.

[Primary Funding Partner: N/A: \$9,797/9,797]

5. Opportunities and Challenges of a Bio-based Economy

Canadian Agricultural New Uses Council FY 02/03
An Assessment of the Opportunities and Challenges of a Bio-Based Economy for Agriculture and Food Research in Canada

This report focuses on a selected number of industrial sectors (biofuels, bioplastics, bioadhesives, natural fibres, biolubricants and bioprocess chemicals) which might play an important role in the control of GHG emissions and in providing new economic opportunities to farmers and rural communities.

[Primary Funding Partner: CARC: \$32,000/16,000]

Pollution Probe FY 02/03
Primer on the Technologies of Renewable Energy

This primer includes a clear and concise description of major renewable energy sources, including water, solar, wind and biomass.

[Primary Funding Partner: Various: 0/0]†

Wood, Susan and David Layzell (BIOCAP Canada Foundation) FY 02/03
A Canadian Biomass Inventory: Feedstocks for a Bio-based Economy

This paper estimates the magnitude of biomass resources from Canada's municipalities, forestry and agricultural sectors available to support a bioeconomy. It calculates the carbon and energy content of these and compares it to the nation's existing fossil fuel use.

[Primary Funding Partner: Ind. Canada: \$20,000/0]

Pollution Probe and BIOCAP Canada Foundation FY 03/04
Primer on Bioproducts

This primer provides a thorough overview of the emerging bioproducts industry and explores the potential for use of the biosphere as feedstocks for the development of future sustainable energy, chemicals and materials.

[Primary Funding Partner: N/A: \$20,000/20,000]†

Van Loon, Gary (Dept. of Chemistry, Queen's Univ.)	FY 03/04-06/07
International CHEMRAWN Congress on Greenhouse Gas Mitigation Strategies (Co applicant: Jessop).	
<i>BIOCAP sponsored the planning of an international conference by CHEMRAWN (a subcommittee of the International Union of Pure and Applied Chemistry). Seed funding was allocated for initial conference planning and management. [Primary Funding Partner: N/A: \$10,000/\$10,000]</i>	
Sokhansanj, Shahab (Adjunct Professor, Univ. of British Columbia)	FY 04/05
British Columbia's beetle infested pine: biomass feedstock for producing power (Co applicants: Flynn, Kumar).	
<i>The objective of this project was to conduct a conceptual approach to techno-economic assessment of using a portion of BC's MPB damaged pine as a fuel source to generate power. The assessment estimates the cost of harvesting and transporting a portion of the infested pine wood to support a dedicated wood burning power plant for a period of 20 years. [Primary Funding Partner: BC Govt: \$22,000/11,000]</i>	
ULERN (Deyoe, David – Ontario Ministry of Natural Resources)	FY 04/05-05/06
BIOS: Forest Biomass Opportunities Supply Model for Ontario (Co applicant: Ryans).	
<i>This project consisted of 4 phases: 1) Literature review that updates knowledge on the use of biomass for energy, 2) Development of an economic model which will enable partners to use survey data in the context of existing and/or future processes and technologies to optimize financial scenarios, 3) Validation of the model using case studies in which forest biomass survey information will be analyzed using base case and alternative option scenarios, 4) Generated information will be used to develop policy and institutional protocols that facilitate adoption of practices, processes and technologies that optimize energy production and use, and encourage advances in bio-based products. [Primary Funding Partner: FERIC: \$103,500/15,000]</i>	
Kumar, Amit (Assistant Professor, Dept. of Mechanical Engineering, Univ. of Alberta)	FY 05/06
Feedstock Availability and Power Costs Associated with using BC's Beetle-Infested Pine (Co applicants: Flynn, Sokhansanj).	
<i>This project was a continuation of "British Columbia's beetle infested pine: biomass feedstock for producing power" (Sokhansanj 05). The report provides a conceptual engineering-economic analysis of generating electrical power from MPB infested wood in BC. MPB infested wood provides a unique opportunity to convert otherwise unharvested biomass into electrical power at a reasonable cost while also providing rural employment, a cleaner environment, and help to Canada in meeting its commitments under the Kyoto Accord. [Primary Funding Partner: BC Govt: \$25,000/10,000]</i>	
Kumar, Amit (Assistant Professor, Dept. of Mechanical Eng, Univ. of Alberta)	FY 05/06
A conceptual comparison of bioenergy options for using BC's mountain pine beetle infested wood	
<i>This study estimates the cost of producing bio-oil and ethanol from MPB infested wood for the Nazko Road and Quesnel region of BC. It includes an estimation of GHG credit value for bio-oil and ethanol production using MPB wood and compares it with power estimates from previous studies. This report outlines better investment decision-making for the mitigation of MPB wood by supplying further data on bioenergy options and their costs. [Primary Funding Partner: PI funds: \$21,910/19,910]</i>	
Layzell, David (BIOCAP Canada Foundation)	FY 05/06
Exploring the Potential for Biomass Power in Ontario: A Response to the OPA Supply Mix Report (Co applicants: Stephen, Wood).	
<i>This report was written in response to the Ontario Power Authority's Supply Mix Advice Report and focuses on the potential for biomass-based power generation to make a significant, cost-competitive contribution to Ontario's electricity requirements. [Primary Funding Partner: N/A: 0/0] †</i>	
Mabee, Warren (Research Associate, Faculty of Forestry, Univ. British Columbia)	FY 05/06
Economic, Environmental and Social Benefits of 2nd Generation Biofuels in Canada (Co applicant: Saddler).	
<i>This report estimates the potential supply of 2nd Generation biofuels (<30 years since development), the costs associated with producing these fuels and the benefits of their use in Canada. The potential benefits include reduced GHGs, improved environmental performance, increased/new economic development in rural Canada, better employment in resource-based communities, protection against depletion of/rising costs in fossil fuels. [Primary Funding Partner: NRCAN: \$38,181/18,181]</i>	

<p>Reaney, Martin (Research Scientist, BioProducts and Processing, Univ. of Saskatchewan) A critical cost-benefit analysis of oilseed based biodiesel (Co applicants: Furtan, Loutas).</p> <p><i>In this study, the cost-benefit elements of biodiesel threads are explored from farm production of seed to consumers. To consider the mitigation of oilseed costs, an investigation into the production of low cost oilseed crops and the subsequent opportunities for profitable production of biodiesel is also included.</i></p> <p>[Primary Funding Partner: NRCan: \$49,220/26,169]</p>	FY 05/06
<p>Sokhansanj, Shahab (Adjunct Professor, University of British Columbia) Cost benefit of biomass supply and pre-processing enterprises in Canada (Co applicant: Fenton).</p> <p><i>This project addressed the costs and benefits of establishing sustainable biomass supply solutions for support of profitable biorefineries. The features of the report include a cost-benefit analysis for biomass collection and pre-processing enterprises in Canada and a dynamic model that simulates the collection, storage, transport, and pre-processing operations for supplying agricultural and forestry biomass to biorefineries. Biomass to biorefinery threads are outlined and capital and operating costs are documented.</i></p> <p>[Primary Funding Partner: N/A: \$31,244/31,244]</p>	FY 05/06
<p>Walburger, Allan (Professor, Dept. of Economics, Univ. of Lethbridge) Policies to Stimulate Biofuel Production in Canada: Lessons from Europe and United States (Co applicants: LeRoy, Klein, Kaushik).</p> <p><i>The purpose of this project was to aid policy makers in Canada to choose among the most effective means to encourage the use and production of bioenergy. To realize this purpose, this report first describes existing policies for managing and promoting the production and consumption of bioenergy in the US and selected European countries. The policies in other jurisdictions are then compared with those in Canada to identify the strengths and weaknesses inherent in the various policies and to suggest which are best suited to enhance bioenergy production and use in Canada.</i></p> <p>[Primary Funding Partner: N/A: \$18,600/18,600]</p>	FY 05/06
<p>Layzell, David (CEO, BIOCAP Canada Foundation) National Dialogue on Bioenergy (Co applicant: Stephen, James).</p> <p><i>BIOCAP and Energy INet partnered to launch a National Dialogue to develop a profitable, integrated and environmentally sustainable bioenergy industry in Canada. This consultative process culminated in a collective vision for the potential of biomass energy in Canada, and plans to facilitate the development of the bioenergy sector, to focus and integrate research and development efforts, and to support and integrate emerging bioenergy flagship projects.</i></p> <p>[Primary Funding Partner: Energy INet: \$90,000/45,000][†]</p>	FY 05/06-06/07
<p>Layzell, David (CEO, BIOCAP Canada Foundation) An Inventory of the Bioenergy Potential of British Columbia (Co applicant: Raylevic).</p> <p><i>BIOCAP and Energy INet partnered to launch a National Dialogue to develop a profitable, integrated and environmentally sustainable bioenergy industry in Canada. This consultative process culminated in a collective vision for the potential of biomass energy in Canada, and plans to facilitate the development of the bioenergy sector, to focus and integrate research and development efforts, and to support and integrate emerging bioenergy flagship projects.</i></p> <p>[Primary Funding Partner: BC Gov't: \$8,000/0][†]</p>	FY 05/06-06/07
<p>Tampier, Martin (ENVINT Consulting) A Primer on Pursuing Biomass Energy Opportunities and Technologies in British Columbia (Co applicant: Layzell).</p> <p><i>This Primer is designed to assist stakeholders in small communities, aboriginal groups, municipalities and industry in developing and pursuing bioenergy options in the Province of British Columbia. The Guide is specific to biomass and emphasizes technological and implementation questions.</i></p> <p>[Primary Funding Partner: BC Gov't: \$40,000/0][†]</p>	FY 05/06-06/07
<p>Samson, Roger (Executive Director – REAP-Canada) Comparing Policy Incentives for Encouraging Climate-friendly Energy in Canada: Implications for the emerging bioeconomy (Co applicants: Layzell, Bailey-Stamler, Ho Lem).</p> <p><i>This project involves the creation of a report and supporting documentation that summarizes the subsidies that are currently provided by federal and provincial governments in Canada for a range of energy alternatives. In addition, published reports on life cycle assessments will be used to estimate the net GHG emissions associated with each energy pathway so the GHG mitigation cost can be calculated.</i></p> <p>[Primary Funding Partner: n/a: \$21,200/21,200][†]</p>	FY 06/07